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ECONOMIC IMPACT AND REGULATORY FLEXIBILITY ANALYSIS OF PROPOSED EFFLUENT GUIDELINES AND NESHAP FOR THE PULP, PAPER, AND PAPERBOARD INDUSTRY

FINAL REPORT

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Office of Water
U.S. Environmental Protection Agency
Washington, DC 20460

and

Emission Standards Division
Office of Air Quality Planning and Standards
Office of Air and Radiation
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

November 1993

Recycled/Recyclable
Printed with Soy/Canola Ink on paper that contains at least 50% recycled fiber

ACKNOWLEDGEMENTS

This report was prepared under the direction and review of the Economic and Statistical Analysis Branch of the Office of Water, and the Standards Development Branch of the Office of Air and Radiation. Economic analysis support was provided by Eastern Research Group, Inc. and Research Triangle Institute under Contract Numbers 68-C8-0084, 68-C8-0302, and 68-D1-0142 with special thanks to Maureen F. Kaplan, Tayler H. Bingham, and Tyler Fox.

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EXECUTIVE SUMMARY

ES.1 BACKGROUND

The proposed rulemaking for the pulp, paper, and paperboard industry includes requirements for both air and water pollution control. A consent decree with the Environmental Defense Fund and the National Wildlife Federation requires the Agency to propose effluent regulations for dioxin by October 1993. The Clean Air Act Amendments of 1990 require the Agency to set maximum achievable control technology (MACT) standards for the pulp, paper, and paperboard industry by 1997. The Agency integrated the water and air rulemaking efforts for several reasons:

- Pollution prevention approaches that reduce the formation of pollutants can be applied.
- The possibility of cross-media pollutant transfers is reduced.
- The Agency can consider controls that achieve the most total pollutant reduction for the least cost.

Industry benefits from the integrated rulemaking via cost savings in compliance planning by knowing the requirements for all rules at the beginning of the planning effort. Industry also can select the best combination of controls to meet all rules, thus potentially reducing capital equipment costs.

The control technologies considered by the Agency emphasize pollution prevention. They include process changes that reduce the formation of pollutants and control technologies to remove pollutants before their release to air or water. For example, a process change that prevents chloroform formation might also prevent or minimize the formation of dioxin and chlorinated organics. The same process change, however, could affect the amount and type of volatile contaminants sent to the air pollution control equipment. The engineering analysis evaluates the interactions among process changes, the amount and type of contaminants sent to

water and air pollution control treatment, and the final releases. This systems analysis evaluates the many interactions of pulping and papermaking operations.

ES.2 INDUSTRY PROFILE

Where possible, the Agency made use of publicly available data. Facility- and company-specific data not available through public sources were collected by the *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities*. There are approximately 565 facilities in 42 states and 200 companies in the industry. In 1989, the industry shipped about 12 million tons of pulp, 38 million tons of paper, and 37 million tons of paperboard for a combined value of $59 billion. Nearly $6 billion of these shipments were exports. About 220,000 people are employed in the manufacturing of pulp, paper, and paperboard.

The industry is cyclical, with a recent low point in 1985 and peak years in 1988 and 1989. It is a capital-intensive industry. In 1989, the industry invested about $8 billion, or $47,000 per employee in new plants and equipment. About 14 percent of these expenditures were for environmental protection. The U.S. industry holds a dominant position in the global marketplace. In 1991, the U.S. produced 30 percent of the world's paper and paperboard and 35 percent of the world's wood pulp. U.S. production levels exceeded the total pulp and paper output of the next four largest pulp- and paper-producing nations combined—Japan, Canada, Germany, and China.

ES.3 METHODOLOGY

The cost of incremental pollution control can be expressed in several different ways. One way is to estimate what a business would actually pay to purchase, install, and operate new pollution control equipment. The components considered in the calculation include the capital investment, annual cost of operation and maintenance, annual general and administrative cost, cost of money, and tax savings through depreciation and reduced taxes because of higher costs. This cost estimate is called the industry compliance cost or the private cost of the regulation.

The social cost of the regulation uses microeconomic concepts to model the changes in aggregate economic welfare by measuring the changes in consumer and producer surpluses. The social cost includes consideration of the value society places on the use of these resources for pollution control, and is generally larger than the industry compliance cost.

The industry compliance cost is used with both a financial impact analysis (which focuses on individual facilities) and a market impact analysis (which examines interactions among all facilities) to evaluate the economic impacts of environmental regulation. Mill closure projections are based on quantitative estimates of several economic factors, but the decision to close an industrial facility depends on many judgements outside the scope of the Agency's analysis. Thus, the Agency's projections of potential closures is interpreted as an indication of the extent of plant impact rather than as a prediction of certain closure.

The financial impact analysis estimates the incidence of mill closures, the potential employment, output, and export impacts associated with mill closures, and the change in key financial ratios attributable to the incremental compliance costs. To estimate mill closure, the analysis compares estimates of the discounted present value of future earnings to estimates of mill salvage value. The comparison is made to determine whether, after imposing regulatory compliance costs, the mill would be more valuable to the current owner if it were shut down and liquidated rather than in continued operation. The analysis also estimates the changes in key financial ratios after imposing regulatory compliance costs, and compares the changes to fluctuations that have historically occurred in the business cycle.

The market impact analysis estimates mill supply responses and end-use demand responses to regulatory compliance costs for all market factors in 31 product markets. This analysis estimates the potential changes in pulp, paper, and paperboard product prices; individual and overall mill production and employment levels; foreign imports and domestic exports; and mill production costs and revenues. The analysis evaluates the potential for mill closure by estimating the post-regulatory earnings before interest, depreciation and taxes (EBIDT). Negative earnings indicate potential closure.

ES.4 REGULATORY ALTERNATIVES AND COMPLIANCE COSTS

Effluent guidelines and MACT standards are technology-based regulations. While the source of discharge or emission need not install any specific pollution control technology, the regulatory requirements must be based on a technology that can achieve the regulatory requirements. The Development Document and Background Information Document detail the technology basis for effluent guidelines and MACT standards.

For the purpose of establishing effluent limitations guidelines and emission standards for hazardous air pollutants, an industry may be subcategorized based on manufacturing process and/or other distinguishing characteristics. The pulp, paper, and paperboard industry is divided into 12 subcategories that incur additional pollution control requirements under the proposed rulemaking. Table ES-1 lists the subcategories and references the regulatory requirements for each of them.

The Agency analyzed many combinations of technologies as the basis for the proposed regulations. A subset of these combinations, or regulatory alternatives, are analyzed in this report. There are seven components of an integrated regulatory alternative:

- Process change for the dissolving kraft subcategory (BAT/PSES).
- Process change for the bleached papergrade kraft and soda subcategory (BAT/PSES).
- Process change for the dissolving sulfite subcategory (BAT/PSES).
- Process change for the papergrade sulfite subcategory (BAT/PSES).
- Air controls for all subcategories (MACT).
- Best management practices for all subcategories (BMP).
- Wastewater treatment improvements for all subcategories (BPT).

Table ES-2 summarizes a subset of the regulatory alternatives to which the Agency devoted most of its analysis. Table ES-3 summarizes the capital, annual, and annualized costs associated with

TABLE ES-1

SUBCATEGORIES AND REGULATORY COVERAGE

Effluent Subcategory	Number of Mills in this Subcategory	Clean Air Act MACT	Clean Water Act		
			BAT & PSES	BPT/ BCT	BMP
Dissolving Kraft	3	X	X	X	X
Bleached Papergrade Kraft and Soda	88	X	X	X	X
Unbleached Kraft	58	X	X	X	X
Semichemical	21	X	X	X	X
Dissolving Sulfite	5	X	X	X	X
Papergrade Sulfite	11	X	X	X	X
Mechanical Pulp	57			X	
Non-wood Chemical	12			X	X
Secondary Fiber, Deink	43			X	
Secondary Fiber, Non-deink	342			X	
Fine and Lightweight Papers from Purchased Pulp	115			X	
Tissue, Filter, Nonwoven, and Paperboard from Purchased Pulp	169			X	
Number of Mills		161	160	325	172

TABLE ES-2

DESCRIPTION OF REGULATORY ALTERNATIVES[1]

Reg. Alt.	Process Changes				Air Controls			End of Pipe	Best Management Practices
	Bleached Papergrade Kraft and Soda	Papergrade Sulfite	Dissolving Sulfite	Dissolving Kraft	Pulp Area Vents	Bleach Area Vents	Condensate Wastewater		
1	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
2	Baseline	Baseline	Baseline	Baseline	Digester, evaporator, WBL storage, washer, knotter, and foam tank	Scrub C, D1, D2, E1, E1, H stage	100 ppmw	Baseline	Baseline
3	Baseline	Baseline	Baseline	Baseline	Reg alt 2 points plus OD	Scrub C, D1, D2, E1, E2, H stage	100 ppmw	Baseline	Baseline
4	Baseline	Baseline	Baseline	Baseline	Reg alt 3 points plus decker	Scrub C, D1, D2, E1, E2, H stage	100 ppmw	Baseline	Baseline
5	Baseline	Baseline	Baseline	Baseline	Reg alt 3 points plus decker	Duct scrubber to combustion device	100 ppmw	Baseline	Baseline
11	OD or EC + 70% ClO_2	TCF	TCF	OD + 70% ClO_2	Digester, evaporator, WBL storage, washer, knotter, and foam tank	Scrub C, D1, D2, E1, E2, H stage	100 ppmw	Treatment used by average of best 50%	Yes
16	OD or EC + 70% ClO_2	TCF	TCF	OD + 70% ClO_2	Reg alt 10 points plus OD	Scrub C, D1, D2, E1, E2, H stage	100 ppmw	Treatment used by average of best 50%	Yes

TABLE ES-2 (cont.)

Reg. Alt.	Process Changes				Air Controls			End of Pipe	Best Management Practices
	Bleached Papergrade Kraft and Soda	Papergrade Sulfite	Dissolving Sulfite	Dissolving Kraft	Pulp Area Vents	Bleach Area Vents	Condensate Wastewater		
17	OD or EC + 70% ClO_2	TCF	TCF	OD + 70% ClO_2	Reg alt 16 points plus decker	Scrub C, D1, D2, E1, E2, H stage	100 ppmw	Treatment used by average of best 50%	Yes
18	OD or EC + 70% ClO_2	TCF	TCF	OD + 70% ClO_2	Reg alt 16 points plus decker	Duct scrubber to combustion device	100 ppmw	Treatment used by average of best 50%	Yes
22	OD or EC + 100% ClO_2	TCF	TCF	OD + 70% ClO_2	Digester, evaporator, WBL storage, washer, knotter, and foam tank	Scrub C, D1, D2, E1, E2, H stage	100 ppmw	Treatment used by average of best 50%	Yes
23	OD or EC + 100% ClO_2	TCF	TCF	OD + 70% ClO_2	Reg alt 22 points plus OD	Scrub C, D1, D2, E1, E2, H stage1	100 ppmw	Treatment used by average of best 50%	Yes
24	OD or EC + 100% ClO_2	TCF	TCF	OD + 70% ClO_2	Reg alt 23 points plus decker	Scrub C, D1, D2, E1, E2, H stage	100 ppmw	Treatment used by average of best 50%	Yes
25	OD or EC + 100% ClO_2	TCF	TCF	OD + 70% ClO_2	Reg alt 23 points plus decker	Duct scrubber to combustion device	100 ppmw	Treatment used by average of best 50%	Yes

TABLE ES-2 (cont.)

Reg. Alt.	Process Changes				Air Controls			End of Pipe	Best Management Practices
	Bleached Papergrade Kraft and Soda	Papergrade Sulfite	Dissolving Sulfite	Dissolving Kraft	Pulp Area Vents	Bleach Area Vents	Condensate Wastewater		
26*	OD or EC + 100% ClO_2	TCF	OD + 100% ClO_2	OD + 70% ClO_2	Reg alt 22 points plus OD	Scrub C, D1, D2, E1, E2, H stage	500 ppmw	Treatment used by average of best 50%	Yes

[1] OD = Oxygen Delignification
EC = Extended Cook
D = Chlorine Dioxide
TCF = Totally Chlorine-free
ClO_2 = Chlorine Dioxide Substitution
WBL = Weak Black Liquor
C = Chlorination
E = Extraction
H = Hypochlorite

* Proposed Alternative

TABLE ES-3

SUMMARY OF POLLUTION CONTROL COSTS ASSOCIATED WITH REGULATORY ALTERNATIVES
(THOUSANDS OF 1991 DOLLARS)

Regulatory Alternative	Capital Cost	O&M Expense	Annualized Cost
2	$775,481	$174,370	$173,494
3	$779,559	$174,618	$173,960
4	$884,787	$186,972	$190,842
5	$1,161,872	$208,907	$229,365
11	$3,708,235	$322,353	$531,706
16	$3,742,111	$324,414	$536,092
17	$3,847,339	$336,767	$552,974
18	$4,126,487	$358,417	$591,619
22	$3,846,775	$413,723	$597,078
23	$3,880,651	$415,784	$601,465
24	$3,985,879	$428,137	$618,346
25	$4,265,027	$449,787	$656,991
26	$3,903,850	$395,708	$591,580

About 350 mills were analyzed to calculate pollution control costs of regulatory alternatives.

each of the alternatives. The annualized industry compliance cost for Regulatory Alternative 26 is about $592 million (1991 dollars). The social cost for the same alternative is estimated at nearly $920 million (1991 dollars). The economic impacts for Regulatory Alternative 26 are summarized in Section ES.5. The results of a regulatory flexibility analysis (for small entities) are summarized in Section ES.6.

The economic impact analysis also investigated the costs and impacts for several individual components of the regulatory alternatives: two options for wastewater treatment improvements (BPT), and from two to five options for process changes for the dissolving kraft, dissolving sulfite, bleached papergrade kraft and soda, and papergrade sulfite subcategories.

ES.5 IMPACTS

The Agency estimates that the proposed regulations will apply to nearly 350 pulp, paper, and paperboard mills. The Agency estimates that between 11 and 13 mills will face the possibility of closure as a result of the change in production costs due to the integrated regulatory alternative, and from 2,800 to 10,700 jobs could be lost. The range of these estimates is created by differences in the assumptions used in estimating them. The upper end of the ranges reflects more conservative assumptions.

Market prices for pulp, paper, and paperboard products are not expected to be significantly affected, with the largest price increase being 2.7 percent for uncoated free sheet (used to make copy paper, writing tablets, etc.). The estimated overall impact of the integrated regulatory alternative on the total value and quantity of foreign imports of pulp, paper, and paperboard products is minor; an increase of less than 1 percent. The most significant estimated increases in imports for individual product groups are 1.4 percent increase for clay-coated printing paper, 1.5 percent for recycled paperboard, and 6.1 percent for folding carton board. The estimated overall impact on the total value and quantity of exports is also minor. Individual product groups, however, might experience significant declines in export value. The most significant estimated declines in exports for individual product groups are 23 percent for

uncoated free sheet, 8.5 percent for recycled paperboard, 6.7 percent for newsprint, and 3.9 percent for bleached sulfite pulp.

ES.6 REGULATORY FLEXIBILITY ANALYSIS

Part of the Agency's task of complying with the Regulatory Flexibility Act (5 U.S.C. 601 et seq., Pub. L.96-354) is to examine the potential economic impact of regulatory actions on small entities. The Agency has estimated the economic impact of the integrated regulatory alternative on small mills and small companies involved in pulp, paper, and paperboard manufacturing, and has attempted to illustrate the potential disparate impacts between the groups of large and small manufacturers.

For purposes of this proposed rule, the Agency has considered several alternative definitions for small entities to capture the unique size and structural characteristics of this industry. Among the definitions considered in the analysis, the Agency has considered small entities to be:

- Individual mills employing fewer than 750 workers
- Individual mills employing fewer than 125 workers
- Independently owned and operated companies employing fewer than 750 workers

Under the last definition, small companies can be independently-owned single-facility entities, or multifacility companies that own more than one pulp and paper mill, or own multiple businesses in two or more SIC categories. The Agency used each of these definitions to characterize the impacts of the proposed standards on small entities.

The Agency estimates that 35 percent of the mills in the industry employ less than 125 workers and 85 percent employ less than 750 workers. Of the approximately 200 companies, 75 percent meet the definition of small. The analyses indicate that between one and six estimated mill closures are mills employing less than 125 workers, and between nine and ten are mills

employing less than 750 workers. This indicates that a small majority of the facility closures are small mills but that the proportion is less than the percentage of small mills in the entire population. While small companies form about 75 percent of the population, about 40 to 45 percent of all estimated closures are mills owned by small companies.

The Agency examined the impact of the proposed rules on relevant financial ratios of both large and small facilities. The median results show that facilities employing less than 125 workers experience less deterioration in financial health than larger facilities. The results were similar for facilities employing less than 750 employees. The company-level ratio analysis generally indicates less deterioration in financial health for small companies as well.

The Agency also examined potential changes in facility earnings before interest, taxes, and depreciation (EBITD). The results indicate the facilities employing less than 125 workers had a smaller decline in EBITD than large facilities. The same is true for facilities employing less than 750 workers.

The Agency also employed the Altman Z-score method to estimate the likelihood of bankruptcy for companies to assess potential differences between large and small company impacts of the proposed standards. This analysis indicates that small companies are not any more likely to face bankruptcy after regulation than large companies.

In general, there is no consistent pattern of disproportionate impacts on small entities. The results indicate the regulatory alternatives do not cause a significant impact on a substantial number of small entities. This conclusion is reached for all definitions of small entity used in both analytical models.

SECTION ONE

INTRODUCTION

1.1 SCOPE AND PURPOSE

This report evaluates the economic impacts of additional pollution control requirements for the pulp, paper, and paperboard industry. The regulatory options examined evaluate controls on releases to both air and water.

The Federal Water Pollution Control Act (commonly known as the Clean Water Act) established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Section 101(a)). The U.S. Environmental Protection Agency (EPA) is required under Sections 301, 304, 306, and 307 of the Clean Water Act to establish effluent limitations guidelines and standards of performance for industrial dischargers. In particular, EPA establishes:

- Best Practicable Control Technology Currently Available (BPT). These rules apply to existing industrial direct dischargers, and generally cover control of conventional pollutant discharge, such as biochemical oxygen demand (BOD), total suspended solids (TSS), pH, and oil and grease.

- Best Conventional Pollutant Control Technology (BCT). These rules apply to existing industrial point sources that discharge conventional pollutants. Section 304(b)(4)(B) adds the requirement that BCT effluent guidelines costs must be "reasonable" in relation to effluent reductions. If BCT effluent limitations guidelines fail the cost-reasonableness tests, the BPT limitations form the floor below which BCT guidelines cannot be established.

- Best Available Technology Economically Achievable (BAT). Required under Section 304(b)(2), these rules control the discharge of priority and non-conventional pollutants and apply to existing industrial direct dischargers.

- Pretreatment Standards for Existing Sources (PSES). Analogous to BAT controls, these rules apply to existing indirect dischargers (whose discharges flow to publicly owned treatment works, or POTWs).

- New Source Performance Standards (NSPS). Required under Section 306(b), these rules control the discharge of priority and non-conventional pollutants and apply to new source industrial direct dischargers.

- Pretreatment Standards for New Sources (PSNS). Analogous to NSPS controls, these rules apply to new source indirect dischargers (whose discharges flow to publicly owned treatment works, or POTWs).

The Clean Air Act's purpose is "to protect and enhance the quality of the Nation's air resources" (Section 101(b)). Section 112 of the Clean Air Act as amended in 1990 establishes the authority to set national emission standards for 189 hazardous air pollutants (NESHAP). NESHAPs are industry-specific. For air pollutants, EPA establishes:

- MACT: Maximum Achievable Control Technology. MACT standards are set by the NESHAP. The term "MACT floor" refers to minimum control technology on which MACT can be based. For existing sources, the MACT floor is the average emissions limitation achieved by the best performing 12 percent of sources (if there are 30 or more sources in the category or subcategory), or best performing 5 sources (if there are fewer than 30 sources in the category or subcategory). MACT can be more stringent than the floor considering costs, non-air quality health and environmental impacts, and energy requirements.

1.2 INTEGRATED RULEMAKING EFFORT BY THE OFFICE OF AIR AND THE OFFICE OF WATER

The rulemaking for the pulp, paper, and paperboard industry is an integrated effort coordinated by the Office of Air and Radiation and the Office of Water. Both Offices are required by law to set pollution control requirements for this industry. A lawsuit filed by the Environmental Defense Fund and the National Wildlife Federation requires the Agency to propose water regulations for dioxin by 1993. The Clean Air Act Amendments of 1990 require the Agency to set MACT standards for the pulp, paper, and paperboard industry by 1997. The Agency decided to integrate the rulemaking efforts for several reasons:

- Pollution prevention approaches that reduce the formation of pollutants can be applied.

- The possibility of cross-media pollutant transfers is reduced.
- The Agency can select controls that get the most total pollutant reduction for the least cost.

Industry benefits from the integrated rulemaking via cost savings in compliance planning by knowing the requirements for all rules at the beginning of the planning effort. Industry also can select the best combination of controls to meet all rules, thus potentially reducing capital equipment costs.

This rulemaking is distinguished from previous rulemakings by its emphasis on pollution prevention. The control technologies considered by the Agency include process changes that avoid or minimize the formation of pollutants, as well as control technologies to remove pollutants before their release to air or water. For example, a process change that prevents chloroform formation might also prevent or minimize the formation of dioxin and chlorinated organics. The same process change, however, could affect the amount and type of volatile contaminants sent to the air pollution control equipment. The engineering analysis evaluates the interactions among process changes, the amount and type of contaminants sent to water and air pollution control treatment, and the final releases. This systems analysis evaluates the many interactions of pulping and papermaking operations.

1.3 DATA SOURCES

Where possible, the Agency made use of publicly available data. These information sources included U.S. Bureau of the Census documents, such as Current Industrial Reports and Annual Survey of Manufactures, and industry data, such as the American Forest and Paper Association (formerly American Paper Institute) annual compilation of statistics for the pulp, paper, and paperboard industry. In addition, conference proceedings, journal articles, and industry experts all provided information for the analysis.

General industry-wide information from such publicly available sources provided a solid technical base for evaluating processes and control technologies. Then, the engineering analysis addressed the question of what equipment and costs would be necessary for a facility to meet a

particular set of pollution requirements. The answer depends, in part, on the facility's pulping or papermaking processes, the equipment already in place, and the new requirements. While detailed information at the facility level is not publicly available, the Agency is authorized by Section 308 of the Clean Water Act and Section 114 of the Clean Air Act to collect such information for rulemaking purposes. Because facilities in this industry vary greatly in size, processes, and production, the Agency determined that a census, rather than a sample, was necessary to gather the needed data. Facility- and company-specific data were collected by the 1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities which was divided into two parts—Part A collected technical information and Part B collected financial and economic information. The economic impact analysis relies heavily on the information gathered in this survey.

1.4 ORGANIZATION OF THE REST OF THE REPORT

Section Two presents the industry profile. Based primarily on the Part B survey data and on publicly available information, the section begins with an overview of the industry, its processes, and the environmental issues that affect the rulemaking. Data are presented on industry products, the industry's production facilities (including how those facilities correspond to the effluent guidelines subcategories), the companies that own and operate the facilities, industry-wide financial characteristics, and international issues.

Section Three reviews the economic impact and regulatory flexibility methodologies. Two methodologies are used to evaluate the economic impacts of the regulatory options. The first is a financial model that focuses on individual facilities, and the second is a market model that examines interactions among all facilities. Section Three also contains a discussion of the various categories used in a regulatory flexibility analysis to evaluate the small business impacts of the regulation.

Pollution control components examined in the rulemaking include process changes, wastewater treatment, best management practices, and emission controls to reduce air pollution. Section Four describes these components, the subcategories to which they relate, and how the components are combined to create regulatory alternatives. The costs associated with the alternatives also are presented.

Section Five describes the economic impacts of the additional pollution control costs. Small business entity impacts are discussed in Section Six.

SECTION TWO

INDUSTRY PROFILE

Paper has become an ubiquitous element of American society. Nearly every activity of daily life—whether cleaning or shopping, writing or reading—involves at least one of the thousands of diverse paper products manufactured today. Scholars credit several cultures with the invention of some form of paper. The conceptual foundation of modern papermaking, however, is attributed to a Chinese Minister of Agriculture who, in 105 A.D., used fibers from silk and mulberry bark to form sheets of paper. The multibillion-dollar pulp and paper industry thriving today is based on this same 2,000-year-old idea of reducing fiber to its individual strands, and reforming the strands into a flat sheet. When dry, the sheet can be converted into one of the many paper products we use in everyday life (Kline, 1982).

This process of liberating individual strands of fiber from raw material sources is called pulping, and the end product is called pulp. Paper is a broad term for the thin sheets of hydrogen-bound fibers made from pulp. Paperboard is manufactured the same way as paper but is often thicker and used for packaging, while paper grades are used primarily for communications.

The pulp and paper industry ranks eighth among all U.S. manufacturing industries and third among the nondurables sector in value of shipments—$126 billion in 1992 (ITA, 1993). In addition, the industry currently enjoys a dominant position in the international paper, paperboard, and pulp markets because of its low unit labor costs, high-quality production, and favorable exchange rates. Historically, the pulp and paper industry has represented one of the nation's most heavily capitalized economic sectors. Capital expenditures in 1992 were approximately $11.3 billion (ITA, 1993).

This section provides a simplified introduction to the diverse pulp and paper industry. The intent is to give the reader a general understanding of the technical, economic, and

environmental issues faced by pulp and paper manufacturers and to identify topics that affect the economic impact analysis. Section 2.1 briefly describes the raw materials and industrial processes of the pulp and paper industry. More detailed information on these subjects is located in the Office of Water's Development Document and the Office of Air's Background Information Document accompanying the proposed rule. Section 2.2 discusses environmental protection issues relevant to this rulemaking. Section 2.3 presents product information from the U.S. Environmental Protection Agency's (EPA's) survey and compares EPA's 1989 data to similar compilations by the American Forest and Paper Association (formerly American Paper Institute) and by the U.S. Bureau of the Census from that year. Section 2.4 summarizes the number of facilities by location, production, and other parameters. Section 2.5 briefly describes the effluent subcategories for the pulp and paper industry and how they relate to individual facilities. General information on companies and employment levels is given in Section 2.6. Financial patterns for the industry are examined in Section 2.7, and Section 2.8 summarizes international trade and competition issues facing the pulp and paper industry.

2.1 OVERVIEW OF INDUSTRY PROCESSES

To meet the constantly increasing demand for their products and to maintain market competitiveness, pulp and paper manufacturers traditionally have followed a policy of installing the latest production technology at their mills. This section will discuss the most common types of equipment and industrial processes employed at pulp and paper mills. The discussion is divided into three general categories: fiber sources and their preparation; pulping and bleaching; and papermaking. In addition, the effluents and emissions resulting from these processes are examined.

2.1.1 Fiber Sources and Preparation

All paper and paperboard have two common characteristics. First, each consists of fibers that are capable of bonding together through chemical reactions. Second, these fibers have been

formed into a layered structure where each fiber has random orientation (Kline, 1982). Paper can be made from almost any substance containing fiber as long as technology exists to liberate the individual fiber strands for further manipulation. Tree wood is the primary fiber source used by today's pulp and paper manufacturers because of its renewability and the favorable physical characteristics of its cellulose fiber.[1] In the past, however, cotton, straw, sugar cane, rice, and rags all have been used as primary fiber sources in paper production and in some cases continue to be added today to certain grades of paper to achieve special product attributes. For instance, cotton is blended with wood fibers to enhance the strength and permanence of some high-quality paper grades.

Trees typically are divided into two general categories: hardwoods and softwoods. Hardwoods are the broad-leafed trees, such as maple, oak, birch, and gum, which have fibers that are characteristically small. Softwood fibers are derived primarily from evergreens, including pine, spruce, and fir, and are larger than hardwood fibers. Larger fibers result in a stronger, but coarser, internal bond. Although fibers do vary among different tree species within a category, this variation is usually too small to affect final product properties.

Most paper and paperboard is produced by blending fibers from the hardwood and softwood categories until the desired properties are achieved. In these blends, softwood fiber provides strength, while hardwood fiber is used to fill in the gaps between large softwood fibers to create a smoother, more opaque grade of paper (Kline, 1982). Hardwood and softwood fibers are obtained from two sources: pulp wood, where entire logs are used solely for pulping and papermaking; and wood wastes and forest and sawmill residues generated from logging and timber production.

The growing environmental awareness among consumers and industry has prompted an increase in the use of wastepaper as a fiber source for pulping and papermaking. In 1992, wastepaper (also called secondary fiber) accounted for 29 percent of the fiber used at pulp and paper mills (ITA, 1993). About one-third of the paper and paperboard mills in operation in 1992 used wastepaper as their principal fiber component, while another 50 percent used waste

[1]Bark and leaves are unsuitable for pulping.

materials for up to half of their fiber mix. Other mills continue to update and install technology to recover secondary fiber. Old corrugated containers (OCC) and old newsprint (ONP) accounted for the bulk of the total recovered paper and paperboard in 1992 (ITA, 1993).

As is the case with virgin hardwood and softwood fiber sources, the type of final product made from secondary paper is determined largely by the quality and purity of the fiber. ONP, for example, is recycled primarily into newsprint and paperboard and cannot be used in printing and writing paper. Fibers generally sustain some quality degradation during recovery; consequently, virgin fiber frequently is used in conjunction with secondary fiber to maintain marketability of paper grades. Section 2.2.1 gives a more detailed discussion of recycling in the pulp and paper industry.

2.1.2 Pulping and Bleaching

2.1.2.1 Wood Pulping

Pulping is the liberation of individual fibers from the wood structure by breaking down *lignin*, an adhesive substance that impairs the formation of sturdy bonds in paper. Lignin is also responsible for the coloration visible in unbleached paper such as paper bags; and, after reacting with sunlight, lignin causes the yellowing often detectable in old newspapers and books. Pulping operations fall into three broad categories: mechanical, chemical, and semichemical. The type of pulping process used depends on the desired properties of the end product, and on the costs for raw materials, for energy requirements, and, increasingly, for effluent and emissions treatment and control (EPA, 1991a). This discussion will focus on the processes and equipment employed during log pulping; wastepaper fiber sources will be mentioned briefly at the end of this section and in more detail in Section 2.2.1. For each pulping process, logs undergo a debarking stage prior to pulping to remove undesirable fibers from the tree's outer shell.

Mechanical Pulping. In mechanical pulping, physical force is applied to reduce logs to their component fibers. The oldest form of mechanical pulping is groundwood pulping, where a log is pressed against a grooved cylindrical grinding stone, which tears fibers from the log. The

fibers are washed into a slurry using jets of water. Modern groundwood processes employ hydraulic presses to push logs against the grinding stone.

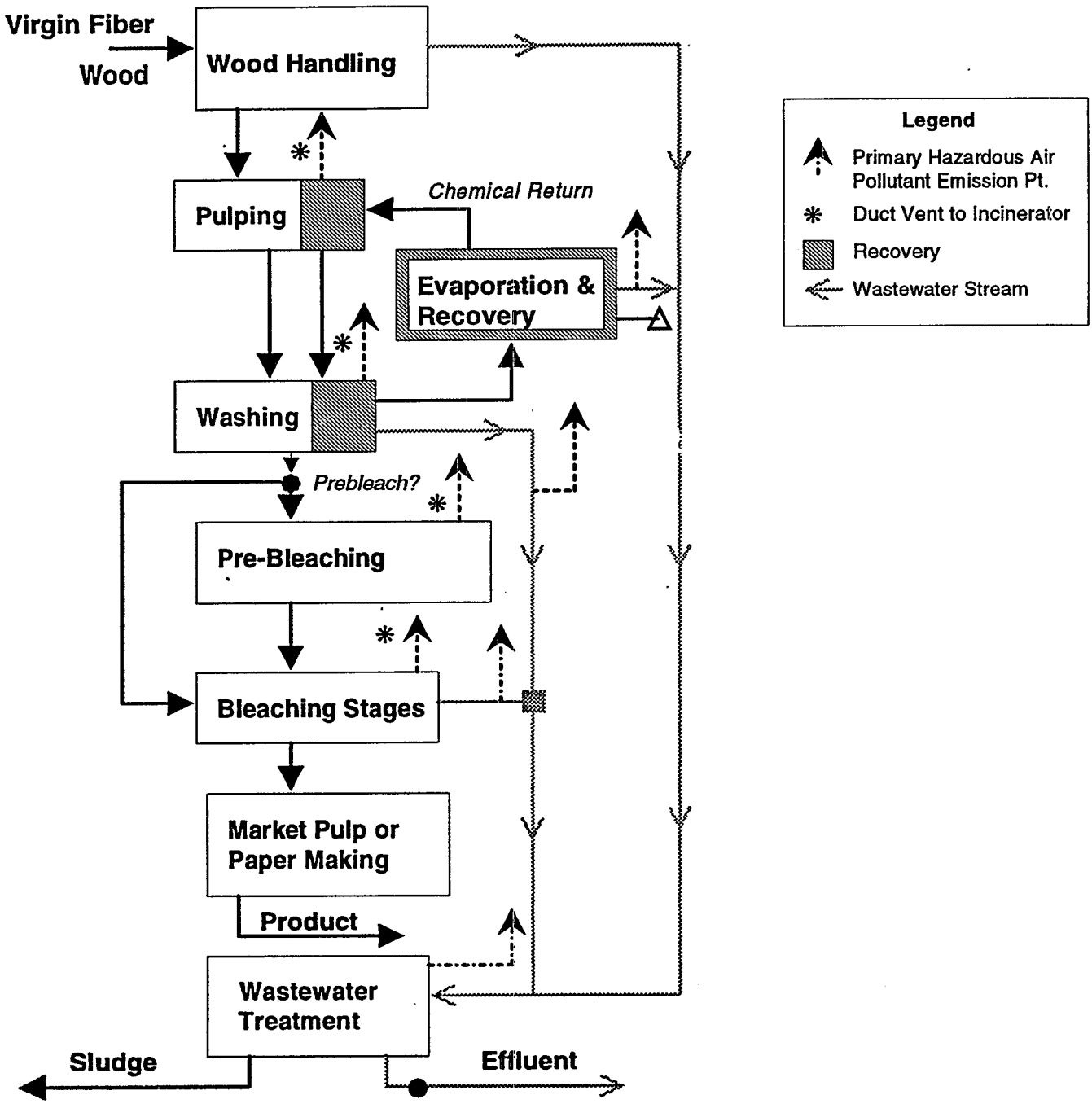
Wood chips also can be pulped mechanically with a refiner mechanical pulping (RMP) process. This method grinds or shreds the chips between two cylindrical disks, one or both of which are rotating. Chips are fed into the center of the disks and forced outward into smaller and smaller pieces.

Because mechanical processes do not remove lignin from the fibers, the resultant pulp does not bleach well and yellows quickly. Consequently, the use of mechanical pulp is limited to unbleached paper and paperboard, or grades of paper that are discarded prior to yellowing, such as newsprint and advertising circulars. Methods exist to increase the brightness, finish, and printability of mechanical pulp during the papermaking process, thus rendering high-quality mechanical pulp competitive with its low-grade chemical counterparts. As a result, mechanical pulping is still widely employed in North America (EPA, 1991a). Mechanical pulping currently accounts for approximately 10 percent of total U.S. pulp production (AFPA, 1992a).

Chemical Pulping. In chemical pulping, cellulose fibers are liberated from the wood structure with chemicals. Pulping chemicals, though designed to eliminate lignin, also can dissolve cellulose if left in contact long enough with fiber sources. Therefore, to ensure full and even penetration of pulping chemicals and to minimize damage to cellulose, wood is first chipped into pieces of uniform size and thickness through a process called chip control. This process avoids both underpulping some chips (which lowers the yield of the pulping process) and excessively damaging cellulose in other pieces. Figure 2-1 illustrates the steps involved in a chemical pulping operation.

Kraft and sulfite pulping are the two most prevalent methods of chemical pulping used today. Of these two processes, kraft (or sulfate) pulping is far more common, accounting for approximately 77 percent of U.S. pulpmaking capacity in 1991 (AFPA, 1992a). Its success is due to several factors. First, kraft chemicals are selective in their attack on wood constituents, minimizing damage to cellulose and resulting in a stronger product. In addition, the kraft process is applicable to a variety of wood types and can tolerate contaminants such as high resin

FIGURE 2-1
CHEMICAL PULPING AND BLEACHING OPERATIONS



content. Kraft chemicals can be recovered and reused, which reduces expenditures for chemical supplies. Finally, the kraft process benefits from a high degree of heat recovery for process use (EPA, 1991a).

In the kraft process, wood chips are immersed in a mixture of caustic soda (sodium hydroxide, or NaOH) and sodium sulfide (Na_2S) at roughly a 10-percent concentration in a reaction vessel called the digester. This chemical mixture, called white liquor or cooking liquor, attacks the lignin in the fiber, breaking it into smaller, soluble segments. Temperature and pressure in the digester are controlled for optimal cooking conditions. As delignification proceeds, the reaction chemicals begin to attack the cellulose. Under extreme time and temperature conditions, the cellulose degrades, which reduces process yield. Lignin removal therefore must be balanced to prevent yield losses. The output of kraft pulping consists of the separated wood fibers and a black liquor, the spent cooking liquor, which contains the dissolved lignin solids in a solution of reacted and unreacted pulping chemicals.

Unlike the kraft process, sulfite pulping employs acid to break down lignin. The acids are formed by dissolving sulfur dioxide (SO_2) in water. After contact with chips, the resultant lignosulfonic acids are tempered with a base chemical to prevent degradation of cellulose. Until recently, calcium was used as the base compound in sulfite processing. Calcium, however, can produce scale that clogs pipes and tanks. Sulfite cooking liquor is not recoverable, making the process less economical than kraft pulping (Kline, 1982). Recently, sodium, magnesium, and ammonia have been used as base chemicals in the sulfite process with fairly good results. Another problem associated with sulfite process is the use of sulfur dioxide, a toxic gas that must be handled with great care.

The sulfite process tends to produce pulp with favorable properties. Upon exit from the digester, sulfite pulp is considerably whiter than kraft pulp. Unless high brightness is required, sulfite pulp can be used directly in paper or board applications without bleaching. Sulfite pulp fibers also can make paper that is softer or smoother than kraft pulp fibers. Sulfite pulps therefore are used in tissue, in high-quality bond and writing papers, and in fluff pulp (used in hygiene products). In addition, fibers in sulfite pulp tend to contain more cellulose, resulting in brighter, more permanent paper after bleaching (Kline, 1982).

Several factors have limited the use of the sulfite pulping process, however. First, most manufacturers lack a recovery system for sulfite pulping chemicals, and disposal costs are rising with increased environmental regulation. Second, paper produced from sulfite pulp tends to be weaker than its kraft counterpart. Finally, the sulfite process is not compatible with the fiber characteristics of many trees, seriously limiting its applicability. As a result, sulfite pulp currently comprises only slightly over 2 percent of total U.S. pulp production.

Chemical pulping can be performed in one of two ways: batch or continuous mode. In batch operations, the digester is filled with chips and chemicals, temperature and pressure are adjusted to optimize cooking conditions, and the cooking liquor is circulated throughout the digester until pulping is complete. Pulp and black liquor are discharged from the bottom of the digester through a blow valve and then screened to remove rejects (i.e., unreacted chips and bundles of fiber). These rejects can be either sent back into the digester or consumed as fuel to power the chemical recovery furnace. From the digester, spent liquor is sent to recovery operations. The recovery boiler's capacity is an important parameter considered in estimating costs for process changes.

Separated pulp then proceeds to washing equipment where it is cleansed of spent cooking liquor. Washing is critical for removing any excess lignin and unreacted chemicals from the pulp. Poor washing means more chemicals are needed to bleach the pulp to needed brightness. If lignin is carried over to the bleaching stage, chlorinated organic pollutants can be formed at chlorine bleaching kraft plants. Most mills employ a countercurrent series of washers, where filtrate from each wash stage is used to clean pulp in previous stages. Freshwater is used to wash pulp in the last washing stage. The resulting liquid mix of liquor and water is sent to the central stages where it gathers more liquor. The concentrated wash filtrate from the earliest wash stage is sent to the recovery boiler for evaporation and chemical recovery. After washing, pulp may be thickened and blended with other pulps before it either goes to the bleach plant or papermaking machine, or is dried and shipped to market.

To operate efficiently, both bleaching and papermaking equipment must function continuously with a constant stream of pulp. To achieve this constant flow, mills using batch

pulping normally install a series of digesters alongside one another. Batch digesters range in size from 6,000 to 8,000 cubic feet and are several stories high (EPA, 1991a).

In continuous pulping, wood chips are fed through tubes where they are steamed and then injected with cooking liquor. The pretreated chips are deposited into the top of the continuous reaction vessel. The chip mass travels down through the vessel's top portion, called the cooking zone, while lignin normally travels up in ever-increasing amounts. The fiber is exposed to cooking liquor in controlled temperature and pressure conditions (EPA, 1991a). At the end of cooking zone, spent liquor is strained from the pulp and routed to the liquor recovery system.

The pulp then enters the digester's washing zone. Here, water is forced up to wash progressively dirtier masses of pulp, using the same countercurrent washing concept employed in batch pulp washers. Washed pulp is then screened and sent to papermaking machines, or is dried and sold. To supply the enormous volume of pulp needed for papermaking machines, continuous digesters can be as large 20 feet in diameter and 200 feet tall (Kline, 1982).

Semichemical Pulping. In chemical processes, spent liquor often is burned to produce steam for the pulping operations, whereas groundwood pulping requires constant energy input. On the other hand, mechanical processes yield more pulp per unit of raw material as a result of the absence of chemicals that inevitably destroy some fiber. Semichemical pulping is an attempt to find a middle ground between these two pulping categories and to capitalize on their respective advantages. Most semichemical pulping operations employ some form of thermal or chemical pretreatment prior to mechanical refining. Pulps from these processes are frequently used to produce corrugated board and constitute about 7 percent of the wood pulp produced (AFPA, 1992a).

Secondary Fiber Pulping. For some wastepaper pulps, the recycled furnish need only be mixed with water, repulped, and screened prior to reuse. For other grades of products, however, the pulp must be deinked—treated to remove coatings, inks, adhesives, and fillers in the original paper. Flotation and washing are two processes to remove these contaminants. Deinking

chemicals include caustic, sodium silicate, hydrogen peroxide, calcium chloride, and soap (Broeren, 1990).

2.1.2.2 Bleaching

While pulp created by the pulping process is suitable as is for products such as grocery sacks and cardboard boxes, the pulp must be bleached for products requiring lighter, brighter fibers. Bleaching plants typically use either an oxidative or reductive chemical process that increases the solubility of the pulp's color bodies, thereby whitening the fiber and enhancing the permanence of the whiteness.

For kraft pulping mills, the bleaching process, or sequence, involves a variety of chemicals and process conditions in several stages. These stages and their abbreviations are listed below.

- Chlorination and washing (C)
- Chlorine dioxide addition and washing (D)
- Alkaline extraction and washing (E)
- Hypochlorite addition (H)
- Hydrosulfite addition (HS)
- Oxygen addition (O)
- Peroxide addition (P)

Successive stages in the bleaching sequence can be implemented to achieve one of three purposes: lignin removal, lignin decolorization (brightening), or extraction of dissolved lignin. In the recent past, the two most widely used bleaching sequences in U.S. and Canadian mills were C-E-D-E-D and C-E-D-H or C-E-H-E-D, where the chlorine (C) removes lignin, the alkaline (E) extracts lignin, and the chlorine dioxide (D) and hypochlorite (H) brighten lignin. Because lignin concentrations are so high in the initial bleaching stages, chemicals such as chlorine can be used without significantly damaging cellulose fibers. Chlorine is an aggressive oxidant that dissolves lignin effectively. After the first removal and extraction stage, 80 to 90 percent of the lignin in the pulp is removed (EPA, 1991a). More recently, mills have been shortening bleaching

sequences and have been substituting different bleaching chemicals to reduce the formation of chlorinated organics. Bleaching sequences that substitute chlorine dioxide (ClO_2) for chlorine (Cl_2) are elemental chlorine free, or ECF; bleaching sequences that eliminate all usage of chlorine, be it Cl_2 or ClO_2, are totally chlorine free, or TCF.

Bleaching is performed in tanks in which pulp is mixed with bleaching chemicals and water. Enough liquid is present to carry the pulp suspension throughout the operations. Rotary drums serve as between-stage washing devices for the pulp. More recently, mills have added an oxygen-based prebleaching stage called oxygen delignification, which lowers the lignin content of pulp prior to its exposure to bleaching chemicals (see Figure 2-1). Changes in the bleaching process itself, such as split chlorine addition and chlorine dioxide substitution, are aimed at lowering the amount of chlorinated organics and other pollutants formed in the bleaching process.

Groundwood and secondary pulps frequently undergo only one stage of bleaching, with either hypochlorite or peroxide. Secondary fibers are usually pure enough not to need chlorination and extraction, and groundwood pulps contain too much lignin to be subjected to a comprehensive bleaching sequence. Hydrogen peroxide is the preferred bleaching chemical for sulfite pulps, which enter the bleaching plant considerably brighter than kraft pulps.

2.1.3 Papermaking Operations

After pulping and (optionally) bleaching, fibers often are not ready to be sent directly to the papermaking machine. Instead, they sometimes undergo stock preparation, designed to enhance the fiber's bonding properties. Stock preparation, also called "refining" or "beating," can involve fiber cutting, crushing, or rolling, which reduces the strength of paper but improves uniformity and results in increased hydrogen bonding among fibrils, the tiny strands surrounding each individual fiber. Stock preparation also might involve the blending of different pulps, such as virgin and secondary fibers, to produce a sheet with a certain percentage of recycled content or with certain physical properties.

The oldest and most established piece of papermaking equipment is called the fourdrinier machine, named after the two brothers who invented the process around 1800. The fourdrinier machine forms a sheet of paper by depositing pulp and water stock onto a thin wire mesh through which excess water drains. The remaining sheet of wet, thick pulp stock spools onto a press that gently squeezes out more water and consolidates the web of paper by bringing fibers together for bonding. The web leaves the press section and is passed around a series of steam-filled drums, called dryer cans, where additional water is removed by evaporation. In this stage, the web is held to the cylindrical dryer cans by a thin cloth or plastic felts that allow evaporated water to pass through. The dryer section also might include a size press, which can apply chemical solutions to the sheet's surface to improve water resistance. The sheet might also receive additional coatings to create the needed paper grade. Finally, the web is wound into a roll by a series of calendars, reels, and rewinders, which also controls thickness. From the rewinder, the roll of paper is removed and prepared for shipping or converting to final products (Kline, 1982).

The fourdrinier machine primarily produces lightweight paper. A multicylinder machine is employed to manufacture heavier stocks of paper and paperboard. With this machine, a series of cylinders are submerged into vats of fiber suspension. Water from the suspension passes through the wire on the cylinder leaving a fiber web on the outer surface of the cylinder. A wool felt is then passed over the succession of cylinders, one at a time, collecting more and more web from each cylinder. In this manner, a thick sheet of web is formed, which subsequently proceeds to a series of dryers where the large amount of water is removed. The multicylinder machine also effectively produces combination boxboard, in which two different stocks of paperboard are pressed together to create the grey-interior, white-exterior paperboard used in cereal cartons and some pizza boxes.

Papermaking requires enormous quantities of water to operate. A normal concentration of the fiber suspension sent to the wire or cylinder is 0.5 percent. In other words, every 250 tons of stock sent to a papermaking machine, for example, consists of 1.25 tons of fiber and 248.75 tons of water. As the fiber suspension passes over the wire, the consistency rises to anywhere from 10 to 16 percent, depending on the type of water removal devices used. After passing through presses, the web contains 36 percent fiber. Dryers remove the remaining excess water

until a standard 5-percent moisture content is attained. Nearly all water passing through the wire is recovered, along with any escaped fibers, by a device known as the save-all and remixed with stock to achieve the needed 0.5 percent fiber concentration (Kline, 1982).

Although pulp and papermaking mills have significantly reduced their water requirements by recovering and reusing water within their industrial operations, an average of 16,000 to 17,000 gallons of water is still expended for each ton of paper produced. A 600-ton-per-day papermaking facility, for example, would need 10 million gallons of influent water to operate. Because such huge volumes of water are needed, pulping and integrated pulping and papermaking mills must be near bodies of water.

Pulpmaking and papermaking machines are highly individualized devices designed to produce a specific product 24 hours a day, 365 days a year. Their operating parameters may be varied to produce different grades within a product category, but major shifts between categories are not feasible. According to a survey conducted by *Pulp & Paper*, U.S. companies plan to spend $13.4 billion on projects for completion during the 1992-1994 period. Expenditures on new pulp and paper machines account for $3.1 billion in capital outlays (Espe, 1993). These figures indicate the industry's capital-intensive nature, which affects the ability for new companies to enter the industry. Increased pollution control costs can be put into perspective when compared to the industry's annual capital expenditures. Capital expenditures are discussed further in Section 2.4.4.

Converting Operations. Paper and paperboard are shipped to converting operations where they are cut, trimmed, and formed into final products such as envelopes, boxes, and reams of paper. Cuttings and other wastes from these operations are a major source of high-quality pulp substitutes also known as preconsumer secondary fiber. Converting operations are not covered by the rulemaking and are not discussed further in this report.

2.1.4 Pollution and Pollution Control

2.1.4.1 Effluent Discharges

The tremendous daily intakes of water at pulp and papermaking mills translate into equally large quantities of effluent water that mills must recycle, treat, or discharge. The four main categories of aquatic pollutants found in pulp and paper mill effluent are total suspended solids (TSS), biochemical oxygen demand (BOD), color, and toxics. Conventional pollution abatement in the U.S. paper industry has concentrated on reducing solids and oxygen demand. Recent investigations, however, have found toxic contaminants, including dioxin, in bleach mill effluents, and effluent color is becoming a concern in some areas of the country (EPA, 1991a).

Suspended solids include dirt, grit, and fiber from wood preparation; fiber and dissolved lignin solids from the pulp bleaching stages; and fiber and additives washed from the early stages of papermaking. Solids have the potential to coat the bottom of receiving water bodies and could destroy or impair the habitat of bottom-living organisms. As the blanket of solids decomposes, anoxic conditions could develop, releasing methane, hydrogen sulfide, and other noxious and/or toxic gases. To control solids, most North American mills have installed primary and secondary effluent treatment equipment that removes solids from the effluent prior to discharge into receiving waters. Suspended solids are extracted primarily through settling or flotation processes.

Biochemical oxygen demand (BOD_5)[2] measures the tendency of an effluent to consume oxygen from receiving waters during biological degradation. High levels of BOD_5 can deprive fish, fungi, bacteria, and other nonplant matter of needed oxygen. BOD_5, which is comprised primarily of organic material, is produced during several pulping and bleach stages. For example, effluents from debarking contain wood particles, and spent cooking liquor has high concentrations of lignin and other organics. Mills usually retain wastewater in an oxidated or aerated lagoon that allows 85 to 90 percent of BOD_5 to degrade.

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[2]The abbreviation BOD_5 represents oxygen demand as measured by the standard 5-day test.

Chlorinated organic compounds represent the major toxic constituents in pulp mill effluent. They are generated almost exclusively at bleach plant operations that use elemental chlorine or chlorine-containing bleaching chemicals. Minuscule quantities of these toxics also are produced at paper mills (or papermaking operations at integrated pulp and paper mills) that use chlorine-bleached pulps (EPA, 1991a). Many individual chlorinated organic compounds have been identified in bleach plant effluents; the reader is directed to the Development Document for more details. Among these compounds are various dioxins and furans, chloroform, and chlorinated phenolics.

Dioxin and furans are a byproduct of the complex reactions occurring during bleaching. The concentrations of these toxics are usually in the parts per billion or parts per quadrillion even in uncontrolled effluents, but because of their high toxicity and capacity to bioaccumulate, dioxins and furans have become a prime concern (EPA, 1991a). Secondary wastewater treatment is moderately effective in transferring dioxins and furans from effluents to treatment sludges. Therefore, much scientific and regulatory attention concentrates on preventing the formation of dioxins and furans during bleaching, rather than on biological or chemical effluent treatment. Pollution prevention is further investigated in the Development Document and in Section 2.2.4 of this report.

Chloroform is a byproduct primarily of the hypochlorite bleaching stage, where used. Because of this compound's volatility, most chloroform escapes the pulp mill as fugitive emissions, with more vaporizing from secondary wastewater treatment systems. While an important consideration in air pollution control, chloroform in pulp and paper water effluents is not considered as significant an environmental hazard because its aquatic toxicity and bioaccumulation potential are low. Chlorates are a potential concern because some compounds harm plant life. At concentrations present in pulp and paper effluent, chlorate damage to marine algae populations has been documented in Scandinavia. Secondary wastewater treatment, however, normally is effective in removing chlorates from effluents (EPA, 1991a).

2.1.4.2 Air Emissions

The major air pollutants from pulp operations include reduced sulfur compounds, particulates, volatile organic compounds (VOCs), and various hazardous air pollutants (HAPs). According to baseline emission estimates, noncombustion processes in the pulp and paper industry emit approximately 170,000 Mg of hazardous air pollutants annually. Air emissions of 1-butanone (MEK), 2-propanone, chloroform, hexane, methanol, and toluene comprise the majority of HAP emissions. Some of these pollutants, including chloroform, are known or probable human carcinogens while others have been linked to causing respiratory and other health problems in humans, or causing cancer in animals.

Reduced sulfur compounds are associated with the kraft pulping process, and are generated from chemical reactions of sodium sulfide that occur during the initial kraft cook. The presence of reduced sulfur compounds causes the rotten egg or rotten cabbage odor in areas near pulp mills. In addition to odor problems, reduced sulfur compounds have been linked to causing shortness of breath, nasal irritation, and headaches.

VOCs include a broad class of organic gases such as vapors from solvents and gasoline. In the pulp and paper industry, VOCs are generated from the complex reactions of lignin, carbohydrates, and extractives in the pulp furnish. VOC emissions are a concern because they chemically react with nitrogen oxide in the atmosphere to form ground-level ozone, or smog. Studies of the effects of ozone have shown that it is responsible for health problems such as respiratory problems and premature aging of the lungs. Ozone has also been linked with contributing to damage of crops and other plants.

The major source of particulates are fly ash and bottom ash from power boilers and chemical recovery furnaces. Fine particulates are a particular concern because they tend to settle from the atmosphere and might be associated with more significant health impacts than large particulates. The major effects of concern include breathing and respiratory symptoms, damage to lung tissue, and aggravation of existing respiratory and cardiovascular disease. Particulate matter also causes material soiling and can substantially impair visibility.

2.1.5 Related Chemical Supplier Industries

As quality demands of paper consumers have increased, the pulp and paper industry has relied more and more on chemicals to achieve improved product properties. Historically, the pulp and paper industry has consumed large amounts of chlorine for bleaching operations. Chlorine is produced by the chlor-alkali production process, which electrically induces reactions of water with table salt (NaCl) to generate elemental chlorine (Cl_2) and caustic soda (NaOH) in a fixed ratio. The pulp and paper industry is a major consumer of both chlor-alkali products. Chlor-alkali production occurs at approximately 50 plants in the United States and 12 plants in Canada. Because of high capital costs of production, chlor-alkali manufacturers tend to be large, diversified chemical companies that produce numerous chemical products. Two large companies are responsible for half the U.S. chlor-alkali capacity.

Facing regulations and demand for dioxin-free products, pulp and paper manufacturers are shifting away from chlorine usage in their bleaching sequence. As chlorine demand decreases and demand for caustic soda remains relatively stable, chlor-alkali producers are searching for methods to manufacture caustic soda independently of chlorine.

In recent years, pulp and paper manufacturers have investigated and experimented with alternative bleaching chemicals, technologies, and processes. Perhaps the most widespread current alternative is chlorine dioxide substitution, which reduces dioxin and furan concentrations in pulp and paper effluents. Chlorine dioxide usually is produced from sodium chlorate in onsite reactors located at pulp and paper mills. As of 1988, sodium chlorate was produced at 11 locations in the United States, as well as several facilities in Canada. Although the use of chlorine dioxide substitution in the first stage is increasing, the overall use of chlorine dioxide in U.S. mills may not be increasing because mills are being careful not to overchlorinate in all bleaching stages (Falatko, 1993).

Another process change to reduce chlorine usage in the bleaching sequence is oxygen delignification. Oxygen gas (O_2) used in a prebleaching stage effectively removes residual lignin content in brownstock pulp by up to 50 percent. This removal rate can lead to proportional reductions in first-stage chlorine usage and chlorinated organic formation. Oxygen usage in

bleaching extraction stages is increasing; 72 of the U.S. mills that chemically pulp and bleach wood were using oxygen-reinforced extraction as of December 1992 (Falatko, 1993). Ozone bleaching (O_3), a process that has been commercialized just recently, has the potential to eliminate entirely the need for chlorine compounds in the bleaching sequence. Oxygen traditionally has been supplied in liquid form by large chemical producers; with increased consumption due to oxygen enhanced delignification and bleaching, however, a rising number of mills are installing onsite oxygen production units (Ducey, 1989).

In recent years, hydrogen peroxide (H_2O_2) also has been used bleaching agent at an increasing number of kraft mills. H_2O_2 has traditionally been used to brighten mechanical pulps, but kraft mills increasingly use it in the alkaline extraction stage, for the final brightening stage, and to prevent brightness reversion. While not requiring major capital outlays to introduce, peroxide is considerably more expensive than most bleaching chemicals. The pulp and paper industry accounts for over 25 percent of domestic demand for peroxide (Young, 1991). Most peroxide suppliers are large, diversified chemical companies.

2.2 ENVIRONMENTAL PROTECTION ISSUES

As with most other major U.S. industries, the pulp and paper industry has come under increasing governmental, public, and market pressure in the last quarter century to minimize the environmental impacts of its operations. The first section of this industry profile introduced several pollution and pollution control issues faced by pulp and paper manufacturers. This section will focus on further efforts by U.S. paper companies and researchers to protect the nation's air, land, and waterways. In addition, the possible influence these efforts have on the impact analysis of effluent guidelines and emission standards will be examined.

2.2.1 Recycling

The history of recycling in the U.S. pulp and paper industry dates back almost 300 years, when small recycling mills thrashed cotton rags into fiber strands for paper production. Since

then, recycling has continued in some form among many pulp and paper mills, primarily for economic reasons: for mills located near urban areas, repulping secondary fiber was often more profitable than transporting virgin raw materials from the country's rural sectors (Congreve, 1992).

The recent surge in paper recycling has been guided not only by economic forces, but by public interest as well. Inspired by the solid waste crisis of the mid-1980s, private citizens have become more aware of what they throw away and where. With capacity decreasing at many U.S. landfills and costs of safe disposal rising steadily, many communities, businesses, and governments have started recycling programs as less expensive alternatives to old waste disposal options. The supply side of the recycling equation has thus been growing consistently. In 1990, Americans recovered 17 percent of the 195.7 million tons in the total municipal solid waste stream for recycling and composting, an almost 73-percent increase over 1985 rates (see Figure 2-2). In that same year paper and paperboard garnered the highest recovery rate among all major components of the waste stream: 28.6 percent of the 73.3 million tons of postconsumer wastepaper generated[3] (EPA, 1992a) (see Figure 2-3).

In 1990, the American Forest and Paper Association (formerly the American Paper Institute), announced a goal of achieving a 40-percent recovery rate of both pre- and post-consumer paper by 1995. According to AFPA statistics, 35 percent of the paper consumed in the United States in 1992 was recovered for reuse and export. To attain the 40-percent recovery goal, different recovery targets have been established for various paper grades. The Paper Standards Institute of America has established more than 70 grades of wastepaper which are generally divided into five categories: news, corrugated, mixed, pulp substitutes, and high-grade deinking. The AFPA asserts that nearly 90 percent of the increased recycled paper needed over the next several years will have to come from the postconsumer stream (AFPA, 1992a).

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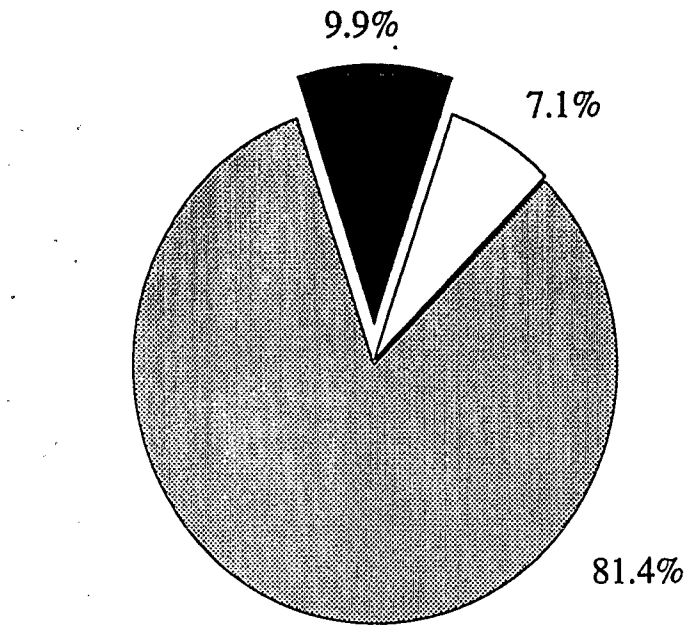
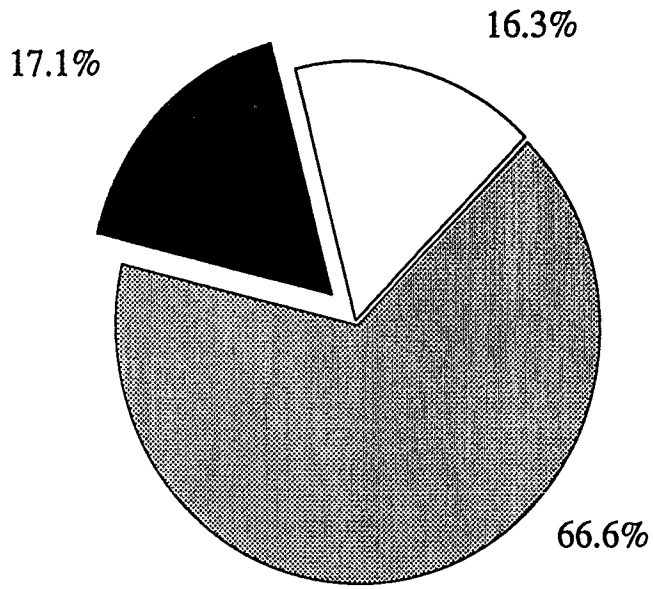
[3]EPA defines postconsumer recycling as the reuse of materials generated from residential and commercial waste. In contrast, preconsumer recycling is the reuse of materials from industrial processes that have not reached the consumer such as broke, paper that has broken as it is formed and wound on the paper machine but is reprocessed into paper.

FIGURE 2-2
MANAGEMENT OF MUNICIPAL SOLID WASTE (MSW) IN U.S., 1985 and 1990



1985
Total MSW = 164.4 million tons

- **Recovery** - 16.4 million tons
- **Combustion** - 11.7 million tons
- **Landfill** - 136.4 million tons

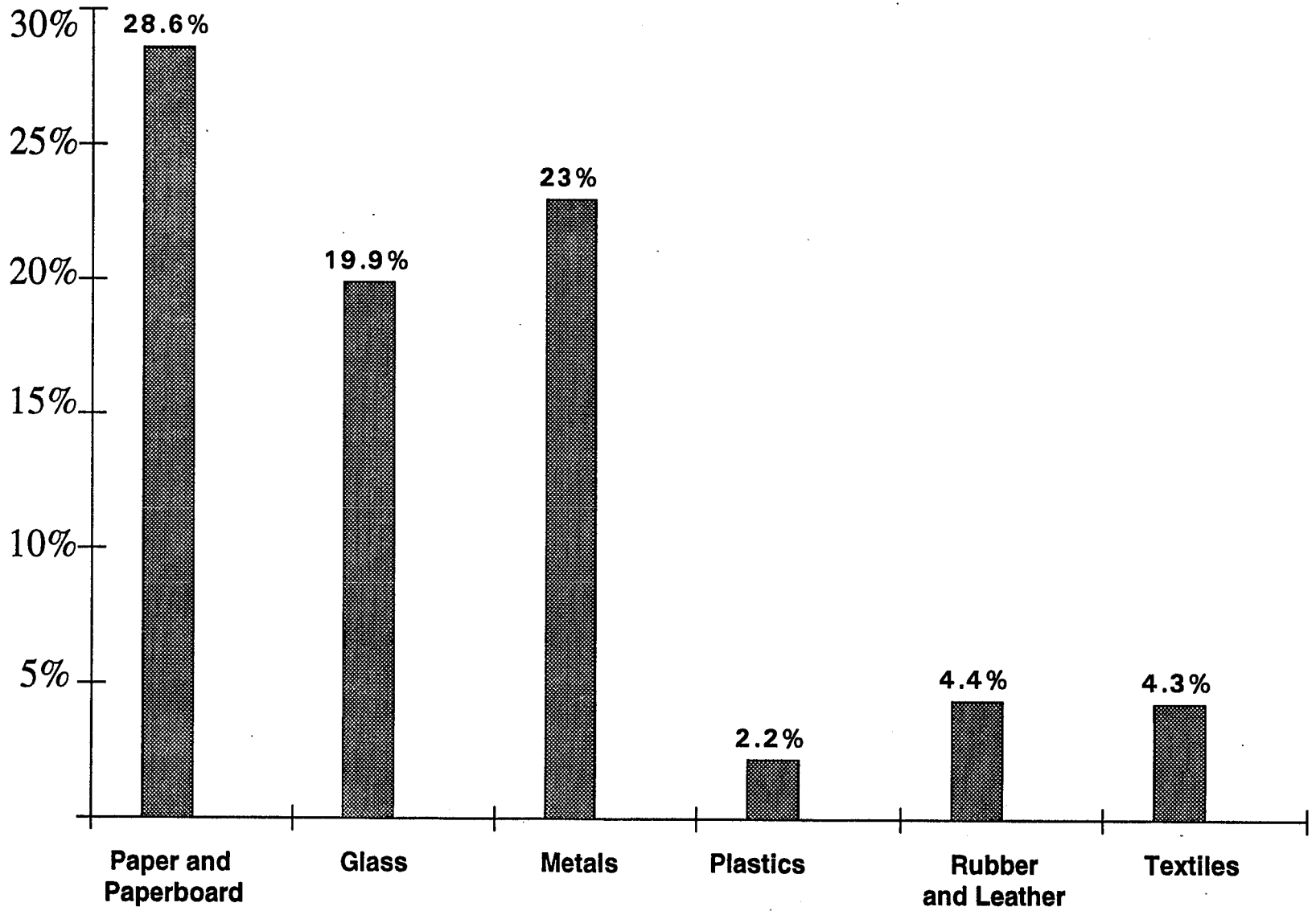


1990
Total MSW = 195.7 million tons

- **Recovery** - 33.4 million tons
- **Combustion** - 31.9 million tons
- **Landfill** - 130.4 million tons

Source: EPA, 1992a.

FIGURE 2-3
OVERALL RECOVERY RATES OF SOME MUNICIPAL SOLID WASTE COMPONENTS



Source: EPA, 1992a.

At present, wastepaper, both pre- and postconsumer, constitutes over 28 percent of the fiber sources for the U.S. paper industry. AFPA reports that over 75 percent of the more than 500 domestic paper mills recycle some pre- and/or post-consumer paper, and that 200 mills rely solely on wastepaper for fiber (AFPA, 1992a). In addition, several billion dollars in capital outlays have been earmarked to expand the industry's recycling capacity with either new mills or additions to existing mills. Table 2-1 lists new recycling-related mills and similar mills under construction (Espe, 1993). Consequently, demand for wastepaper as a source material for recycled-content products should rise in the future.

Paper recycling involves a complex series of operations, including collection, transport, sorting, baling, and marketing. After delivery to pulp and paper mills, secondary paper must undergo repulping and, in some cases, deinking prior to being mixed with other pulps and sent to the paper machine. Secondary fiber repulping is generally simpler than wood pulping. The most common process entails loading a device called the pulper with water, and feeding wastepaper into the water with conveyor belts until a solids concentration of 5 to 6 percent is reached. A high-speed rotor at the bottom of the pulper agitates the wastepaper-water mixture, causing fibers to break free and pass through a screen onto either the paper machine or the deinking equipment. Some repulping employs chemicals and/or thermal energy to break down coated or chemically treated papers, or paper printed with ink that is difficult to remove (Kline, 1982).

Most repulped secondary fiber is clean enough to proceed to paper machines for the production of newsprint, tissue paper, and paperboard grades. Wastepaper designated for reuse in white-paper manufacture must be deinked, however. Deinking operations usually commence in the repulper, where chemicals are added to the wastepaper-water suspension. Repulped paper then passes through washers designed to remove dispersed ink. The washers are often drum washers, screens, or slotted plates, or, most recently, flotation chambers, where ink latches onto foam or gas bubbles floating through the slurry and is carried to the chamber top and removed (Kline, 1982).

Secondary fiber typically does not undergo bleaching prior to the papermaking stage. Where bleaching is practiced, chemical concentrations are typically smaller and conditions less severe than required to bleach virgin pulps. Bleaching sequences of only one or two stages are

TABLE 2-1

NEW U.S. MILLS INVOLVED IN RECYCLING START-UPS OR UNDER CONSTRUCTION-1992

STARTED IN 1992

NAME	LOCATION	TYPE OF MILL
EcoFibre	De Pere, Wisconsin	Market deinked pulp mill
Fox River Fiber	De Pere, Wisconsin	200-tpd market deinked pulp plant
Inland Container	Maysville, Kentucky	600-tpd recycled containerboard
Lin Pac	Gaffney, South Carolina	250-tpd "mini-mill" to produce recycled containerboard

APPROVED OR UNDER CONSTRUCTION AS OF 1992

NAME	LOCATION	TYPE OF MILL
Southern Container	Syracuse, New York	100,000-tpy recycled containerboard mill
Amcor	Prewitt, New Mexico	130,000-tpy recycled linerboard mill
American Power Recyclers	Barrackville, West Virginia	400-tpd market deinked pulp mill
Ponderosa Fibres	Northhampton, Pennsylvania	400-tpd market deinked pulp mill
Solar International	Morrisville Pennsylvania	100,000-tpy market deinked pulp mill
Muskogee Linerboard	Muskogee, Oklahoma	272-500 tpy recycled linerboard mill

Note: tpd = tons per day
tpy = tons per year

Source: Espe, 1993.

common. Hydrogen peroxide is the dominant bleaching chemical for secondary fiber, although other chemicals are used, including chlorine, chlorine dioxide, sodium hypochlorite, and others. While most secondary fiber is used in products that do not require bleached pulp, the degree to which recycled high-grade paper replaces chlorine-bleached virgin fibers to produce white-paper grades will affect the amount chlorinated organics contained in mill effluent (EPA, 1991b).

A brief description and overview of the market for each of the five major categories of wastepaper is provided below. Figure 2-4 shows current and potential recycling rates for these categories of paper.

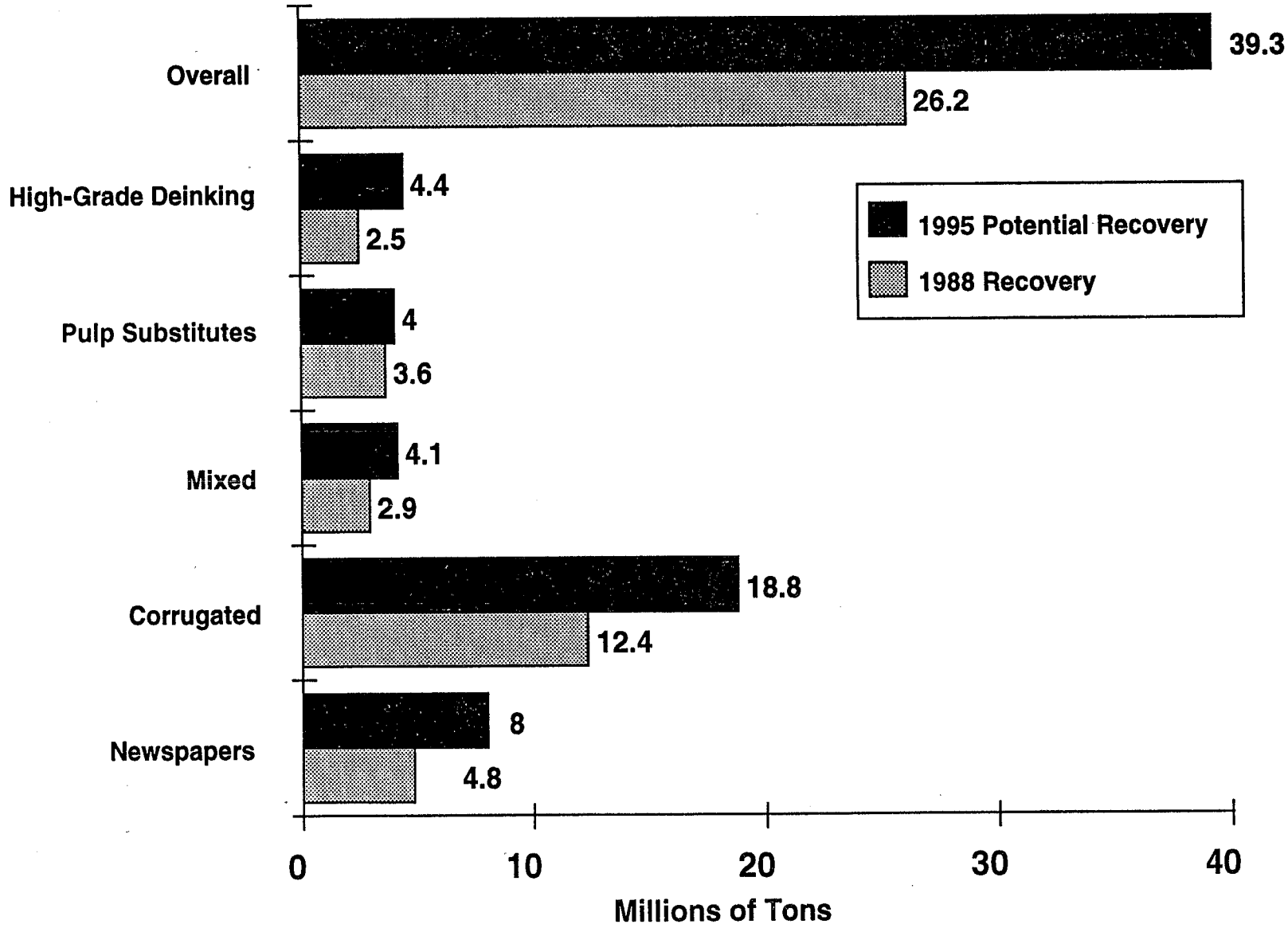
2.2.1.1 News

The news category of wastepaper consists predominantly of old newspaper (ONP). ONP is supplied by private residences through curbside and dropoff collection programs, as well as newspaper drives. In addition, unprinted and excess newspapers from publishers and newsstands contribute about 5 percent of overall news supply (EPA, 1991b). This source is called new newspapers (NNP). ONP recovery is increasing because of the rising number of municipal recycling programs being implemented across the nation. Some areas of the nation have even experienced a glut of recovered newspaper, attributable to lagging demand for this category of wastepaper. Demand for ONP is slated to increase in the near future as new newsprint mills come on line across the nation (AFPA, 1992a). According to the American Forest and Paper Association (AFPA), in 1991 more than 4.2 million tons of news wastepaper were used to produce newsprint, tissue products, recycled paperboard, and other paper products at U.S. mills. An additional 1.28 million tons were exported (AFPA, 1993).

2.2.1.2 Corrugated

Corrugated is the common trade term for corrugated boxes and boxplant cuttings. The old corrugated container (OCC) grade of wastepaper is considered postconsumer, since the boxes have been used, generally to ship goods to a factory, retail business, warehouse, or other

FIGURE 2-4
CURRENT AND POTENTIAL RECOVERY TONNAGE OF DIFFERENT CATEGORIES OF WASTE PAPER



Source: AFPA, 1992a.

commercial establishment. OCC is collected mainly by commercial haulers, although a portion is recovered from households in dropoff and curbside collection programs. In 1991, 13.9 million of the 24.7 million tons of used corrugated were recovered for recycling or export, representing a 56.5-percent recovery rate (AFPA, 1993). The supply network for OCC is already well established among American commercial institutions, and should continue to provide increasing amounts of OCC in the future.

Used corrugated is reprocessed into unbleached kraft paperboard, recycled linerboard, and other recycled paperboard products. Like supply, demand for used corrugated has been increasing in recent years and should continue this trend in the future.

2.2.1.3 Mixed Paper

Mixed paper is a term the paper industry uses to refer to a wide range of wastepaper that has been combined without regard to grade. Mixed paper is often collected from homes and offices or is left at paper recovery plants after higher grades have been sorted out. Mixed paper might contain magazines, groundwood papers, and colored papers that are not extremely valuable on the recyclables market. Mixed office papers might contain large amounts of high-grade white paper, which is sometimes sorted by a paper dealer to obtain a more valuable commodity (EPA, 1991b). Mixed paper generally is used to produce recycled construction board and other building products. About 3.7 million tons of mixed paper was recovered in 1991 (AFPA, 1992b).

2.2.1.4 Pulp Substitutes

Pulp substitutes are a very high grade of wastepaper that can be used directly in papermaking to substitute for virgin pulp. They are almost always recovered from paper mills, converting operations, and printers, and as such are considered preconsumer waste. Some of the most common sources are bleached kraft paperboard cuttings from carton plants, envelope cuttings, grocery sack trim and misprints, and shavings from cut paper converting. Because of

their favorable properties, pulp substitutes are recovered at about a 100-percent rate (EPA, 1991b).

2.2.1.5 High-Grade Deinking

Bleached papers that have gone through a printing operation and been discarded from data-processing centers, printing and converting operations, and source-separating office recycling programs fall into the high-grade deinking category. Thus, this category consists of both pre- and postconsumer wastes. The most significant end products made from deinking grade wastepaper are printing and writing papers, tissue papers, and other paper and paperboard products. Demand for high-grade deinking papers has increased rapidly in recent years and should continue to do so because of several factors, such as the federal guideline on the procurement of recycled paper products and new production capacity coming on line (EPA, 1991b). AFPA asserts that 50 percent of this grade of wastepaper can be recovered. In 1991, the United States recovered more than 3.2 million tons of high-grade deinking paper (AFPA, 1992b).

2.2.2 Chlorine-Free Products

Since the detection in 1985 of dioxins, furans, and other toxics in pulp and paper mill wastewater effluents, paper companies, environmental groups, and the government have debated the necessity and economic viability of mills adopting chlorine-free technologies. Many mills, sensing new environmental quality demands from customers and facing possible new regulations, have already begun to switch from traditional chlorine bleaching methods to chlorine-dioxide substitution and other technologies that significantly reduce chlorinated organics in wastewater effluents.

Two terms have gained currency in the dialogue on chlorine-free pulp and paper production: elemental chlorine free (ECF) and totally chlorine free (TCF). ECF manufacturing is the use of a bleaching sequence in which no elemental chlorine is used; TCF manufacturing is the use of a bleaching sequence in which no chlorine or chlorine-containing compounds are used,

thus preventing the generation of potentially toxic chlorinated organics. In recent years, many mills in North America (where kraft pulping predominates) have investigated and changed conventional bleaching sequences where chlorine is used toward ECF sequences, e.g., sequences using more chlorine dioxide substitution. In recent years, many mills in Europe (where sulfite pulping predominates) have begun using TCF processes. From an economic standpoint, comparing the ECF and TCF processes should involve an examination of the cost of increasing existing chlorine dioxide generating capacity versus the cost of using other bleaching chemicals such as ozone or hydrogen peroxide, and should consider the compatibility of new bleaching chemicals with existing equipment. It is still uncertain if the full range of kraft and sulfite pulp grades currently produced can be manufactured using TCF processes while providing equivalent chemical and physical characteristics of pulps produced today.

As discussed in Section 2.1, capital improvements in the pulp and paper industry can cost millions of dollars. Implementing oxygen bleaching at one mill, for example, can cost approximately $30 million and take up to 3 years from concept, approval, and design to installation and startup (Erickson, 1993). Cost factors have prompted paper companies to examine the immediate market validity of chlorine-free products. Although environmental groups report that European demand for pulp and paper is shifting to chlorine-free pulp and paper grades, some paper companies have failed to meet European chlorine-free demand requirements. Other companies and environmental organizations claim that perception and lack of education are the only barriers to converting the customers to chlorine-free products (Sproull, 1993). These groups point to widely published studies to support their theory that most consumers have begun considering environmental issues when buying goods and services. With continuing negative media coverage of dioxin, private citizens and businesses across the country have expressed a desire to purchase chlorine-free paper products. Many paper companies, however, point to the international competitiveness of the U.S. pulp and paper industry, asserting that compelling mills to adopt expensive processes could hinder their sales abroad (Erickson, 1993).

Chlorine-free bleaching sequences represent an ultimate goal for many pulp and paper manufacturers, since removing all chlorine from the bleaching process would further the industry's progress toward a no-effect, closed mill where bleaching chemicals can be recovered

and reused. This, in addition to environmental concerns, has led experts to predict a long-term dropoff in chlorine usage (Erickson, 1993). As chlorine-free technologies continue to come on line and the market for chlorine-free paper products expands, an increasing number of pulp and paper companies might recapitalize existing mills to introduce a chlorine-free process.

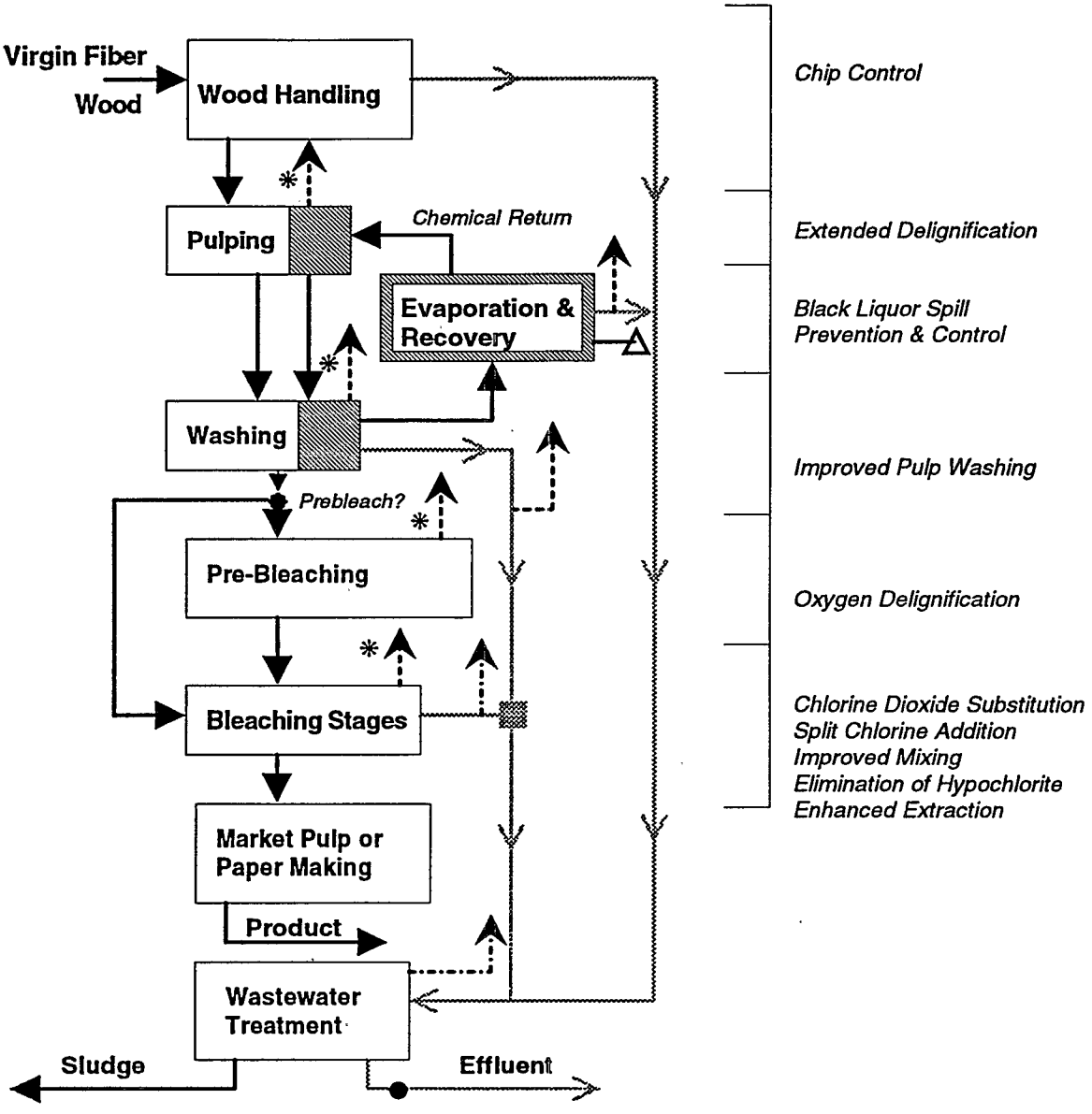
2.2.3 Pollution Prevention

Historically, U.S. industry and regulatory agencies have taken an end-of-the-pipe approach to pollution control, striving to limit the impact of existing pollutants through the treatment of sludges, effluents, and emissions. In recent years, however, EPA and many businesses and organizations have shifted toward preventing the generation of pollutants in the first place.

Pollution prevention has gained validity as companies discover that some process changes can result in considerable economic savings. These savings are manifested in many forms, including reduced waste disposal costs, increased productivity, and diminished liability. Barriers to broader consideration of pollution prevention possibilities still exist, however. A methodology for analyzing benefits of pollution prevention schemes has not been well-refined or widely adopted by U.S. companies (Becker and White, 1993). Implementation of pollution prevention programs can require significant capital expenditures. As such, pollution prevention capital outlays must compete with other capital outlays with respect to rate of return. Savings from pollution prevention often are imbedded in overhead expenses, a lump expenditure that frequently is not broken down by U.S. companies to analyze its separate sources. In addition, benefits from pollution prevention might materialize over a longer time period than benefits of other capital outlays (Becker and White, 1993). The economic analysis contained in this report incorporates many of the features discussed in the total cost assessment approach of Becker and White (see Sections 3.1 and 3.2).

With the current emphasis on pollution prevention, EPA and the pulp and paper industry are examining potential process changes aimed at reducing toxins in mill effluents. Figure 2-5 repeats the process diagram for pulping and bleaching operations with the addition of possible

FIGURE 2-5
POLLUTION PREVENTION AND CONTROL MEASURES



pollution prevention and control measures at each stage. Most of these process changes aim to reduce chloroform generation and lignin concentrations in pulp before it enters the bleaching sequence. Once lignin is successfully decreased, fewer chemicals such as chlorine are needed to brighten the pulp, to produce a high-quality product, and to reduce the potential for the formation of chlorinated organics. Some of the process changes that EPA considered during regulatory development include:

- Chip control. The purpose of chipping is to reduce logs to a chip size suitable for pulping. Since chip uniformity is extremely important for pulping chemicals' proper circulation and penetration, considerable attention is paid to operational control and maintenance of the chipper. Both absolute chip thickness and thickness uniformity affect delignification, since the kraft cooking liquor can penetrate the chip only to a certain thickness. Thin chips are easier to cook to lower lignin levels. Thick chips, in contrast, could have a core of lignin unaffected by the pulping chemicals. Without treatment, this lignin is passed to the bleaching process. To improve thickness uniformity, many mills are now adopting screening equipment that separates chips according to thickness. Chips that exceed the maximum acceptable thickness are diverted to a chip slicer that cuts them radially and reintroduces them to the screening system.

- Extended delignification. Over the past decade, pulp equipment manufacturers and pulping mills have been devising ways to extend the cooking process to remove more lignin without damaging cellulose. Extended delignification has been achieved with better controls over the pulping process conditions (namely, temperature, pressure, chemical composition of the cooking liquor, and mixing).

- Black liquor spill prevention and control. Black liquor could be spilled occasionally because of equipment failure, design flaws, or human error. Losses can result from overflows or leaks from process equipment (spills), or from deliberate operator action (diversions) taken to avoid much more serious consequences. Black liquor spills can release volatile pollutants to the air, and spill cleanup could send an effluent with a very high oxygen demand to the wastewater treatment system. Several design, engineering, and training measures can limit the number of spills, mitigate spill impacts, or prevent spills in general. These measures include physical isolation of individual pieces of equipment so that spills can be collected and recovered; modifications to the floor drainage system so that spills are collected and returned to the recovery system; provision of additional backup storage capacity; sensors and other systems that immediately warn of potential or actual spill conditions; and replacement of open washing and/or screening equipment with closed equipment.

- Improved pulp washing. In recent years, the efficiency of brownstock pulp washing systems has been improved substantially. These advances have been aimed at reducing effluent flows, improving energy efficiency, and achieving better removal of dissolved lignin solids and spent liquor from the pulp. Improved pulp

washing can lower the consumption of bleaching chemicals and hence the formation of chlorinated organics. Washing improvements include belt washers, diffusion system washers, and computer control systems for better washer operation.

- Oxygen delignification. Oxygen delignification is another way to extend the pulp cooking process, thereby lowering the bleaching chemical demands and the amount of pollution associated with chlorine-based bleaching stages. The technique involves integrating an oxygen reaction tower between the kraft pulping stages and the bleach plant. The brownstock pulp from the digester is first washed and then mixed with oxygen and sodium hydroxide as it enters the pressurized reactor. There, the pulp undergoes oxidative delignification and is washed again to removed dissolved lignin. Oxygen delignification can reduce lignin content by up to 50 percent.

- Chlorine dioxide substitution. Chlorine dioxide (ClO_2), while it has been used for about 30 years as a bleaching agent for later stages in the bleaching sequence, has only recently been considered as a primary bleaching agent. Replacing up to 50 to 70 percent of the elemental chlorine in the first bleaching stage with chlorine dioxide is now an accepted practice for environmental improvement and has been widely adopted within the North American pulp and paper industry. ClO_2 acts effectively on lignin because of the presence of oxygen in the molecule, which increases the proportion of oxidative reactions and reduces the formation of chlorinated organic compounds. ClO_2 is produced on site at the mill, because its chemical instability makes shipping dangerous.

- Split chlorine addition/improved pH control. The split chlorine technique is predicated on the notion that more control of the chlorine concentration in the chlorination stage reduces the formation of chlorinated organics. Mills employing split chlorine technique divide the addition of chlorine to pulp into several charges. By splitting the chlorine addition, oxidation reactions between lignin and chlorine will be favored over so-called substitution reactions, which could form chlorinated organics. The pulp's pH is maintained at a high level to increase the formation of hypochlorous acid (HOCl), a powerful agent for the needed oxidation reactions.

- Improved chemical mixing. The equipment used to mix chemicals with pulp is an important factor in controlling formation of chlorinated organics. The high-shear mixer offers greater consistency of chemical mixing, resulting in reduced potential for pockets of excess chlorine or chlorine dioxide within the reactor vessel. The formation of dioxins and furans, therefore, is reduced.

- Elimination of hypochlorite. The substitution of hypochlorite with ClO_2 in secondary bleaching stages further reduces the formation of chlorinated organics in the bleaching effluent. A majority of U.S. bleached pulp and paper mills already have eliminated the use of hypochlorite.

- Enhanced extraction. In a conventional bleaching sequence, the extraction stage follows chlorination, completes the solubilization, and facilitates the removal of chlorinated and oxidized lignin molecules. Adding gaseous oxygen or peroxide to the alkaline extraction stage can enhance the removal of lignin and provide additional bleaching power, thereby reducing the requirements for chlorine and chlorine dioxide (EPA, 1993).

2.2.4 Air Pollution Issues

The move toward reduced-chlorine or chlorine-free production processes offers, in addition to water quality benefits, some air pollution benefits. Most prominent is the reduction in chloroform emissions. However, chlorinated compounds are not the only HAPs of concern, and technologies that reduce or eliminate chlorine in the production process do not reduce all HAPs. In fact, some process change components may actually increase certain HAP emissions. For instance, oxygen delignification units and extended cooking techniques may increase emissions of formaldehyde and methanol, even though they reduce the need for chlorine bleaching. Therefore, the industry must be conscious of the total environmental impact of their decisions in light of overall environmental risks and future regulations.

2.3 PRODUCTS AND MARKETS

The 1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities, Part B: Financial and Economic Information collected information from every pulp, paper, and paperboard manufacturing facility in the United States. Thus, the census provides a view of the industry at the end of 1989. At that time, EPA estimated the mill population to be 566. The market model uses this number of mills and their production characteristics (see Section 3.3). The exact number of mills has changed since the 1990 Census, and EPA attempted to correct mill population estimates by modifying the census data to exclude facilities that closed prior to February 1993 and include mills that began operations after 1989. The more current estimate of mill population is 565 facilities (Rovansek, 1993). The data base comprising the economic portion of the survey responses (also known as QFIN Version 2 or Part B Data) contains

information for 537 mills. The information presented in this industry profile is based on QFIN Version 2.

The survey used four general categories to classify the products produced by this industry—pulp, paper, paperboard, and molded pulp. Section 2.3 presents the information on these categories, and how they compare with categories used by the U.S. Bureau of the Census (DOC, 1989) and the American Forest and Paper Association (AFPA, 1992b).

2.3.1 Market Pulp

Once pulp has been generated by one of the mechanical and chemical methods described in Section 2.1, the pulp can be used within the facility or company to produce paper and/or paperboard products. When sold to other papermaking operations, pulp is called market pulp, and it follows its own supply and demand dynamic. Only market pulp appears in the Part B data.[4] Table 2-2 cross-references the pulp categories used by the survey, the U.S. Bureau of the Census, and AFPA. Note that a separate category appears for secondary fiber as a market product in the survey, but not in the other two sources.

Table 2-3 lists pulp shipments in tons for 1985, 1988, and 1989. The amount shipped in 1989 was more than 25 percent higher than in 1985. Table 2-3 also compares the 1989 shipment data with U.S. Bureau of Census and AFPA data. Census and AFPA estimates vary substantially; the survey data is very similar to the Census data. A few surveys have not been included in the data base; hence, the survey data might be slightly lower than the other estimates. The survey also includes mechanical pulp production that is not broken out in the other data; the total estimates of market pulp produced are very similar.

Table 2-4 lists the value of pulp shipments for 1985, 1988, and 1989, as well as the 1989 values from Census and AFPA data. The value of shipments doubled within that period. The

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[4]Pulp that is generated and used within an integrated facility does not appear in the Part B data because it is not sold as a separate product. The Part B information contains shipment and revenue information on final paper products, but not the pulp consumed in final product manufacture.

TABLE 2-2

1990 NATIONAL CENSUS
PRODUCT CATEGORY CROSS-REFERENCES
U.S. PULP, PAPER, AND PAPERBOARD INDUSTRY

PULP AND MOLDED PULP

1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities		Current Industrial Report (Form MA 26A-1)		Import/Export Product Category from AFPA's Statistics of Paper, Paperboard, and Wood Pulp	
EPA Survey Code	Product Category	Product Code	Product Category	Exports	Imports
10	Special alpha and dissolving wood pulp	2611	Dissolving and special alpha grades	Dissolving and special alpha	Dissolving and special alpha
11	Sulfate-bleached	2611335	Sulfate-bleached and semi-bleached, including soda	Sulfate-bleached (semi-bleached not included)	Sulfate-bleached (semi-bleached not included)
12	Sulfate-unbleached	2611343	Sulfate-unbleached	Sulfate-unbleached	Sulfate-unbleached
13	Sulfite-bleached	2611416	Sulfite-bleached	Sulfite-bleached	Sulfite-bleached
14	Sulfite-unbleached	2611426	Sulfite-unbleached	Sulfite-unbleached	Sulfite-unbleached
15	Groundwood	2611465	Groundwood	Groundwood	Groundwood
16	Thermomechanical	2611467	Thermomechanical	Thermomechanical	Thermomechanical
17	Semi-chemical	2611472	Semi-chemical	Semi-chemical	Semi-chemical
18	Defibrated or exploded	2611478	Defibrated or exploded	Defibrated or exploded	Defibrated or exploded
19	Secondary fiber				
70	Molded pulp products including fruit and vegetable packs and egg cartons	2646 1987 on, 26794	Pressed and molded pulp goods; 1987 on, molded pulp goods	2567140; pressed or molded pulp goods including trays, dishes, cups, egg cartons; 1989 on, 4823700000, molded or pressed articles of paper pulp	2567000; pulp articles exc. paper and paperboard, NSPF; 1989 on, 4823700000, molded or pressed articles of paper pulp

TABLE 2-3

PULP SHIPMENT TONNAGE STATISTICS FROM EPA SURVEY, CURRENT INDUSTRIAL REPORTS, AND AFPA

	Shipments (tons)						
	EPA Survey			Current Industrial Reports		AFPA Statistics	
Product Name	1985	1988	1989	1989	Percent*	1989	Percent*
Pulp							
Special Alpha and dissolving woodpulp	1,345,855	1,565,563	1,564,402	1,390,238	12.53%	1,423,000	9.94%
Sulfate-bleached	7,482,666	8,994,179	9,641,598	9,076,248	6.23%	6,842,000	40.92%
Sulfate-unbleached	57,046	134,490	109,825	218,681	-49.78%	161,000	-31.79%
Sulfite-bleached	279,747	264,342	242,781	495,054	-50.96%	237,000	2.44%
Sulfite-unbleached	0	0	0	0	0.00%	0	0.00%
Groundwood	0	135	130	D	n/a	n/a	n/a
Thermomechanical	0	0	200	D	n/a	n/a	n/a
Semichemical	381,459	432,509	432,334	D	n/a	n/a	n/a
Defibrated	21,689	113,591	53,045	D	n/a	n/a	n/a
Molded Pulp (egg cartons, fruit and vegetable containers)	216,724	204,115	270,182	n/a	n/a	n/a	n/a
Total	9,785,186	11,708,924	12,314,497	11,423,483 **	7.80%	8,663,000	42.15%

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'D' indicates data withheld to avoid disclosing figures for individual companies
* column measures percentage difference between EPA data and other sources
** does not equal sum of individual data due to hidden data

Source: DOC, 1989; AFPA, 1992b.

TABLE 2-4

VALUE OF PULP SHIPMENTS FROM EPA SURVEY, CURRENT INDUSTRIAL REPORTS, AND AFPA

	Shipments (thousands of dollars)						
	EPA Survey			Current Industrial Reports		AFPA Statistics	
Product Category	1985	1988	1989	1989	Percent*	1989	Percent*
Pulp	$3,512,671	$6,598,423	$7,706,049	$7,369,600	4.57%	$7,719,000	-0.17%

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19-Jul-93

* column measures relative concurrence between EPA data and other sources in percentages

Source: DOC, 1989; AFPA, 1992b.

price for market pulp averaged about $360/ton in 1985, and $630/ton in 1989. There is very good agreement among the survey, Census, and AFPA data.

Table 2-5 presents the value of pulp exports for 1985, 1988, and 1989. Exports nearly tripled within this period. Between 1988 and 1989, there was a 25 percent growth in pulp exports. In 1989, market pulp exports contributed nearly $3.4 billion to the U.S. balance of trade. The EPA survey data for pulp exports agrees well with the Census and AFPA statistics.

The Census did not gather data on product imports, since this data is market rather than facility related. Table 2-6 presents AFPA statistics on pulp imports for 1985, 1988, and 1989. The quantity of pulp imports increased by about 10 percent from 1985 to 1989. Table 2-7 presents AFPA statistics on the value of pulp imports for the three years. Not unlike the value of pulp shipments, the value of pulp imports nearly doubled from 1985 to 1989.

2.3.2 Paper Products

Table 2-8 cross-references the paper-product categories used by the survey, the Census, and AFPA. Note that detailed information on some paper products is not available within the AFPA statistics.

Table 2-9 lists paper shipments in tons for 1985, 1988, and 1989, as well as the 1989 shipment data with U.S. Bureau of Census and AFPA. The tons shipped increased by 20 percent from 1985 to 1989. In general, there is good agreement among all sources for the major product categories (e.g., newsprint, uncoated groundwood, clay-coated printed and converted, uncoated freesheet, and tissue). The discrepancies occur with the smaller, less well-defined categories. In several cases, there is more variation between the Census and AFPA estimates than with the survey data.

Table 2-10 lists the value of paper shipments for 1985, 1988, and 1989. The value of shipments increased nearly 50 percent within the period. The survey data correspond well with the Census and AFPA data.

TABLE 2-5

VALUE OF PULP EXPORTS FROM EPA SURVEY, CURRENT INDUSTRIAL REPORTS, AND AFPA

	Shipments (thousands of dollars)						
	EPA SURVEY			Current Industrial Reports		AFPA Statistics	
Product Category	1985	1988	1989	1989	Percent*	1989	Percent*
Pulp	$1,285,547	$2,784,399	$3,466,859	$3,512,601	-1.30%	$3,512,604	-1.30%

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19-Jul-93

* column measures percentage difference between EPA data and other sources

Source: DOC, 1989; AFPA, 1992b.

TABLE 2-6

PULP IMPORT TONNAGE STATISTICS FROM AFPA

Product Category	AFPA Statistics 1985	1988	1989
Pulp	4,465,746	5,038,158	5,004,336

Source: AFPA, 1992b

TABLE 2-7

VALUE OF PULP IMPORTS FROM AFPA

Product Category	AFPA Statistics (thousands of dollars) 1985	1988	1989
Pulp	$1,520,907	$2,663,424	$2,980,197

Source: AFPA, 1992b

TABLE 2-8

1990 NATIONAL CENSUS
PRODUCT CATEGORY CROSS-REFERENCES
U.S. PULP, PAPER, AND PAPERBOARD INDUSTRY

PAPER

1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities		Current Industrial Report (Form MA 26A-1)		Import/Export Product Category from AFPA's Statistics of Paper, Paperboard, and Wood Pulp	
EPA Survey Code	Product Category	Product Code	Product Category	Exports	Imports
20	Newsprint	2611	Newsprint	Newsprint	Newsprint
21	Uncoated groundwood paper (uncoated papers containing more than 10% mechanical fiber)	26212	Uncoated groundwood paper (uncoated papers containing more than 10% mechanical fiber)	Printing and writing paper, uncoated groundwood	Printing and writing paper, uncoated groundwood
22	Clay-coated printing and converted paper	26213	Clay-coated printing and converted paper	Clay-coated printing and converted paper	1978 on, printing and writing paper, coated and impregnated paper
23	Uncoated free sheet (containing not more than 10% mechanical fiber)	26214	Uncoated free sheet (containing not more than 10% mechanical fiber)	Uncoated book; 1978 on, uncoated free sheet	Printing and writing paper, uncoated book
24	Bleached bristols, excluding cotton fiber index and bogus	26215	Bleached bristols, excluding cotton fiber index and bogus	Bristols	Bristols
25	Cotton fiber writing paper and thin paper	26216	Cotton fiber writing paper and thin paper	Writing and related papers; 1978 on, printing and writing paper—thin and cotton fiber	Writing and related papers; 1978 on, writing papers, other fine paper, thin paper
26	Unbleached kraft packaging and industrial converting paper	26217	Unbleached kraft packaging and industrial converting paper	Unbleached kraft (exc. shipping sack)	Unbleached kraft packaging and industrial converting paper
27	Special industrial paper, except specialty packaging	26219	Special industrial paper, except specialty packaging	Special industrial paper	Special industrial paper
28	Tissue	26210	Tissue	Tissue paper	Tissue paper

TABLE 2-8 (cont.)

PAPER

1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities		Current Industrial Report (Form MA 26A-1)		Import/Export Product Category from AFPA's Statistics of Paper, Paperboard, and Wood Pulp	
EPA Survey Code	**Product Category**	**Product Code**	**Product Category**	**Exports**	**Imports**
30	Wrapping	2621812	Wrapping	30 & 32-37 Other packaging and industrial converting papers	30-37 Other packaging and industrial converting papers
31	Shipping sack, unbleached and bleached sulfite, semi-bleached and bleached kraft, and mixtures of both	2621832	Shipping sack, unbleached and bleached sulfite, semi-bleached and bleached kraft, and mixtures of both	Shipping sack, unbleached	
32	Other shipping sack, including rope and combination kraft and rope shipping sack paper	2621834	Other shipping sack paper		
33	Other bag and sack, unbleached and bleached sulfite, semi-bleached and bleached kraft, and mixtures of both, grocers and sack paper	2621851	Other bag and sack, unbleached and bleached sulfite, semi-bleached and bleached kraft, and mixtures of both, grocers and sack paper		
34	Other bag and sack paper for conversion in liquor, millinery, notion, or other variety bags	2621859	Other bag and sack paper for conversion in liquor, millinery, notion, or other variety bags		
35	Waxing stock	2621864	Waxing stock		
36	Other, such as asphalting and creping stocks, coating and laminating, gummed, twisting, and spinning stocks	2621868	Other, such as asphalting and creping stocks, coating and laminating, gummed, twisting, and spinning stocks		
37	Specialty packaging	2621872	Specialty packaging		

TABLE 2-8 (cont.)

PAPER

1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities		Current Industrial Report (Form MA 26A-1)		Import/Export Product Category from AFPA's Statistics of Paper, Paperboard, and Wood Pulp	
EPA Survey Code	Product Category	Product Code	Product Category	Exports	Imports
38	Glassine, greaseproof, and vegetable parchment	2621883	Glassine, greaseproof, and vegetable parchment	Glassine, greaseproof, and vegetable parchment	Glassine, greaseproof, and vegetable parchment (added)

TABLE 2-9

PAPER SHIPMENT TONNAGE FROM EPA SURVEY, CURRENT INDUSTRIAL REPORTS, AND AFPA

	Shipments (tons)						
	EPA Survey			Current Industrial Reports		AFPA Statistics	
Product Name	1985	1988	1989	1989	Percent*	1989	Percent*
Paper							
Newsprint	5,345,249	5,895,948	5,982,294	6,023,900	-0.69%	6,088,000	-1.74%
Uncoated groundwood	1,220,663	1,701,725	1,771,510	1,764,535	0.40%	1,742,700	1.65%
Clay coated printing and converted	6,069,298	8,206,186	8,107,976	7,544,190	7.47%	7,215,400	12.37%
Uncoated free sheet	8,573,717	10,700,833	10,547,085	10,689,808	-1.34%	11,080,700	-4.82%
Bleached bristols	787,404	1,047,328	1,097,508	1,252,243	-12.36%	1,163,100	-5.64%
Cotton fiber writing	439,658	434,509	447,059	425,285	5.12%	160,800	178.02%
Unbleached kraft packaging	3,199,563	3,100,273	3,030,041	2,952,871	2.61%	2,682,100	12.97%
Special industrial	680,578	920,072	947,096	673,925	40.53%	1,247,600	-24.09%
Tissue	4,126,172	5,038,029	5,306,472	5,451,017	-2.65%	5,636,500	-5.86%
Wrapping	171,352	240,502	176,680	50,381	250.69%	28,200	526.52%
Shipping sack	450,632	400,161	334,389	212,961	57.02%	101,900	228.15%
Other shipping sack, incl. rope and kraft/rope	9,338	0	0	14,647	-100.00%	n/a	n/a
Bag and sack	108,679	93,643	75,644	160,021	-52.73%	255,800	-70.43%
Other bag and sack paper for conversion	110,491	186,952	174,205	70,737	146.27%	81,800	112.96%
Waxing stock	34,475	54,243	52,101	109,048	-52.22%		n/a
Asphalting, creping, coating, and laminated	113,692	140,000	128,452	44,115	191.18%		n/a
Specialty packaging	121,599	165,525	163,196	206,950	-21.14%		n/a
Glassine, greaseproof, and vegetable parchm	120,914	109,858	109,833	247,919	-55.70%		n/a
						519,600**	
Total	31,683,474	38,435,787	38,451,541	37,894,553	1.47%	37,484,600	2.58%

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* column measures percentage difference between EPA data and other sources
** AFPA does not subdivide statistics for the categories directly above the number

Source: DOC, 1989; AFPA, 1992b.

TABLE 2-10

VALUE OF PAPER SHIPMENTS FROM EPA SURVEY, CURRENT INDUSTRIAL REPORTS, AND AFPA

	Shipments (thousands of dollars)						
	EPA Survey			Current Industrial Reports		AFPA Statistics	
Product Category	1985	1988	1989	1989	Percent*	1989	Percent*
Paper	$23,687,278	$32,868,117	$34,498,297	$33,367,000	3.39%	$33,293,000	3.62%

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* column measures relative concurrence between EPA data and other sources in percentages

Source: DOC, 1989; AFPA, 1992b.

Table 2-11 presents the information on the value of paper exports for 1985, 1988, and 1989; the value of paper exports nearly doubled in this time period. Although paper exports in 1989 were only about 30 percent of pulp exports, they still contributed nearly $1 billion to the U.S. balance of trade. The survey data are similar to the Census data for paper exports, but are lower than the AFPA value.

Table 2-12 presents AFPA statistics on paper imports for 1985, 1988, and 1989. The quantity of paper imports increased every year after 1982 before declining in 1989. Printing and writing papers made up the bulk of paper imports, comprising nearly 96 percent of total paper imports in 1989. Table 2-13 presents AFPA statistics on the value of paper imports for the 3 years. The value of paper imports did not rise as much as the value of pulp imports, but managed a 41-percent increase from 1985 to 1989.

2.3.3 Paperboard Products

Table 2-14 cross-references the paperboard categories used by the survey, the Census, and AFPA. Table 2-15 lists the paperboard shipments in tons for 1985, 1988, and 1989 as well as the 1989 shipment data from U.S. Bureau of Census and AFPA. There was nearly a 30-percent increase in the tonnage shipped from 1985 to 1989. The value of shipments in 1989 were nearly 50 percent higher than in 1985. In general, there is good agreement among all sources for the major product categories (e.g., unbleached kraft packaging and industrial, semichemical, and recycled paperboard). The discrepancies occur with the small, less well-defined categories (e.g., insulating board and other bleached board). In several cases, there is more variation between the Census and AFPA estimates than with the survey data (e.g., linerboard).

Table 2-16 lists the value of paperboard shipments for 1985, 1988, and 1989, as well as 1989 Census and AFPA data. The value of shipments increases by nearly 50 percent within the period. There is very good agreement among the three data sources.

Table 2-17 presents the value of paperboard exports for 1985, 1988, and 1989. Paperboard exports more than doubled during this period. The value of paperboard exports

TABLE 2-11

VALUE OF PAPER EXPORTS FROM EPA SURVEY, CURRENT INDUSTRIAL REPORTS, AND AFPA

	Shipments (thousands of dollars)						
	EPA SURVEY			Current Industrial Reports		AFPA Statistics	
Product Category	1985	1988	1989	1989	Percent*	1989	Percent*
Paper	$460,523	$832,384	$975,155	$1,025,574	-4.92%	$1,233,526	-20.95%

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* column measures percentage difference between EPA data and other sources

Source: DOC, 1989; AFPA, 1992b.

TABLE 2-12

PAPER IMPORT TONNAGE STATISTICS FROM AFPA

Product Category	AFPA Statistics 1985	1988	1989
Paper	10,637,427	12,063,790	11,814,260

Source: AFPA, 1992b.

TABLE 2-13

VALUE OF PAPER IMPORTS FROM AFPA

Product Category	AFPA Statistics (thousands of dollars) 1985	1988	1989
Paper	$4,906,913	$6,799,044	$6,900,798

Source: AFPA, 1992b.

TABLE 2-14

1990 NATIONAL CENSUS
PRODUCT CATEGORY CROSS-REFERENCES
U.S. PULP, PAPER, AND PAPERBOARD INDUSTRY

PAPERBOARD

1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities		Current Industrial Report (Form MA 26A-1)		Import/Export Product Category from AFPA's Statistics of Paper, Paperboard, and Wood Pulp	
EPA Survey Code	Product Category	Product Code	Product Category	Exports	Imports
40	Unbleached kraft packaging and industrial converting paperboard	26311	Unbleached kraft packaging and industrial converting paperboard	1978 on, other kraft paperboard—unbleached	40 & 42 Other paperboard
41	Semi-chemical paperboard, including corrugated medium and other uses	26313	Semi-chemical paperboard, including corrugated medium and other uses	Corrugating medium semi-chemical	1978 on, semi-chemical corrugating
42	Recycled paperboard	26314	Recycled paperboard	Recycled furnish paperboard	
43	Wet machine board, including binder's board and shoe board	26318	Wet machine board, including binder's board and shoe board	Wet machine board	Wet machine board
50	Construction paper	2621B	Construction paper	Construction paper and board, building paper	Building paper
51	Hardboard	24934	Hardboard	1978-1983, hard pressed board	1967-1983, hard pressed board
52	Insulating board	24934	Insulating board	Insulating and hard pressed board; 1978 on, insulating and other building board	Insulating board and other building board
60	Linerboard	2631210	Linerboard	Kraft linerboard	60-66 Test or container board
61	Folding carton-type board	2631210	Folding carton-type board	61-66 Bleached packaging paperboard; 1984 on, folding boxboard	
62	Milk carton board	1631261	Milk carton board	1984 on, milk carton	

TABLE 2-14 (cont.)

PAPERBOARD

1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities		Current Industrial Report (Form MA 26A-1)		Import/Export Product Category from AFPA's Statistics of Paper, Paperboard, and Wood Pulp	
EPA Survey Code	Product Category	Product Code	Product Category	Exports	Imports
63	Heavyweight cup and round, nested food container	2631262	Heavyweight cup and round, nested food container	1984 on, 63 & 64, plate, dish, tray, and cup	
64	Plate, disk, and tray stock	2631263	Plate, dish, and tray stock		
65	Bleached paperboard for miscellaneous packaging	2631283	Bleached paperboard for miscellaneous packaging	1984 on, 65 & 66 Other bleached packaging paperboard	
66	Other solid bleached board including bleached paperboard for moist, oily, and liquid foods	2631286	Other solid bleached board including bleached paperboard for moist, oily, and liquid foods		

TABLE 2-15

PAPERBOARD SHIPMENT TONNAGE STATISTICS FROM EPA SURVEY, CURRENT INDUSTRIAL REPORTS, AND AFPA

	Shipments (tons)						
	EPA Survey			Current Industrial Reports		AFPA Statistics	
Product Name	1985	1988	1989	1989	Percent*	1989	Percent*
Paperboard							
Unbleached kraft packaging and industrial	14,788,211	18,195,799	18,807,504	18,794,872	0.07%	19,490,100	-3.50%
Semichemical, including corrugated medium	4,662,158	5,312,910	5,363,565	5,198,897	3.17%	5,691,100	-5.76%
Recycled paperboard	5,558,113	7,587,635	7,784,209	9,045,651	-13.95%	8,816,700	-11.71%
Wet machine board (binder and shoe board)	84,464	85,658	85,716	102,258	-16.18%	100,000	-14.28%
Construction paper	240,230	230,770	284,638	334,997	-15.03%	600,000	-52.56%
Insulating Board	54,012	76,704	73,427	517,634	-85.81%	870,000	-91.56%
Linerboard	352,628	446,524	362,833	445,476	-18.55%	177,700	104.18%
Folding carton	1,579,783	2,064,648	2,099,734	2,211,665	-5.06%	1,980,400	6.03%
Milk carton	1,003,732	1,054,387	1,120,306	1,143,115	-2.00%	565,600	98.07%
Heavyweight cup and round nested food container	316,716	456,308	425,541	425,682	-0.03%	452,400	-5.94%
Plate, dish, and tray stock	181,967	225,472	216,543	322,567	-32.87%	362,100	-40.20%
Bleached paperboard for miscellaneous packaging	18,135	62,787	54,853	73,353	-25.22%	915,600	-94.01%
Other bleached, incl. board for moist, oily, & liquid fo	347,513	473,837	531,817	283,777	87.41%	n/a	n/a
Total	29,187,662	36,273,439	37,210,686	38,899,944	-4.34%	40,021,700	-7.02%

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* column measures percentage difference between EPA data and other sources
** AFPA does not subdivide statistics for the categories directly above the number

Source: DOC, 1989; AFPA, 1992b.

TABLE 2-16

VALUE OF PAPERBOARD SHIPMENTS FROM EPA SURVEY, CURRENT INDUSTRIAL REPORTS, AND AFPA

	Shipments (thousands of dollars)						
	EPA Survey			Current Industrial Reports		AFPA Statistics	
Product Category	1985	1988	1989	1989	Percent*	1989	Percent*
Paperboard	$9,675,058	$15,140,102	$16,355,199	$17,135,000	-4.55%	$16,352,000	0.02%

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* column measures percentage difference between EPA data and other sources

Source: DOC, 1989; AFPA, 1992b.

TABLE 2-17

VALUE OF PAPERBOARD EXPORTS FROM EPA SURVEY, CURRENT INDUSTRIAL REPORTS, AND AFPA

	Shipments (thousands of dollars)						
	EPA Survey			Current Industrial Reports		AFPA Statistics	
Product Category	1985	1988	1989	1989	Percent*	1989	Percent*
Paperboard	$635,864	$1,306,459	$1,411,936	$1,473,457	-4.18%	$1,749,159	-19.28%

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* column measures percentage difference between EPA data and other sources

Source: DOC, 1989; AFPA, 1992b.

consistently exceeded that of paper exports during the survey period. In 1989, paperboard exports contributed $1.4 billion toward the balance of trade.

Table 2-18 presents AFPA statistics on paperboard imports for 1985, 1988, and 1989. The quantity of paperboard imports increased 22 percent from 1985 to 1989. Table 2-19 presents AFPA statistics on the value of paperboard imports for the 3 years. The value of paperboard imports increased steadily throughout the 1980s. The 1989 value was nearly double the 1985 value.

2.3.4 Product Prices

Average product price data are available from both the Bureau of Census and the AFPA. Figure 2-6 shows the trend of price indices constructed for the market pulp, paper and paperboard product categories from 1981 to 1989. The price trend somewhat mirrors the industry's business cycle, with low prices prevailing in the early and mid-1980s, and higher prices coinciding with the more prosperous late 1980s. The price of market pulp products is the most cyclical, and the price of paper products is the least cyclical of the three product categories.

2.4 FACILITY-LEVEL INFORMATION

2.4.1 Geographic Distribution of Facilities

Figure 2-7 and Table 2-20 provide a count of facilities by state for 1989 based on the QFIN2 data base. The pulp, paper, and paperboard industry has facilities in 42 states. Most of these facilities are located in the country's eastern portion. Figure 2-8 ranks these states by number of facilities. The bars show the relative proportion of independent facilities.[5] New

[5]An independent facility is a single facility with no other facilities under the same ownership and no other components in the corporate hierarchy. For example, a single U.S. mill that is part of a foreign company or holding company is considered a single mill, but not independent. About 10 percent of the mill population met the definition of an independent facility.

TABLE 2-18

PAPERBOARD IMPORT TONNAGE STATISTICS FROM AFPA

Product Category	AFPA Statistics		
	1985	1988	1989
Paperboard	600,667	663,456	723,211

Source: AFPA, 1992b.

TABLE 2-19

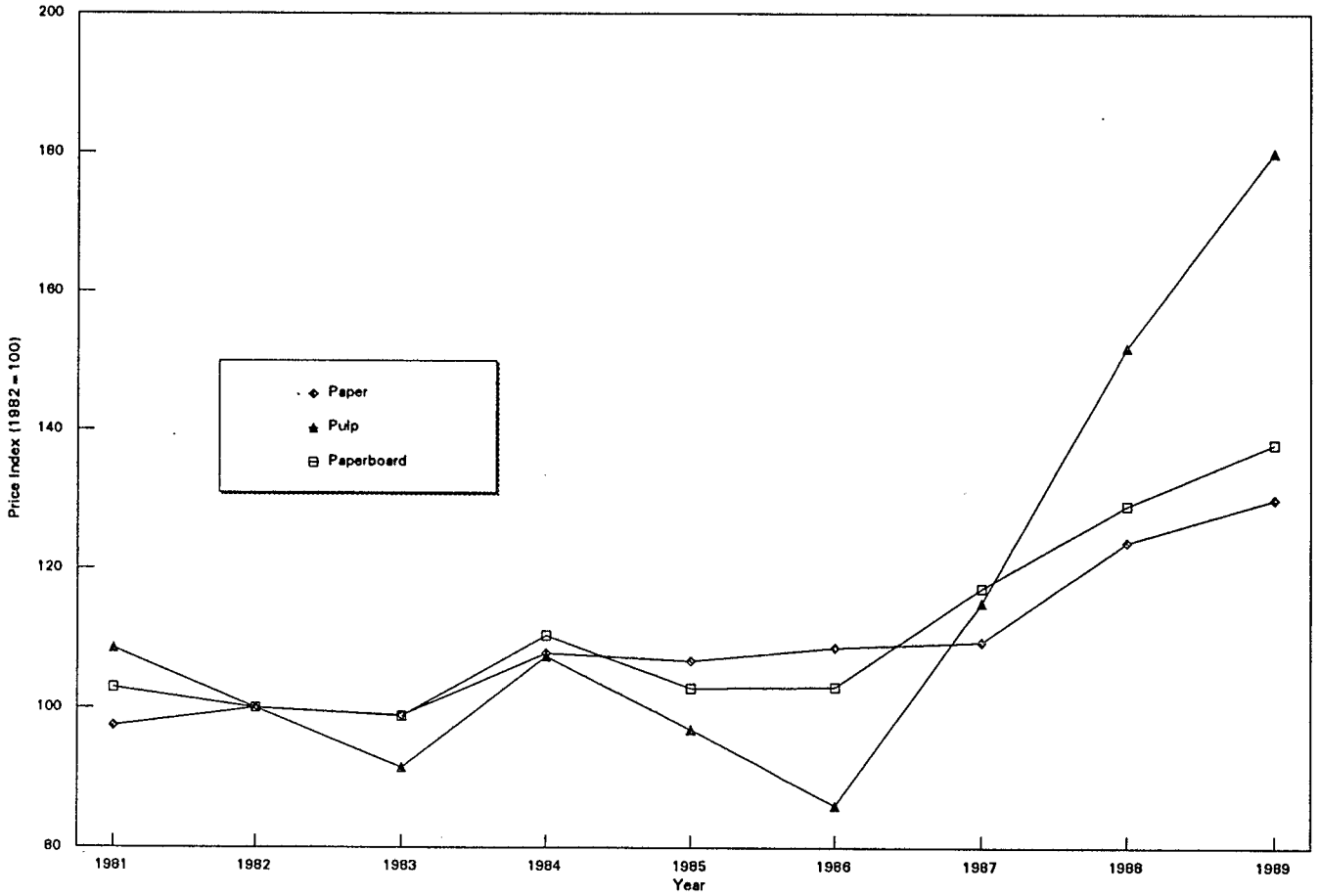
VALUE OF PAPERBOARD IMPORTS FROM AFPA

Product Category	AFPA Statistics (thousands of dollars) 1985	1988	1989
Paperboard	$167,600	$238,584	$330,851

Source: AFPA, 1992b.

FIGURE 2-6

LASPEYRES PRICE INDICES FOR PULP, PAPER, AND PAPERBOARD



SOURCE: DOC, 1990; DOC, 1989;
AFPA, 1992b.

FIGURE 2-7
PULP, PAPER, AND PAPERBOARD MILLS BY STATE

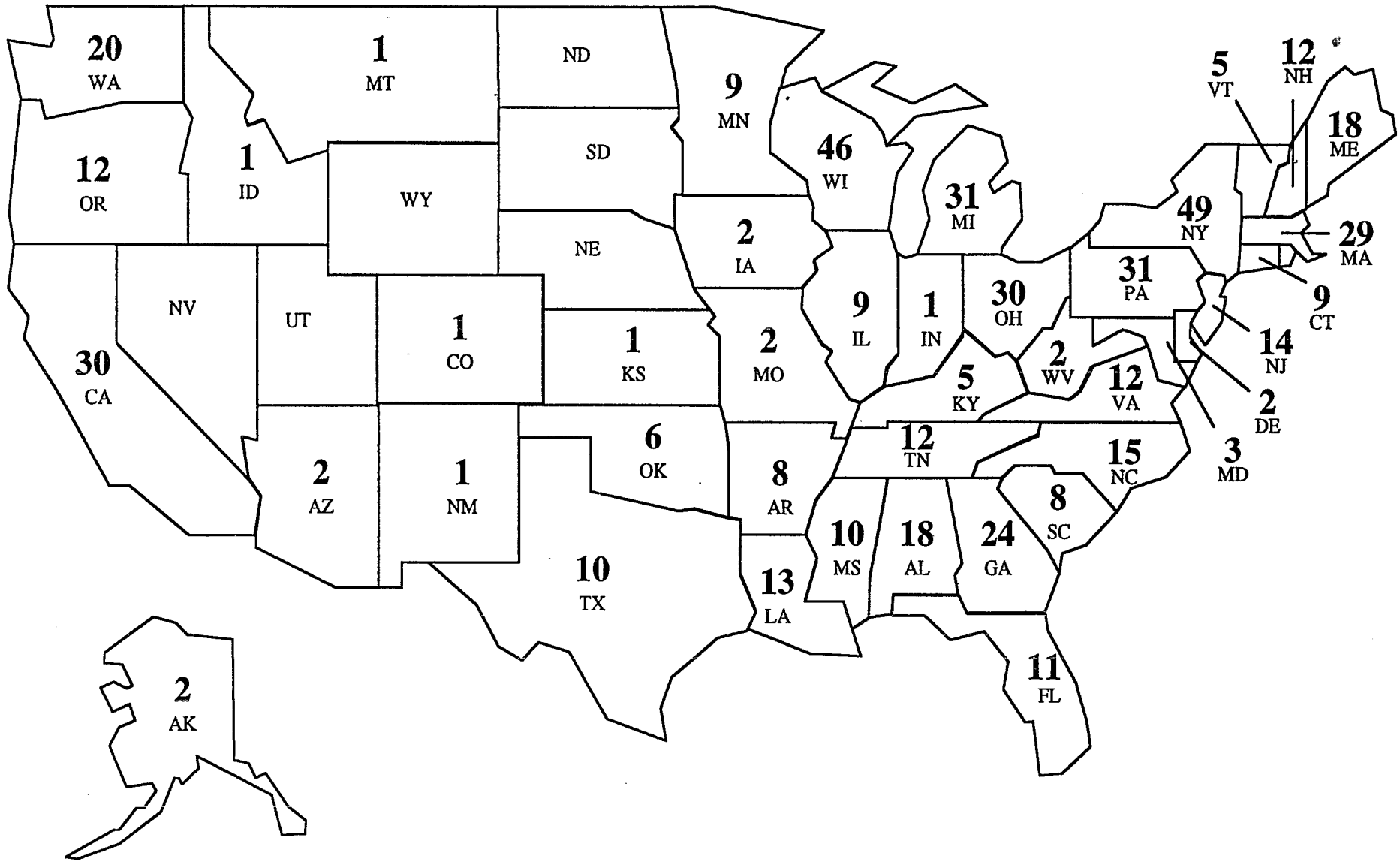


TABLE 2-20

NUMBER OF MILLS BY STATE

State	Number of Mills
AK	2
AL	18
AR	8
AZ	2
CA	30
CO	1
CT	9
DE	2
FL	11
GA	24
IA	2
ID	1
IL	9
IN	11
KS	1
KY	5
LA	13
MA	29
MD	3
ME	18
MI	31
MN	9
MO	2
MS	10
MT	1
NC	15
NH	12
NJ	14
NM	1
NY	49
OH	30
OK	6
OR	12
PA	31
SC	8
TN	12
TX	10
VA	12
VT	5
WA	20
WI	46
WV	2
Total	537

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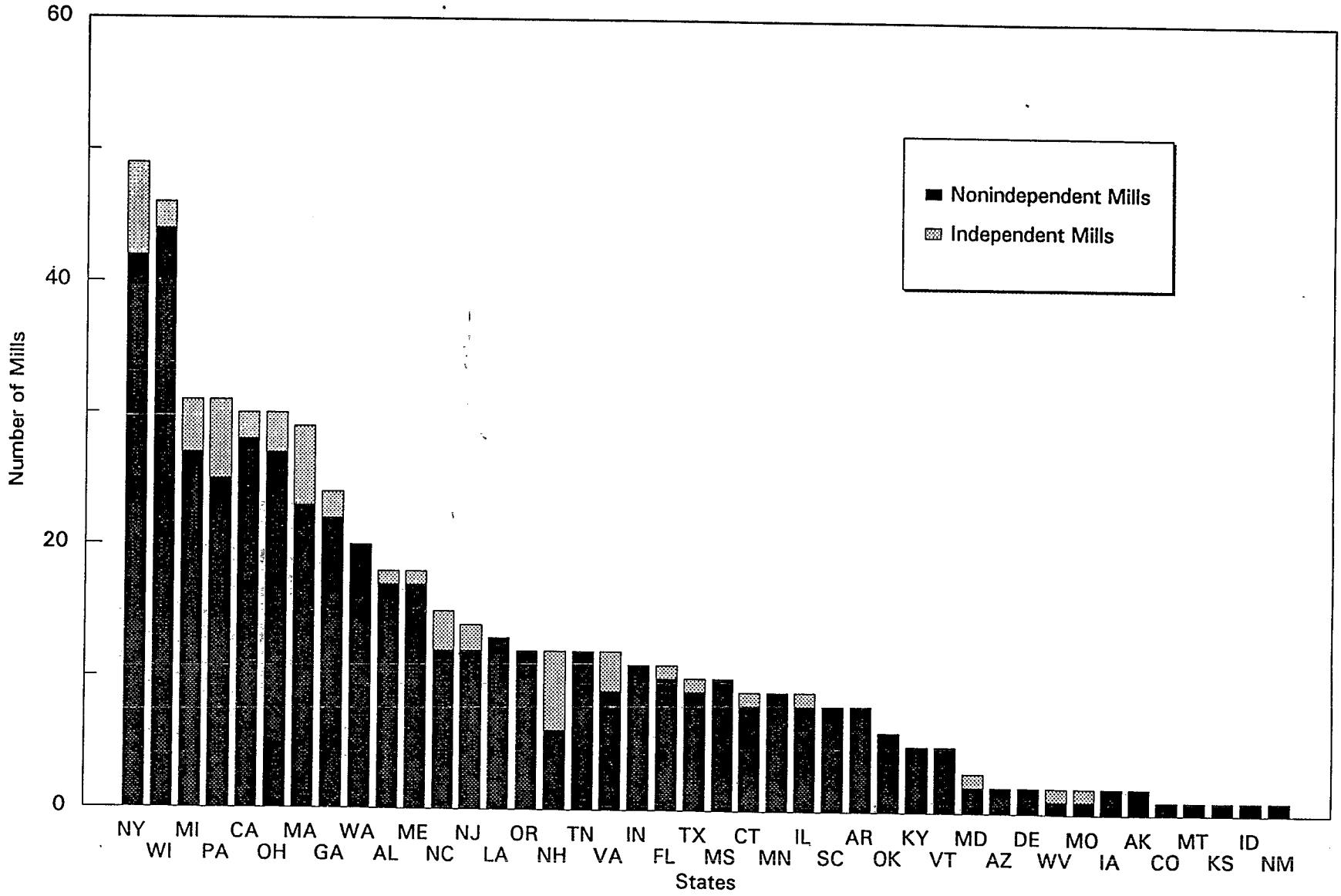
FIGURE 2-8

DISTRIBUTION OF MILLS BY STATE



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York has the most facilities, followed closely by Wisconsin. Pennsylvania, Michigan, Ohio, California, and Massachusetts each have approximately 30 mills. Georgia and Washington have 20 or more mills each. The remaining states have fewer than 20 mills each. New Hampshire ranks near the middle in terms of the number of mills, but half of them are independent facilities.

Table 2-21 and Figure 2-9 summarize facility distribution by EPA region. Region 4 (Southeast) and Region 5 (Great Lakes) dominate the group with more than 100 mills in each. Figure 2-9 also indicates the relative predominance of independent facilities in the middle and northeastern part of the country. Table 2-22 provides a data summary—by EPA region, by state, and by independent facilities.

2.4.2 Facility Size

Assets. There are approximately 516 facilities in EPA's data base with 1989 facility-level asset information.[6] Table 2-23 summarizes the minimum, maximum, mean, and total facility-level assets for 1985, 1988, and 1989. These assets are the total of current and noncurrent assets and are listed in thousands of current dollars (i.e., data for 1985 are in terms of 1985 dollars while data for 1989 are in terms of 1989 dollars). The population size changes for each year; there is asset information for 447 mills in 1985, 508 mills in 1988, and 516 mills in 1989. In most cases, if a mill was sold to a new owner, the new owner had technical information, but not financial information, for earlier years. Table 2-23 indicates that 1985 data were not available for about 13 percent of the facility population, while 1988 data was not available for less than 2 percent of the population. In other words, there is a fair amount of fluidity in mill ownership; a mill might have been operating for decades, but have had several owners during that time.

The data are stratified by whether a mill is part of a multifacility organization. There are several examples of single facilities that are part of a larger corporate hierarchy. According to

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[6]No 1989 data were available for mills that changed ownership after 1989, began operations after 1989, or whose financial information was combined with that of another facility.

TABLE 2-21

NUMBER OF MILLS BY EPA REGION

Region	Number of Mills
Region 1	73
Region 2	63
Region 3	50
Region 4	103
Region 5	136
Region 6	38
Region 7	5
Region 8	2
Region 9	32
Region 10	35
Total	537

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FIGURE 2-9

DISTRIBUTION OF MILLS BY EPA REGION

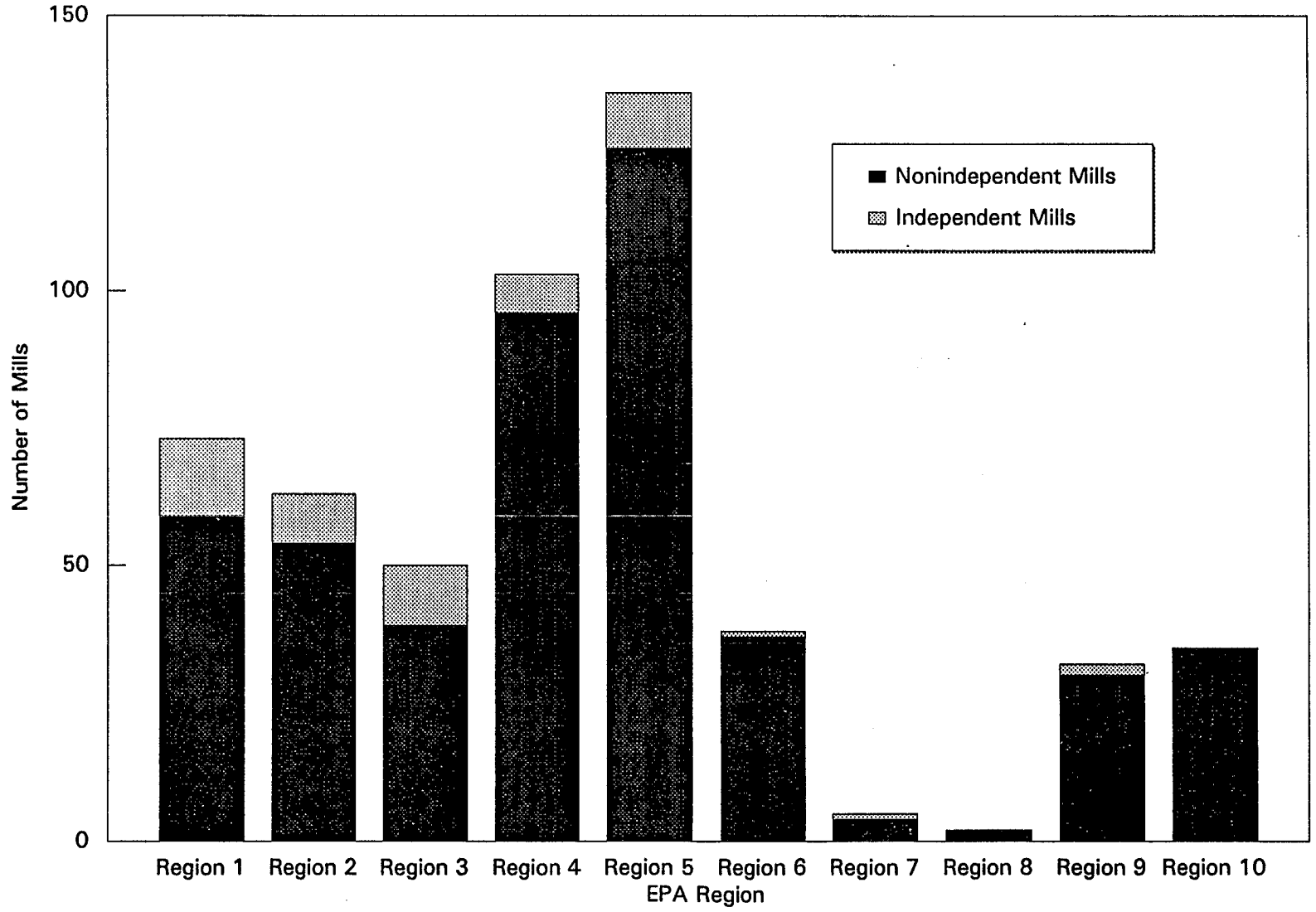

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TABLE 2-22

NUMBER OF MILLS BY EPA REGION, STATE, AND INDEPENDENT STATUS

EPA Region	State	Independent		State Total
		No	Yes	
Region 1	CT	8	1	9
	MA	23	6	29
	ME	17	1	18
	NH	6	6	12
	VT	5	0	5
	Region Total	59	14	73
Region 2				
	NJ	12	2	14
	NY	42	7	49
	Region Total	54	9	63
Region 3				
	DE	2	0	2
	MD	2	1	3
	PA	25	6	31
	VA	9	3	12
	WV	1	1	2
	Region Total	39	11	50
Region 4				
	AL	17	1	18
	FL	10	1	11
	GA	22	2	24
	KY	5	0	5
	MS	10	0	10
	NC	12	3	15
	SC	8	0	8
	TN	12	0	12
	Region Total	96	7	103
Region 5				
	IL	8	1	9
	IN	11	0	11
	MI	27	4	31
	MN	9	0	9
	OH	27	3	30
	WI	44	2	46
	Region Total	126	10	136
Region 6				
	AR	8	0	8
	LA	13	0	13
	NM	1	0	1
	OK	6	0	6
	TX	9	1	10
	Region Total	37	1	38
Region 7				
	IA	2	0	2
	KS	1	0	1
	MO	1	1	2
	Region Total	4	1	5
Region 8				
	CO	1	0	1
	MT	1	0	1
	Region Total	2	0	2
Region 9				
	AZ	2	0	2
	CA	28	2	30
	Region Total	30	2	32
Region 10				
	AK	2	0	2
	ID	1	0	1
	OR	12	0	12
	WA	20	0	20
	Region Total	35	0	35
Total		482	55	537

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TABLE 2-23

FACILITY ASSETS

Year	Facility Type	Observations	Assets (thousands of dollars) Minimum	Maximum	Median	Average Assets	Total Assets
1985							
	Single facility	86	$336	$301,605	$10,764	$33,202	$2,855,376
	Multi-facility	361	($697)	$987,764	$29,225	$92,215	$33,289,644
	Industry Total	447	($697)	$987,764	$21,421	$80,861	$36,145,020
1988							
	Single facility	100	$320	$419,438	$12,702	$46,132	$4,613,151
	Multi-facility	408	$0	$852,194	$34,439	$109,035	$44,486,217
	Industry Total	508	$0	$852,194	$27,650	$96,652	$49,099,368
1989							
	Single facility	104	$326	$525,525	$15,240	$55,627	$5,785,190
	Multi-facility	412	$0	$995,129	$36,589	$119,653	$49,297,057
	Industry Total	516	$0	$995,129	$29,572	$106,749	$55,082,247

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survey data, an intercompany account frequently is kept as a current asset for facilities that are part of a multifacility organization. This intercompany account can have a negative value if, for example, the books close after the payroll has been written but the check from corporate headquarters to cover the payroll has not been received. In other words, negative current assets are a legitimate survey response at the facility level. The negative value for multifacilities in 1985 can be attributed to this intercompany account issue. Several facilities had no assets kept at the facility level, which explains the zeros seen as minimum values for 1988 and 1989.

The average facility had assets of $81 million in 1985, $97 million in 1988, and $107 in 1989. Assets for the population totaled $36 billion in 1985, $49 billion in 1988, and $55 billion in 1989. The average single facility has about one-third to one-half the assets of a multifacility organization's facility. The median assets for a single facility in 1985 were $11 million. While the difference between the median and mean assets for any comparable group indicate that the distribution is skewed by a smaller number of large facilities, even the median values indicate a large asset base per facility. The asset numbers reflect the industry's capital-intensive nature. They may also indicate that assets might not be the best parameter by which to define a small business entity in this analysis.

Shipments. Section 2.3 outlines industrywide summaries of pulp, paper, and paperboard shipments and comparisons with publicly available information. The value of shipments for 1985, 1988, and 1989 are listed in Table 2-24 by whether the mill is independent. Independents account for only 5 percent of the value of pulp shipments and 3 percent of the paper and paperboard shipments. Figure 2-10 is a histogram of the total value of pulp, paper, and paperboard shipments, which peak at about $10 million to $20 million and drop off sharply at higher revenues, but include sporadic occurrences of very high revenues. Figure 2-10 indicates a possible dividing point for identifying small businesses. A mill with a highly-specialized product, however, could have few employees and small production, but large revenues. The possible inverse relationship between product specialization and revenues suggests that the value of shipments (or revenues) is not a logical choice for categorizing small and large business entities.

TABLE 2-24

PULP, PAPER, AND PAPERBOARD VALUE OF SHIPMENTS, 1985, 1988, and 1989

Type of Facility / Statistic	Value of Shipments (thousands of dollars)								
	Pulp			Paper			Paperboard		
	1985	1988	1989	1985	1988	1989	1985	1988	1989
Independent									
Observations	6	7	7	26	28	28	15	18	19
Minimum	$1,314	$2,123	$2,363	$262	$946	$1,076	$151	$482	$508
Maximum	$153,093	$206,395	$258,811	$145,666	$187,557	$198,878	$59,937	$163,600	$196,341
Average	$34,222	$41,219	$51,112	$27,982	$36,628	$38,803	$13,964	$23,760	$26,262
Total Value	$205,329	$288,531	$357,785	$727,530	$1,025,592	$1,086,485	$209,459	$427,673	$498,981
Multi-facility									
Observations	79	87	91	234	260	265	178	199	203
Minimum	$13	$105	$122	$963	$789	$2	$61	$740	$94
Maximum	$240,826	$333,647	$366,918	$542,276	$667,920	$718,702	$274,204	$425,801	$497,031
Average	$41,865	$72,527	$80,750	$98,119	$122,471	$126,082	$53,178	$73,932	$78,109
Total Value	$3,307,342	$6,309,892	$7,348,264	$22,959,748	$31,842,525	$33,411,812	$9,465,599	$14,712,429	$15,856,217
Industry									
Observations	85	94	98	260	288	293	193	217	222
Minimum	$13	$105	$122	$262	$789	$2	$61	$482	$94
Maximum	$240,826	$333,647	$366,918	$542,276	$667,920	$718,702	$274,204	$425,801	$497,031
Average	$41,326	$70,196	$78,633	$91,105	$114,125	$117,742	$50,130	$69,770	$73,672
Total Value	$3,512,671	$6,598,423	$7,706,049	$23,687,278	$32,868,117	$34,498,297	$9,675,058	$15,140,102	$16,355,198

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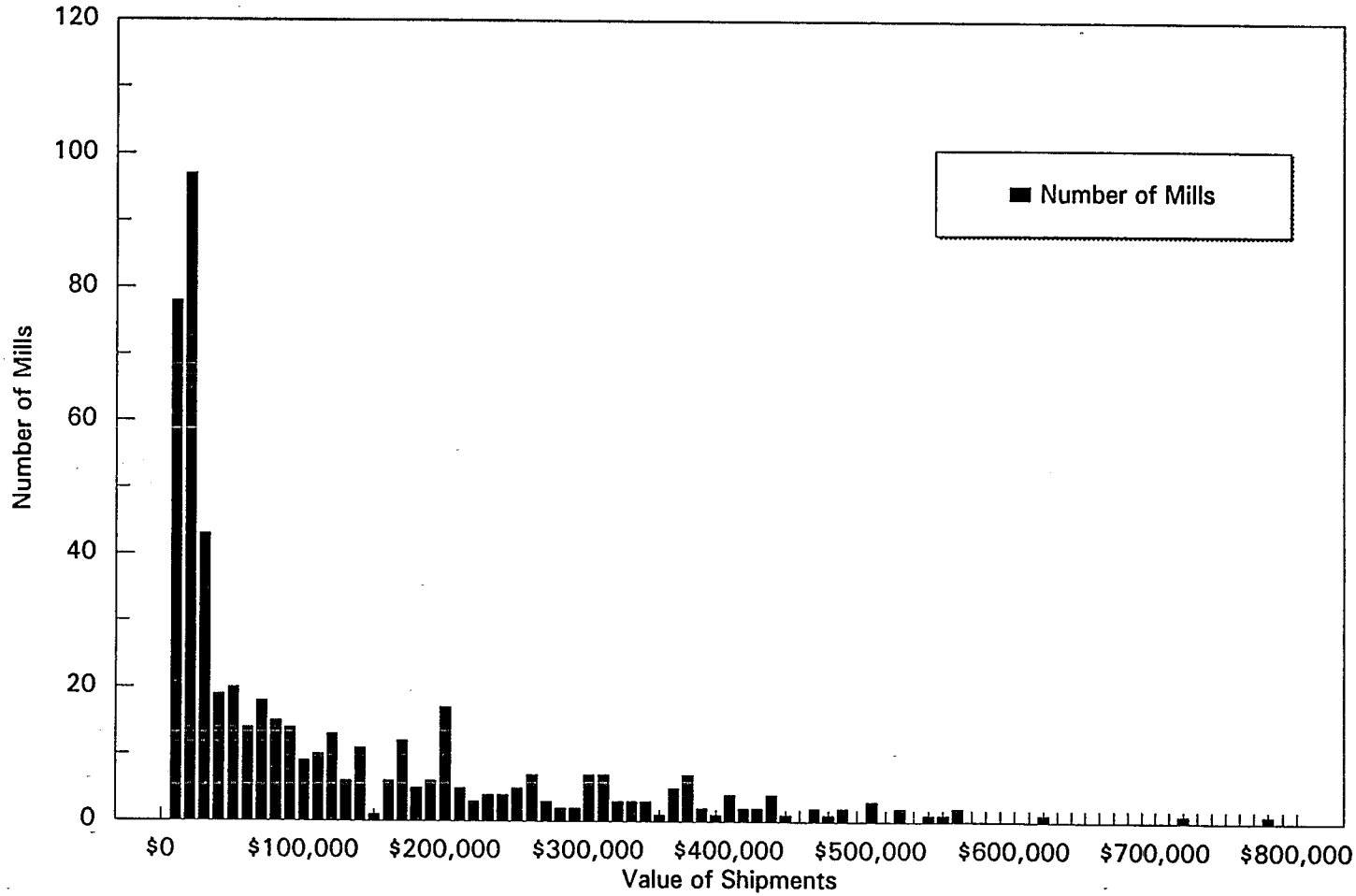
FIGURE 2-10

HISTOGRAM OF TOTAL VALUE OF SHIPMENTS, 1989



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Employees. The survey requested the average number of employees engaged in:

- Pulp, paper, or paperboard operations
- Other production operations
- Nonproduction operations

The data were provided for 1989 and are summarized in Table 2-25. The average independent facility has about one-third the production employees as a multifacility organization's mill. In one independent facility, whose workers are all contracted from another company, the facility's books show zero employees.[7] Zero entries for other production workers imply that the facility makes only pulp, paper, and paperboard. For a few facilities in the survey, papermaking operations form only a small part of the overall business. For example, if a facility makes shingles or wallpaper, papermaking might engage only a small part of the work force. Comparing the number of nonproduction employees to the total number of employees indicates that nearly one in five facility employees is not engaged in production.

The data base shows a total of 220,000 employees in the relevant segments of the industry for 1989. This figure is slightly higher than the 200,000 employees listed for SIC codes 261, 262, and 263 in the 1989 County Business Patterns (DOC, 1991). Employment numbers in the Census data, however, do not include proprietors and partners of unincorporated businesses. AFPA lists 197,000 employees in 1989, of which 153,000 are in production (AFPA, 1992b, Table xxxi, taken from the 1989 Annual Survey of Manufactures). The AFPA value for production workers (153,000) might reflect only those production employees affiliated with non-independent mills. The survey value of 153,711 non-independent production workers agrees with this interpretation of the AFPA value.

[7]Zero employees for a nonindependent mill can occur when the mill (1) started operations after 1989, (2) changed ownership after 1989, or (3) has information combined with that of another mill. In the last case, both mills are kept in the count, but the number of employees for one mill is set to zero.

TABLE 2-25

NUMBER OF EMPLOYEES, 1989 DATA

Type of Employee / Type of Facility	Observations	Employees				
		Minimum	Maximum	Average	Median	Total
Production						
Multi-facility	482	0	2,583	320	170	154,168
Independent	55	0	719	119	68	6,550
Industry	537	0	2,583	299	146	160,718
Non-Production						
Multi-facility	482	0	1,212	86	42	41,402
Independent	55	0	340	40	16	2,226
Industry	537	0	1,212	81	38	43,628
Other						
Multi-facility	482	0	1,500	32	0	15,647
Independent	55	0	200	9	0	498
Industry	537	0	1,500	30	0	16,145
Overall Employment						
Multi-facility	482	0	3,295	438	263	211,217
Independent	55	0	1,055	169	91	9,274
Industry	537	0	3,295	411	228	220,491

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There may be another reason that the survey data indicate a larger number of employees in the pulp, paper, and paperboard industry than shown in AFPA or Census data. The number of employees in SIC code 2661 (building paper and board mills) is included in the survey, but not in the Census or AFPA values.

Figure 2-11 is a histogram of the number of mills by number of employees. The distribution levels off at 750 employees. The Small Business Administration definition of "small" business for this industry is confirmed as a useful distinction in the analysis (discussed below in Section 2.4.2.1). The graph changes also at the 125-employee mark. This cutoff might be useful for distinguishing "very small" business entities.

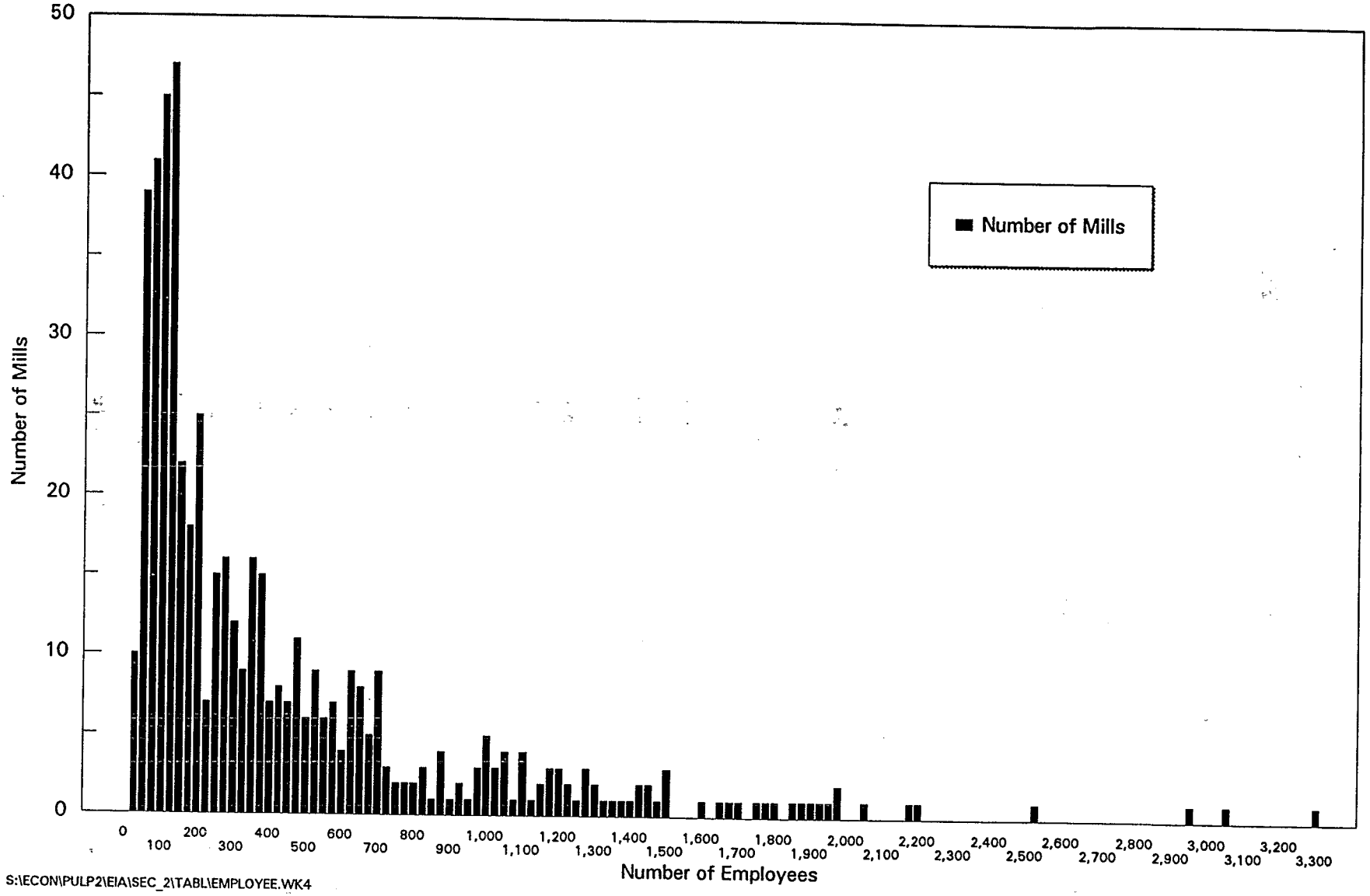
2.4.2.1 Definition of Small Business Entity Used in this Analysis

The Regulatory Flexibility Act came into effect on January 1, 1981 (EPA, 1992b). A goal of the Act is to establish a mechanism to provide policymakers with information about how regulatory options affect small entities. The intent is to ensure, if possible, that the chosen regulatory alternative does not have undue or disproportionate impacts on small entities. The U.S. Small Business Administration issues definitions of "small businesses" in Code of Federal Regulations, Title 13, Part 121. For pulp, paper, and paperboard companies (SIC codes 2611, 2621, and 2631, respectively), the size standard is 750 employees, which is one category that will be used in the regulatory flexibility analysis.

The Act recognizes several definitions of "small" entities: a small business is any business that is independently owned and operated and not dominant in its field (EPA, 1992b). For this analysis, the definition of "small business entity" focuses on both the facility and the company. Independent pulp and paper operations are both single facilities and businesses, so a facility-based definition is appropriate for them. While a multifacility company could have more than 750 employees, those employees could be spread among numerous smaller facilities, some engaged in pulp and paper production and some not. By using a facility-based definition for "small entity," the regulatory flexibility analysis can identify smaller and more localized impacts. The analysis also will examine impacts on companies with 750 or fewer employees.

FIGURE 2-11

HISTOGRAM OF EMPLOYMENT BY FACILITY



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In addition to the number of employees, other possible bases for identifying small entities include assets and value of shipments. A large asset base is needed for any pulp, paper, and paperboard facility, while the importance of the value or number of shipments could vary inversely with product specialization. Since jobs and potential employment loss due to increased pollution control requirements is one focus of this analysis, small entities are defined by the total number of employees at a facility. (If a mill closes, both the production and nonproduction employees will lose their jobs; hence, the definition is based on the facility's total employees.) Based on the sharp break in the histogram in Figure 2-11, 125 employees is a useful cutoff for identifying a subset of small entities:

- Very small business entity: A facility with 0 to 125 employees
- Small business entity: A facility with 126 to 750 employees
- Large business entity: A facility with more than 750 employees

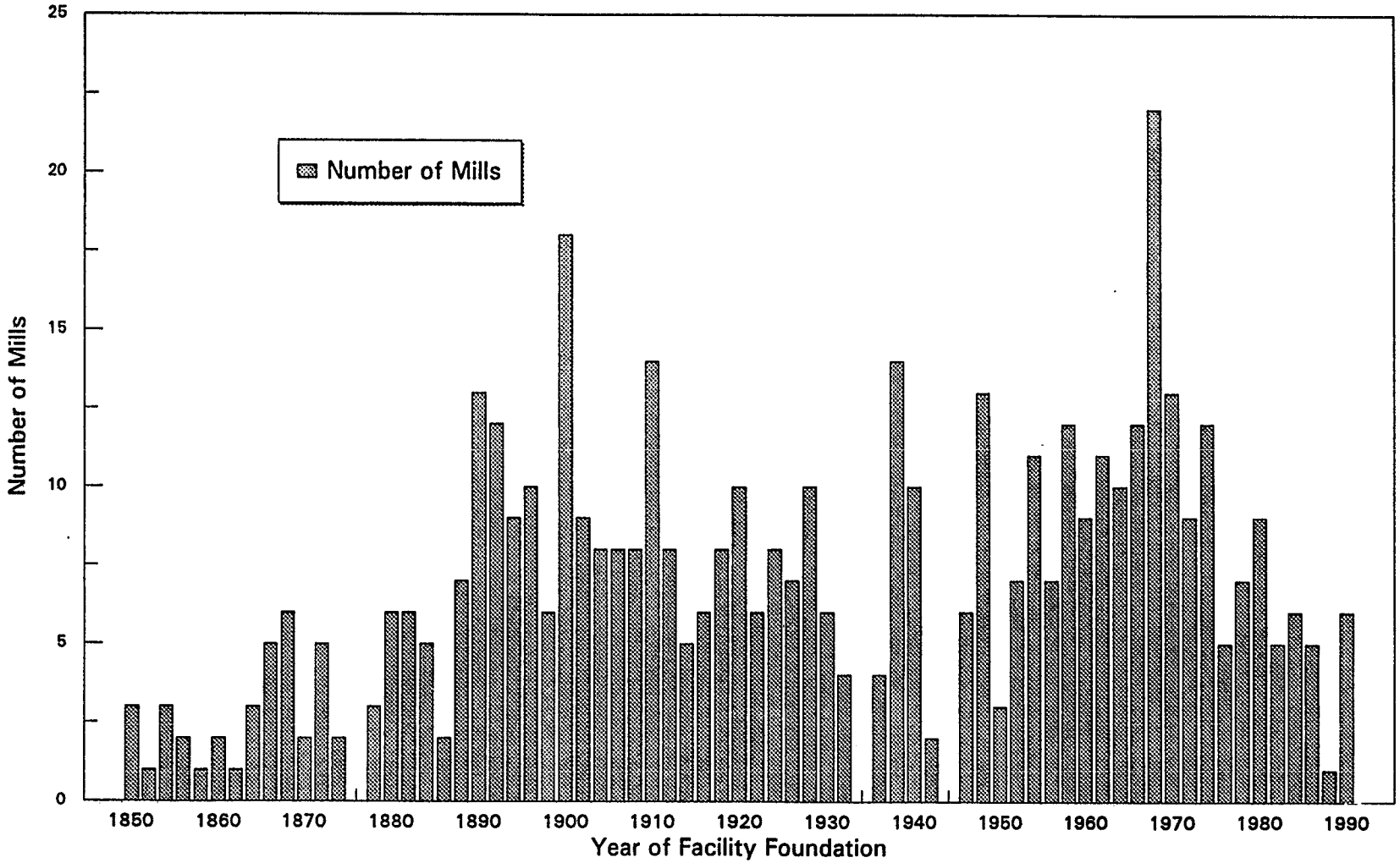
Analyzing the first two categories on a combined basis is consistent with the Small Business Administration definition of a small business entity in the pulp, paper, and paperboard industry. Subdividing the data into "very small" and "small" business entities allows for a closer examination of whether the regulation's impacts fall disproportionately on smaller entities. More discussion of small business entities and companies is included in Section 3.4.

2.4.3 Facility Age

Figures 2-12 and 2-13 plot the age of the facility and the age of pulp and paper operations at the facility, respectively. In some cases, a facility built for one purpose was later transformed into a pulp and paper operation; but the two histograms are very similar. The industry has a long and venerable history in this country; several operations date back to the Colonial period. The kraft pulping process was developed about 100 years ago, immediately followed by a large increase in the number of facilities. The number of facilities dipped during the Great Depression and World War II, and a new influx of facilities came in the postwar phase.

FIGURE 2-12

HISTOGRAM OF FACILITY AGE



25 facilities opened prior to 1850.

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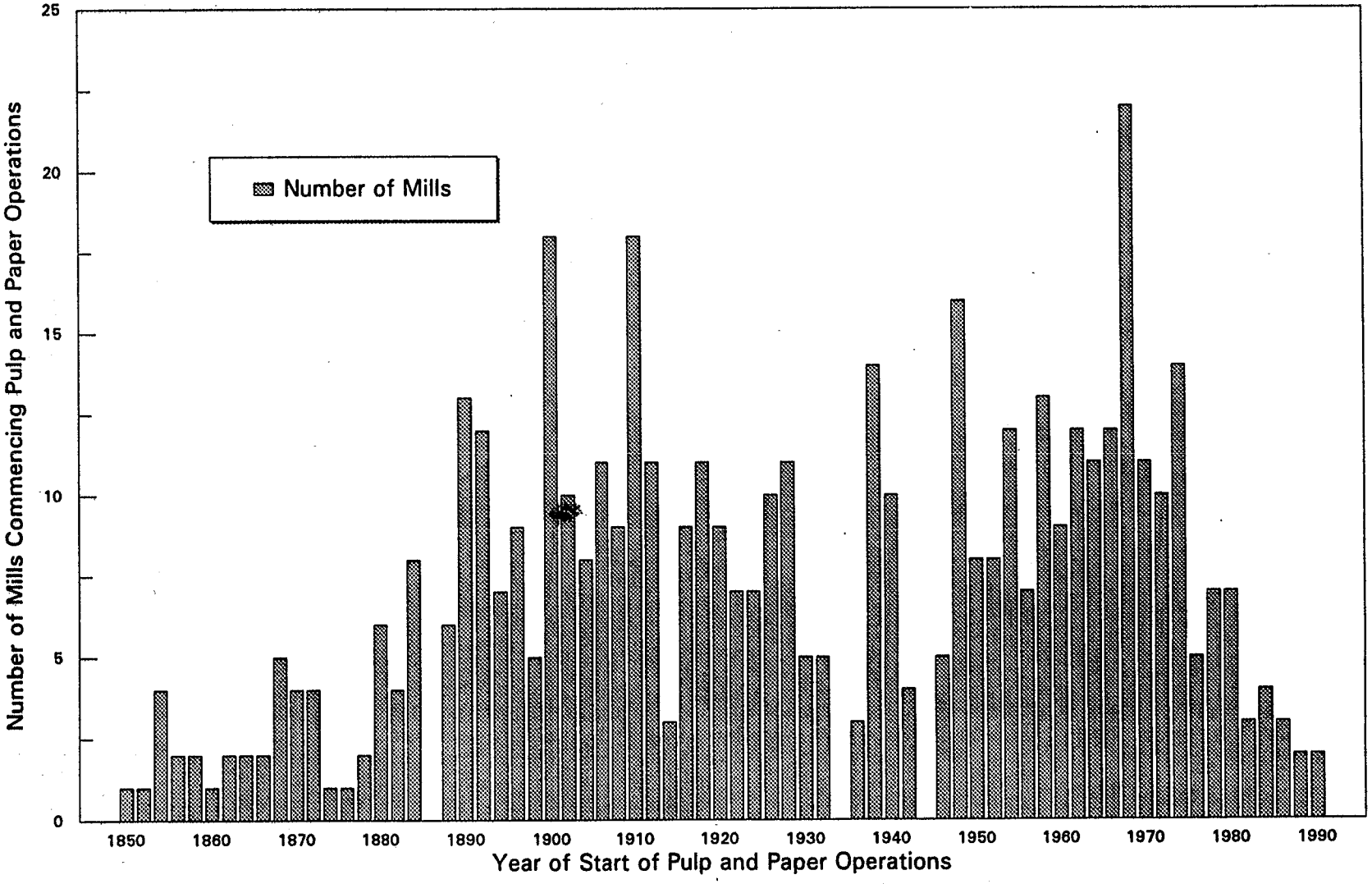
FIGURE 2-13

HISTOGRAM OF AGE OF PULP AND PAPER OPERATIONS



16 facilities began pulp and paper operations prior to 1850.

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These two figures do not tell the industry's whole story. Pulp and paper operations might be long-established, but the large majority of mills continue to update, upgrade, and expand their operations. The survey asked for the date of the most recent renovation/expansion for the facility. To qualify, the renovation/expansion had to be at least 10 percent of the value of the plant's accumulated gross investment. The renovation/expansion dates are shown in Figure 2-14. While a portion of the population functions with decades-old equipment, more than half the mills renovated or expanded between 1985 and 1990. One way to interpret the data is that, if you have a specialized product or niche market, original equipment is sufficient; otherwise, frequent reinvestment is necessary to maintain a competitive edge.

2.4.4 Capital Investment

At the end of 1989, the pulp, paper, and paperboard industry showed an original investment of $68 billion in land, buildings, and equipment (Table 2-26). Even after depreciation, these investments totaled $42 billion. Single-facility establishments accounted for approximately 9 percent of this asset base. There were approximately 161,000 pulp, paper, and paperboard production workers in 1989 (Table 2-25). The original investment per employee, then, is approximately $420,000, indicating the capital-intensive nature of the industry.

Capital investment is a continuing process in this industry. Table 2-27 lists the expenditures on new plant and equipment from 1980 to 1990 (AFPA, 1992b). The investment shows large increases to $5 billion to $8 billion/year for 1988 through 1990. This corresponds to the large peak shown for these years in Figure 2-14. In 1989, the industry invested about $47,000 per employee in new plants and equipment. Table 2-27 also lists the expenditures for environmental protection (AFPA, 1992b). Pollution control accounted for between 6 and 16 percent of new investment during this period. Since the AFPA data on the environmental expenditures do not specify whether the pollution control expenditures are for the entire industry or for primary mills, the percentages listed in Table 2-27 might be overestimates.

FIGURE 2-14

HISTOGRAM OF EXPANSION AND RENOVATION YEARS

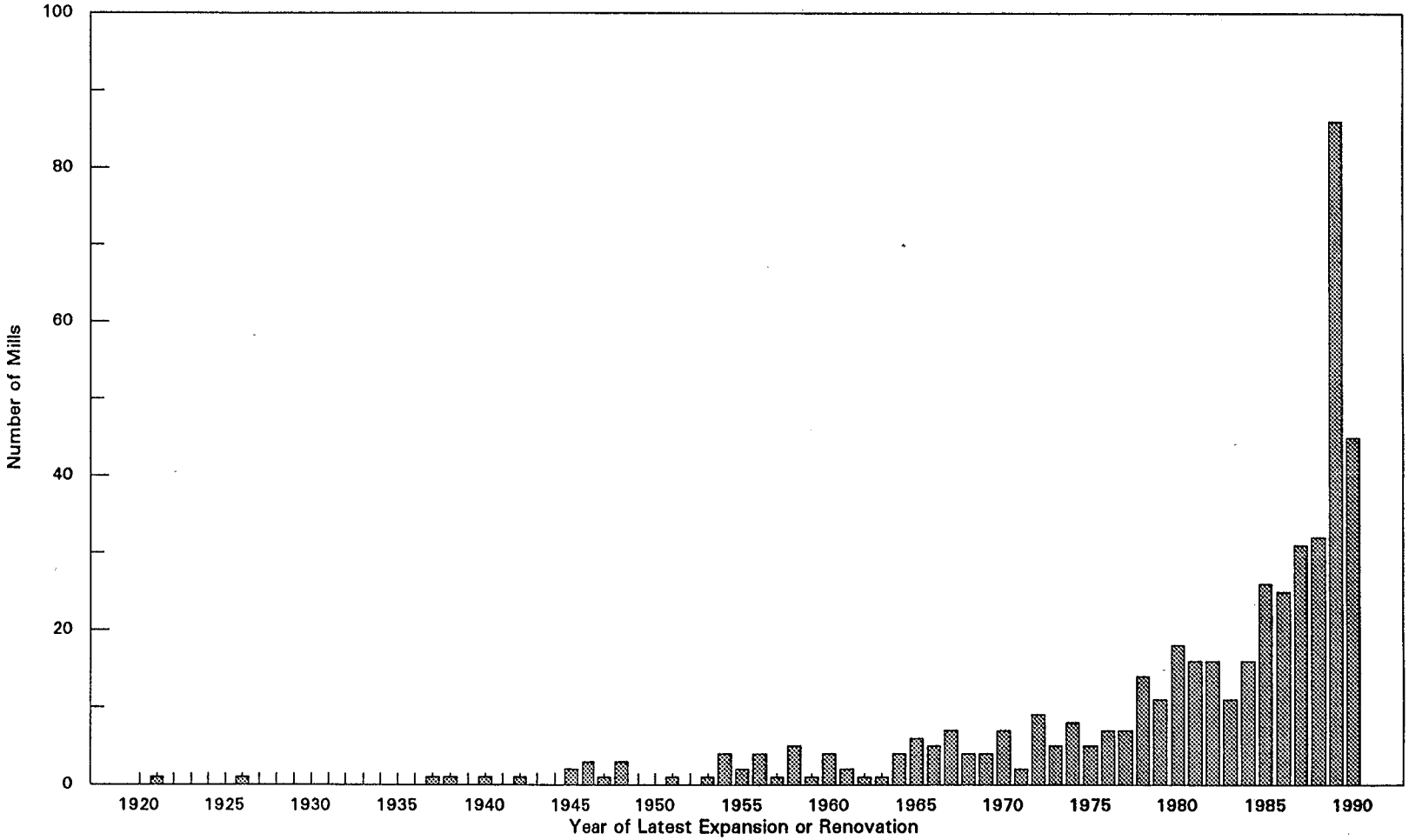

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TABLE 2-26

1989 CAPITAL INVESTMENTS BEFORE AND AFTER DEPRECIATION
EPA SURVEY DATA

Type of Facility Type of Investment	Capital Investment (Thousands of Dollars)
Independent	
Land	$73,559
Buildings	$495,145
Equipment	$5,596,921
Total Capital	$6,165,624
Depreciated Value	$3,934,781
Multi-facility	
Land	$713,870
Buildings	$5,072,318
Equipment	$55,739,993
Total Capital	$61,526,181
Depreciated Value	$37,765,386
Industry	
Land	$787,429
Buildings	$5,567,463
Equipment	$61,336,914
Total Capital	$67,691,805
Depreciated Value	$41,700,167
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TABLE 2-27

EXPENDITURES ON NEW PLANT AND EQUIPMENT, 1980-1990

Year	Expenditures on New Plants and Equipment (Thousands of Dollars)	Expenditures on Environmental Protection (Thousands of Dollars)	Percent of Total
1980	$3,726,000	$368,000	9.88%
1981	$3,957,000	$360,000	9.10%
1982	$3,820,000	$318,000	8.32%
1983	$3,497,000	$327,000	9.35%
1984	$3,713,000	$226,000	6.09%
1985	$4,290,000	$342,000	7.97%
1986	$4,038,000	$237,000	5.87%
1987	$3,764,000	$403,000	10.71%
1988	$5,126,000	$572,000	11.16%
1989	$7,587,000	$1,039,000	13.69%
1990	$8,307,000	$1,292,000	15.55%

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Source: AFPA, 1992b (Tables XXVI and XXVIIA).

2.4.5 Level of Integration

A facility that both produces pulp and uses it to manufacture paper and/or paperboard products is considered an integrated mill. Information in the survey's technical part must be distinguished from that in the financial part. Only products that are sold appear in the survey's financial portion. If a facility manufactures pulp, but consumes it all in the manufacture of paper, that facility will appear as a integrated facility in the technical portion but not in the financial portion of the survey. If that facility sells some of its pulp in addition to its paper products, it would appear as an integrated facility in both the technical and financial portions of the survey.

Production data in the technical portion of the survey indicate that in 1989, 28 mills produced only market pulp, 303 produced only paper or paperboard products, and 235 were integrated facilities. Table 2-28 presents the data on the number of mills by type of production derived from the financial portion of the survey. In 1989, 209 facilities sold only paper, 177 sold only paperboard, 15 sold molded pulp products, and 11 sold other products such as photographic paper and other specialty items. Some of these facilities might be integrated, but data from the survey's financial portion do not identify them. Eighteen facilities sold only pulp. It is highly unlikely that any of these facilities are integrated. There were 61 facilities—about 12 percent—that are identified as integrated facilities with both pulping and papermaking operations.[8]

Mills that exist to serve other facilities under the same ownership also can be considered integrated with respect to company operations. During the survey period, 333 of 519 mills indicated that they transferred pulp, paper, and/or paperboard to other facilities under the same ownership; for example, a mill might produce pulp to transfer it to papermaking operations at other locations. Depending on the year, between 56 and 60 of the 333 mills indicated that 90 percent or more of their revenues from one product came from such transfers (pulp, paper, or

[8]Only 519 mills had 1989 data for products shipped. While even less data are available for 1985 and 1988, the overall pattern seen in Table 2-22 does not change dramatically for these years.

TABLE 2-28

LEVEL OF PRODUCTION INTEGRATION AT U.S. PULP AND PAPER MILLS

Type of Production	Number of Mills
Pulp, paper, and paperboard	15
Pulp and paperboard	6
Pulp and paper	40
Pulp	18
Paperboard and other	1
Paperboard	177
Paper and paperboard	24
Paper and other	3
Paper	209
Other	11
Molded Pulp	15
Total	519
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paperboard). Between 46 and 51 mills reported that over 90 percent of all pulp, paper, and paperboard revenues were from transfers to other facilities under the same ownership (Table 2-29). These mills are considered captive (i.e., they exist to serve other parts of the organization). The majority of the transfers are done at cost.

This information affects the baseline closure analysis. Captive mills will appear to earn little or no revenues in the survey's financial portion. If captive mills have any salvage value, they could be deemed as closures in the economic analysis (i.e., the salvage value exceeds the expected stream of earnings, see Section 3.2) even before the addition of incremental pollution control costs. Because of this phenomenon, the closure analysis should remove this type of baseline closure from consideration when evaluating the impacts of the regulatory options.

2.4.6 Length of Ownership

An idea of the relative length of ownership can be obtained by examining the number of mills without available 1985 or 1988 facility-level data. When a mill changes hands, frequently the process and production information is available for the technical portion of the questionnaire, but the financial data are not. Four mills either started operations or changed ownership between 1989 and 1990 when the survey was performed, and one mill had only one month of data by the end of 1989. Starting with the 516 mills that could provide 1989 asset data at the facility level (Table 2-23), 2 percent could not provide 1988 data and 13 percent could not provide 1985 data. In other words, although companies might have been in existence and the facilities have been in operation for many years, the precise composition of ownership (i.e., which mills are owned by which companies) can change frequently. A value of the EPA survey is that it provides a snapshot of the industry at a certain point. From this baseline snapshot, the potential impacts of additional pollution controls are evaluated. If such a snapshot did not exist, separating regulation-related impacts from natural industry fluctuations might be very difficult to impossible.

TABLE 2-29

CAPTIVE MILLS, 1985, 1988, and 1989

	Number of Captive Mills		
Transfer Price	1985	1988	1989
Market	12	13	13
Manufacturing Cost	26	27	27
Other	8	10	11
Total Number of Captiv	46	50	51

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2.5 SUBCATEGORIES

For the purpose of establishing effluent limitations guidelines and national emission standards for hazardous air pollutants (NESHAP) maximum achievable control technology (MACT), an industry might be subcategorized based on manufacturing process and/or other distinguishing characteristics. For the guidelines, the pulp, paper, and paperboard industry is divided into 12 subcategories (see Development Document for details). The subcategories are listed in Table 2-30. The table's right portion summarizes the pollution control requirements applicable to each subcategory (e.g., all subcategories are subject to best practicable control technology currently available (BPT) requirements, while only six subcategories are subject to revised best available technology economically achievable (BAT)/pretreatment standards for existing sources (PSES) requirements.

The middle columns of the table list the number of mills in each subcategory and the number of mills that appear only in that subcategory. For example, a mill with 70-percent bleached kraft fiber and 30-percent deink secondary fiber would be counted in each of those subcategories. No total is given at the bottom of the column due to this overlap. A "pure" mill has all (100 percent) of its production in a given subcategory; this count is given in the right-hand column. According to Table 2-30, more than half the mills have production in more than one subcategory. There are about 281 pure mills that produce in only one subcategory, 168 of which are in the non-deink secondary category.

Costs of incremental pollution control were determined for individual mills. The required additions and upgrades are based on the current mix of production and processes.

2.6 COMPANY-LEVEL INFORMATION

2.6.1 Number of Companies

The financial portion of the survey identifies approximately 200 to 225 companies engaged in the manufacture of pulp, paper, and paperboard in the United States. The number

TABLE 2-30

SUBCATEGORIES AND REGULATORY COVERAGE

Effluent Subcategory	Number of Mills in this Subcategory	Number of Mills with Production only in this Subcategory	Clean Air Act MACT	Clean Water Act		
				BAT & PSES	BPT/ BCT	BMP
Dissolving Kraft	3	3	X	X	X	X
Bleached Papergrade Kraft and Soda	88	28	X	X	X	X
Unbleached Kraft	58	6	X	X	X	X
Semichemical	21	0	X	X	X	X
Dissolving Sulfite	5	5	X	X	X	X
Papergrade Sulfite	11	0	X	X	X	X
Mechanical Pulp	57	0			X	
Non-wood Chemical	12	4			X	X
Secondary Fiber, Deink	43	20			X	
Secondary Fiber, Non-deink	342	168			X	
Fine and Lightweight Papers from Purchased Pulp	115	19			X	
Tissue, Filter, Nonwoven, and Paperboard from Purchased Pulp	169	28			X	
Number of Mills		281	161	160	325	172

of companies remains in flux, as new companies enter the market and others go out of business or are merged with other entities. Table 2-31 lists the companies in the industry from the survey data; most of these mills are included in the financial and market models.

2.6.2 Number of Facilities by Company

Table 2-32 summarizes the number of mills owned by the business entities. Most companies own only one facility. About a third of the companies own between 2 and 10 facilities. The largest number of facilities owned by a single company is 30. Only about 5 percent of the companies own more than 10 facilities, but they account for nearly 40 percent of employment.

2.6.3 Types of Company Ownership

Approximately 28 percent of the companies are publicly owned, 64 percent are privately owned, and the remainder have an unusual corporate structure. Without the survey, then, EPA could not have analyzed nearly three-quarters of the affected firms. The 8 percent that responded "other" when asked how stock was distributed included partnerships, wholly-owned subsidiaries, joint ownership, and foreign ownership with no stock holdings. There are 55 independent facilities that have no other facilities under the same ownership and no other components in the corporate hierarchy. In other words, of the 126 firms that own one facility, 71 either have other facilities, or are owned by another entity. S corporations can be identified only if the financial information submitted with the survey includes this information. The income from an S corporation would be taxed at the rate for the individual to whom the income is distributed. Less than five S corporations have been identified in the survey.

TABLE 2-31
LIST OF BUSINESS ENTITIES IN SURVEY

A. GUSMER, INC.
AHLSTROM FILTRATION, INC.
ALABAMA RIVER PULP CO.
ALASKA PULP CORPORATION
ALPHA CELLULOSE CORPORATION
AMERICAN FIBRIT, INC.
AMERICAN PAPER PRODUCTS CO.
APPLETON PAPERS, INC.
ASHUELOT PAPER CO.
ATLAS PAPER MILLS
ATLAS ROOFING CORP.
AUGUSTA NEWSPRINT COMPANY
BADGER PAPER MILLS, INC.
BANNER FIBREBOARD CO.
BEAR ISLAND PAPER CO., L.P.
BELOIT BOX BOARD CO.
BLANDIN PAPER COMPANY
BOISE CASCADE CORPORATION AND SUBSIDIARIES
BOWATER INCORPORATED
BRANDYWINE PAPERBOARD MILLS, INC.
BURROWS PAPER CORPORATION
CARAUSTAR INDUSTRIES, INC.
CASCADES, INC.
CELOTEX CORP.
CERTAINTEED CORPORATION
CHAMPION INTERNATIONAL CORPORATION
CHENEY PULP & PAPER CO.
CHESAPEAKE CORPORATION
CHESAPEAKE PAPERBOARD CO.
CLEANERS HANGER COMPANY
CLIMAX MANUFACTURING COMPANY
COLLINS & AIKMAN CORP.
CONNELLY PAPER MILL
CONSOLIDATED PACKAGING CORP.
CONSOLIDATED PAPERS, INC.
CORNWALL PAPER MILLS
CORRUGATED SERVICES, INC.
COTTRELL PAPER CO., INC.
COY PAPER CO.
CPM, INC.
CRANE & CO., INC.
CROCKER TECHNICAL PAPERS, INC.
DAISHOWA AMERICA - PORT ANGELES MILL
DILLARD INVESTMENT/HALLTOWN PAPERBOARD
DOMTAR GYPSUM, INC.
DUPONT SPECIALTY IMAGING MEDIA, INC.
E. B. EDDY PAPER, INC.
EASTERN FINE PAPER, INC.
EASTMAN KODAK COMPANY
EHV-WEIDMANN INDUSTRIES, INC.
EKCO GROUP
EQUITABLE BAG COMPANY, INC.
ERVING PAPER MILLS
ESLEECK MANUFACTURING CO., INC.
FAIRFIELD PAPER CO.
FEDERAL PAPER BOARD COMPANY, INC.
FIBRE FORM CORPORATION
FINCH PRUYN & CO., INC.
FLETCHER PAPER CO.
FLOWER CITY TISSUE MILLS CO.
FONTANA PAPER MILLS, INC.
FORT HOWARD CORPORATION
FORT ORANGE PAPER CO., INC.
FOX RIVER PAPER COMPANY
FRASER PAPER LTD.
FRENCH PAPER COMPANY
FSC PAPER CO.
G. E. ROBERTSON CO.
G.S. ROOFING PRODUCTS COMPANY, INC.
GAF BUILDING MATERIALS CORP.
GARDEN STATE PAPER CO.
GAYLORD CONTAINER CORPORATION
GEO. A. WHITING PAPER CO.
GEORGIA - PACIFIC CORPORATION
GEORGIA BONDED FIBERS, INC.
GILMAN PAPER COMPANY
GLOBE BUILDING MATERIALS, INC.
GOLD BOND BUILDING PRODUCTS, DIVISION OF NATIONAL GYPSUM CO.
GRAYS HARBOR PAPER CO.
GREEN BAY PACKAGING, INC.
GREIF BOARD CORPORATION
GROVETON PAPER BOARD, INC.
GULF STATES PAPER CORPORATION
HALIFAX PAPERBOARD CO., INC.
HENNEPIN PAPER CO.
HENRY MOLDED PRODUCTS, INC.
HOLLINGSWORTH & VOSE CO.
HOMASOTE CO.
HOWARD PAPER GROUP LIMITED
INLAND CONTAINER CORPORATION
INLAND EMPIRE PAPER COMPANY
INTERNATIONAL PAPER COMPANY
INTERSTATE RESOURCES, INC.
ITT RAYONIER, INC.
IVEX PACKAGING CORPORATION
JAMES RIVER CORPORATION
JEFFERSON SMURFIT CORPORATION
KAPACO GROUP
KEYES FIBRE COMPANY
KIEFFER PAPER MILLS, INC.
KIMBERLY-CLARK CORPORATION
KNOWLTON SPECIALTY PAPERS, INC.
LAKE SUPERIOR FOREST PRODUCTS, INC.
LAUREL HILL PAPER COMPANY
LEATHERBACK INDUSTRIES
LINCOLN PULP & PAPER CO., INC.
LITTLE RAPIDS CORPORATION

TABLE 2-31 (Continued)
LIST OF BUSINESS ENTITIES IN SURVEY

LONGVIEW FIBRE CO.
LOS ANGELES PAPER BOX & BOARD MILLS
LOUISIANA-PACIFIC CORPORATION
LUNDAY-THAGARD CO.
LYDALL, INC.
LYONS FALLS PULP & PAPER, INC.
M H DIELECTRICS, INC.
MACMILLAN BLOEDEL, INC.
MACON KRAFT, INC.
MADISON PAPER INDUSTRIES
MANCHESTER BOARD AND PAPER CO., INC.
MANISTIQUE PAPERS, INC.
MANVILLE FOREST PRODUCTS CORPORATION
MARCAL PAPER MILLS, INC.
MARTISCO PAPER CO., INC.
MCINTYRE PAPER CO., INC.
MD VALENTINE PAPER CO.
MEAD CORPORATION
MENASHA CORPORATION
MENOMINEE PAPER CO., INC.
MERRIMAC PAPER CO., INC.
MICHIGAN PAPERBOARD
MIDTEC PAPER CORPORATION
MIDWEST FOLDING CARTON, INC.
MILLEN INDUSTRIES, INC.
MOHAWK PAPER MILLS, INC.
MONADNOCK PAPER MILLS, INC.
MOSINEE PAPER CORPORATION
NEWARK GROUP INDUSTRIES, INC.
NEWMAN AND COMPANY, INC.
NEWSPRINT SOUTH, INC.
NORFOLK PAPER CO.
NVF COMPANY
OHIO PULP MILLS, INC.
ORCHIDS PAPER PRODUCTS COMPANY
P. H. GLATFELTER COMPANY
PACKAGING CORPORATION OF AMERICA
PAPCO PAPER CO.
PAPER SERVICE LTD.
PAPER-PAK PRODUCTS, INC.
PAPERBOARD INDUSTRIES, INC.
PAPERTECH CORPORATION
PAPYRUS NEWTON FALLS, INC.
PATRIOT PAPER CORPORATION
PENACOOK FIBRE CO.
PENNTECH PAPERS, INC.
PENTAIR, INC.
PERKIT FOLDING BOX CORPORATION
PONDEROSA FIBRES OF AMERICA, INC.
POPE & TALBOT, INC.
PORT TOWNSEND PAPER CORPORATION
POTLATCH CORPORATION
PROCTER & GAMBLE
PUTNEY PAPER CO.
PWA ROLAND DECOR, INC.
QUAKER OATS CO.
QUIN-T CORPORATION
RAND-WHITNEY PAPER BOARD CORP.
RED HOOK PAPER, INC.
REPROCELL CO.
REPUBLIC PAPERBOARD COMPANY
RIVERSIDE PAPER CORPORATION
ROCK-TENN COMPANY
ROGERS CORPORATION
SCHOELLER TECHNICAL PAPERS, INC.
SCOTT PAPER COMPANY
SEALED AIR CORPORATION
SEAMAN PAPER CO. OF MASSACHUSETTS
SHRYOCK BROTHERS/REBAR PAPER CORP.
SIERRA TISSUE, INC.
SIMKINS INDUSTRIES, INC.
SIMPLEX PRODUCTS DIVISION
SIMPLICITY PATTERN CO., INC.
SIMPSON PAPER COMPANY
SMURFIT PACKAGING CORP.
SONOCO PRODUCTS COMPANY
SOUTHEAST PAPER MFG. CO.
SOUTHWORTH PAPER CO.
SPAULDING COMPOSITES CO., INC.
SPECIALTY PAPER MILLS, INC.
SPECIALTY PAPERBOARD, INC.
ST. JOE FOREST PRODUCTS COMPANY
STATLER INDUSTRIES, INC.
STEVENS & THOMPSON PAPER CO., INC.
STONE CONTAINER CORPORATION
TAGSONS PAPERS, INC.
TALLMAN CONDUIT CO.
TAMKO ASPHALT PRODUCTS, INC.
TEMPLE-INLAND FOREST PRODUCTS CORP.
THE CRYSTAL TISSUE CO.
THE DAVEY COMPANY
THE DEXTER CORPORATION
THE WESTON PAPER AND MFG. CO.
U.S. PACKAGING, INC.
U.S. PAPER MILLS CORPORATION
UNION CAMP CORPORATION
UNITED STATES GYPSUM COMPANY
USM CORPORATION-TEXON DIVISION
VIRGINIA FIBRE CORP.
W. R. GRACE & CO. - CONN. POLYFIBRON DIVISION
WALDORF CORPORATION
WAUSAU PAPER MILLS, INC.
WESTVACO CORPORATION
WEYERHAEUSER COMPANY
WHITE PIGEON PAPER COMPANY
WILLAMETTE INDUSTRIES, INC.
WINDSOR-STEVENS, INC.
YORKTOWNE PAPER MILLS, INC.

TABLE 2-32

NUMBER OF MILLS OWNED BY EACH BUSINESS ENTITY

	Number of Companies	Percentage of Companies	Number of Employees	Percentage of Employees
One Mill	126	63.3%	32,036	14.5%
2 to 5 Mills	52	26.1%	57,657	26.1%
6 to 10 Mills	12	6.0%	47,373	21.5%
More than 10 Mills	9	4.5%	83,425	37.8%
All Companies	199	100.0%	220,491	100.0%

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2.6.4 Concentration Ratios

There are approximately 200 business entities in the pulp, paper, and paperboard industry. Most of these are single-facility companies; only 5 percent have more than 10 facilities (see Section 2.6.2). One method of examining the extent an industry is concentrated in a few companies is to examine the ratio of production for the top five or ten firms to industry-wide production. EPA examined the concentration ratios for four selected products. Table 2-33 shows the data for the concentration ratios for bleached sulfate pulp, which accounts for nearly 80 percent of domestic market pulp shipments for 1989 (see Table 2-3). The top five producers account for 45 percent of all shipments. The next five producers only account for an additional 24 percent of shipments.

Table 2-34 examines the concentration ratios for three major paper products: newsprint, clay-coated and converting paper, and uncoated free sheet. These three products account for 64 percent of all 1989 paper shipments (see Table 2-9). The top five companies account for between 46 to 58 percent of all shipments for each product. The second five companies account for between 24 to 28 percent of shipments.

Table 2-35 examines the production for unbleached kraft packaging and industrial converting paperboard—a product that accounts for nearly half of all paperboard production in 1989. The same pattern is seen for this industry segment; the top five firms produce nearly half of all domestic production and another 25 percent is produced by the next five firms.

Georgia-Pacific and International Paper are the firms that appear most frequently in the lists of the top five producers (three of five products). The data for Georgia-Pacific reflect the takeover of Great Northern Nekoosa that occurred shortly after the close of the survey period. There are other firms that appear several times on Tables 2-33 through 2-35 and some that appear only once. The picture begins to form of an industry with a small number of large firms that control substantial portions of major commodities and numerous small firms in specialized niches.

TABLE 2-33

CONCENTRATION RATIOS FOR MARKET PULP

Product	Off-Machine Tons (1989)	Cumulative Percent
Bleached Sulfate Pulp		
GEORGIA - PACIFIC CORPORATION INTERNATIONAL PAPER COMPANY SCOTT PAPER COMPANY P & G (PROCTER & GAMBLE CELLULOSE) FEDERAL PAPER BOARD COMPANY, INC.		
Top 5 Companies	4,352,549	45.14%
WEYERHAEUSER COMPANY CHAMPION INTERNATIONAL CORPORATION JAMES RIVER CORPORATION BOISE CASCADE CORP. AND SUBSIDIARIES ALABAMA RIVER PULP CO.		
Top 10 Companies	6,613,499	68.59%
Total Tons Shipped (All Companies)	9,641,598	100.00%
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TABLE 2-34

CONCENTRATION RATIOS FOR PAPER

Product	Off-Machine Tons (1989)	Cumulative Percent
Newsprint		
BOWATER INCORPORATED CHAMPION INTERNATIONAL CORPORATION JEFFERSON SMURFIT CORPORATION BOISE CASCADE CORP. AND SUBSIDIARIES WEYERHAEUSER COMPANY		
Top 5 Companies	3,483,226	58.23%
AUGUSTA NEWSPRINT COMPANY GEORGIA - PACIFIC CORPORATION KIMBERLY - CLARK CORPORATION STONE CONTAINER CORPORATION SOUTHEAST PAPER MFG. CO.		
Top 10 Companies	5,120,043	85.59%
Total Tons Shipped (All Companies)	5,982,294	100.00%
Clay Coated Printing and Converted Paper		
CONSOLIDATED PAPERS, INC. SCOTT PAPER COMPANY CHAMPION INTERNATIONAL CORPORATION MEAD CORPORATION BOWATER INCORPORATED		
Top 5 Companies	3,710,994	45.77%
INTERNATIONAL PAPER COMPANY JAMES RIVER CORPORATION WESTVACO CORPORATION BOISE CASCADE CORP. AND SUBSIDIARIES MIDTEC PAPER CORPORATION		
Top 10 Companies	5,995,405	73.94%
Total Tons Shipped (All Companies)	8,107,976	100.00%
Uncoated Free Sheet		
INTERNATIONAL PAPER COMPANY GEORGIA - PACIFIC CORPORATION CHAMPION INTERNATIONAL CORPORATION BOISE CASCADE CORP. AND SUBSIDIARIES UNION CAMP CORPORATION		
Top 5 Companies	5,775,492	54.76%
JAMES RIVER CORPORATION WEYERHAEUSER COMPANY MEAD CORPORATION P. H. GLATFELTER COMPANY SIMPSON PAPER COMPANY		
Top 10 Companies	8,276,367	78.47%
Total Tons Shipped (All Companies)	10,547,085	100.00%

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TABLE 2-35

CONCENTRATION RATIOS FOR PAPERBOARD

Product	Off-Machine Tons (1989)	Cumulative Percent
Unbleached Kraft Packaging and Industrial Converting Paperboard		
STONE CONTAINER CORPORATION GEORGIA - PACIFIC CORPORATION INTERNATIONAL PAPER COMPANY WEYERHAEUSER COMPANY UNION CAMP CORPORATION		
Top 5 Companies	9,366,049	49.80%
JEFFERSON SMURFIT CORPORATION INLAND CONTAINER CORPORATION WESTVACO CORPORATION WILLAMETTE INDUSTRIES, INC. PACKAGING CORPORATION OF AMERICA		
Top 10 Companies	14,053,170	74.72%
Total Tons Shipped (All Companies)	18,807,504	100.00%
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The high level of concentration and specialization is echoed in Census data which calculates coverage and specialization ratios. A coverage ratio represents the ratio of primary products shipped by the facilities in the industry to the total quantity of these products shipped by all manufacturing establishments wherever classified. A specialization ratio represents the ratio of primary product shipments to total product shipments for the establishment classified in the industry. These ratios are calculated on the basis of pulp, paper, and paperboard production by establishment, while the concentration ratio examines individual product groups by company. In the 1987 Census data, both the specialization and coverage ratios were about 87 and 69 percent, respectively, for pulp mills, 91 and 96 percent for paper mills, and 91 and 90 percent for paperboard mills (DOC, 1990). Loosely interpreted, these ratios indicate that paper and paperboard tend to be made only at paper and paperboard mills, respectively, and that is all the establishments make. In contrast, pulp mills tend to make only pulp, but a larger proportion of pulp is manufactured at establishments not classified as pulp mills.

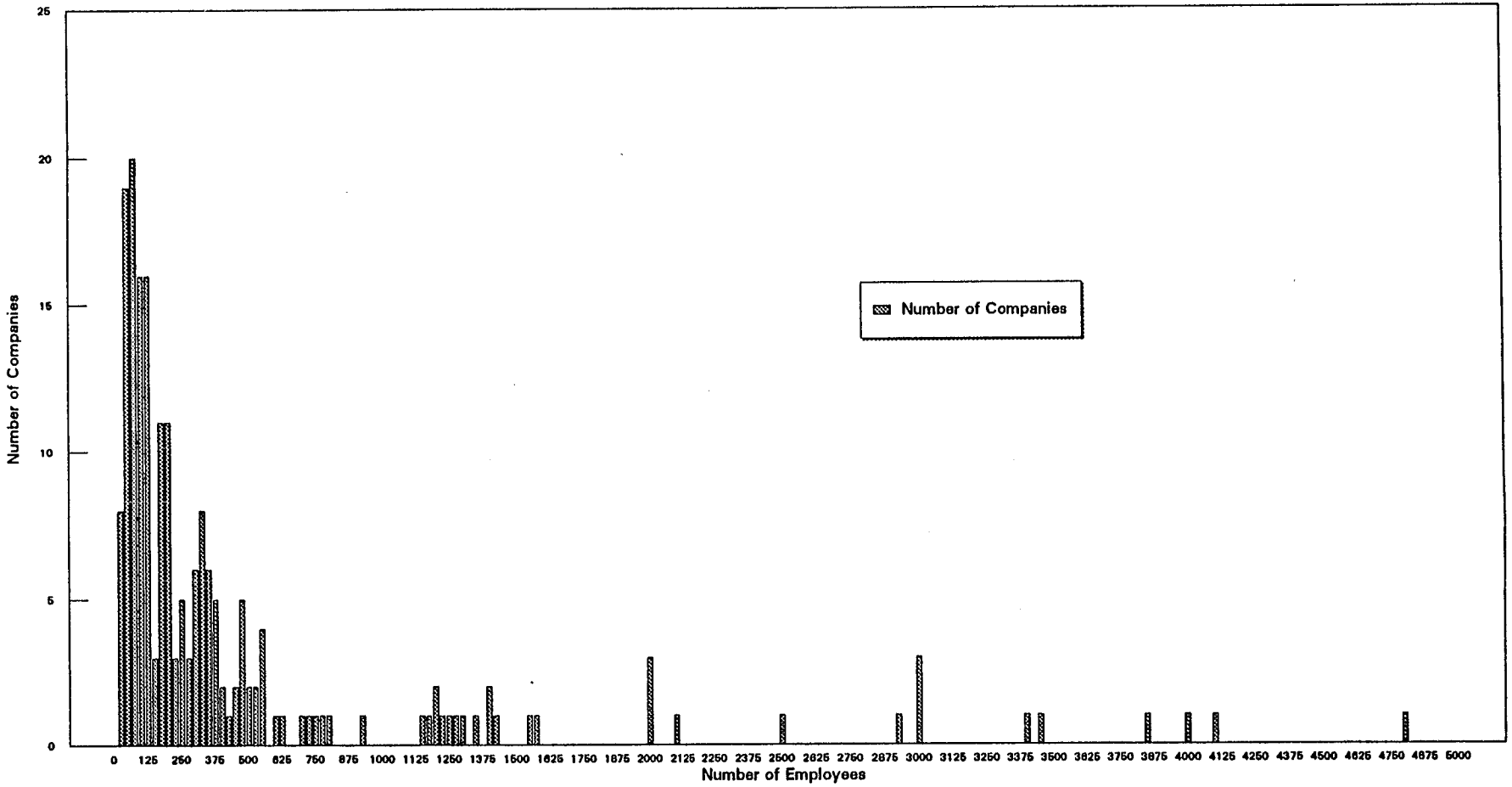
2.6.5 Employment

In 1989 the pulp, paper, and paperboard manufacturing industry included approximately 220,000 production and nonproduction employees. Section 2.4.2 provides details on the number of employees per facility and how the survey value compares with Census and AFPA data. This total number is approximately one-third of all employees associated with the paper and allied products industry (SIC 26) (DOC, 1991). Of the estimated 90.5 million people employed in the private sector in the United States during the 1989, paper and allied products account for nearly 1 percent, at 697,000 people (DOL, 1992). Furthermore, the paper and allied products industry accounts for 4 percent of U.S. manufacturing jobs.

Employment by company is available from a combination of survey data and data published by American Business Institute (ABI, 1993). Total employment for companies involved in pulp, paper, or paperboard production (listed in Section 2.6.1) is over 650,000. Figure 2-15 is a histogram showing the number of companies by number of employees. The figure indicates that the majority of companies involved in pulp, paper, or paperboard production

FIGURE 2-15

HISTOGRAM OF EMPLOYMENT BY COMPANY



There are 20 companies with 5,000 to 20,600 employees.

employ fewer than 700 employees, although several large conglomerates employ more than 10,000 people. The largest, Proctor and Gamble, employs nearly 95,000 company-wide.

2.6.6 Observations

The companies in the U.S. pulp, paper, and paperboard manufacturing industry are not easy to characterize. Some companies also have operations in other related industries, such as forest products (e.g., Georgia-Pacific and St. Joe Forest Products). For other companies, papermaking is but one of several industries (e.g., Quaker Oats, Eastman Kodak, E.I. du Pont de Nemours & Co., and Sonoco Products Company). While a few business entities own or control more than 10 facilities, the majority are single-facility operations. There is a small number of foreign corporate parents in the survey, but identifying them illustrates the complexity of some corporate hierarchies. For example, in the data base, a company lists itself as the corporate parent for other companies in addition to facilities under its own name. The responses to survey questions that ask for the business entity and the corporate parent do not identify the corporate parent as an indirect wholly owned subsidiary of a European company; that information is contained in the 10K forms submitted with the survey. Foreign corporate parents with U.S. facilities—identifiable in the survey—include: Compagnie de Saint Gobain, Daishowa America Co. Ltd., Deutsche Fibrit Gesellschaft, Jefferson Smurfit Corporation, and Noranda Forest, Inc. In two cases, a joint corporate parent controls the business entity.

The industry is marked by the diversity of its companies, which in turn reflects the variation in products—ranging from large-volume common commodities (such as tissue) to specialized products (such as paper used in printing money).

2.7 FINANCIAL PATTERNS FOR THE INDUSTRY

The value of shipments, which is the best estimate of pulp, paper, and paperboard manufacturing revenues, grew from $37 billion to $59 billion from 1985 to 1989 (see Section 2.3).

Revenue and profit data are reported by AFPA (1992b), but these relate to paper and allied products. As seen in the employee data in Section 2.6, this category includes much more than the industry studied in this analysis. The value of exported products also increased from $2.4 billion to $6 billion during the 1985 to 1989 period. According to *Fortune* magazine, a leading U.S. business journal, the pulp and paper industry is one of the few domestic industries capable of competing well in an international market (Kupfer, 1992).

The discount rate is an estimate of the pulp facilities' average cost of capital. In the data base, respondents provided discount rates of 1 percent to 50 percent. In addition, nearly one in five facilities said they did not use a discount rate when evaluating capital investments. Another eight mills gave a discount rate of zero, ostensibly because they do not borrow money. These facilities are assigned the average discount rate to represent the cost of having to raise the money through a loan or from diverting the cash from a revenue-producing project (opportunity cost). In the cost annualization model (described in Section 3.1), discount rates less than 5 percent or greater than 19 percent are replaced with the average discount rate. A rate below 5 percent is suspiciously low given that banks in 1989 charged a prime rate of nearly 11 percent, and the discount rate at the Federal Reserve Bank of New York was nearly 7 percent (CEA, 1993). A rate above 19 percent is more likely to be a "hurdle" rate—the rate of return desired in a project before it will be undertaken. About 7 percent of the responses that provided a discount rate fell into the "unacceptable" range (37 mills). For the remaining questionnaires, the average discount rate was 13 percent.

Based on survey data, predictions can be made about the financial health of the facilities and companies potentially affected by the regulation. Financial ratios derived from facility and company income statements and balance sheets provide insight into the industry's financial health and how it changes through time. Ratios, depending on how they are calculated, can be used to evaluate profitability, leverage, and liquidity. Section 3.1.3 describes the ratios used in the analysis. After the ratios are calculated for each facility and/or business entity, the average and median values are calculated. Table 2-36 shows the facility-level ratio analysis for 1985, 1988, and 1989. Both the median and mean value are presented because of the variability in the ratios; median values are much less affected by outliers. The median 1985 gross income margin and return on assets values indicate how poor a year it was; these ratios are almost half the values for 1989. The current ratio, on the other hand, remains above 1.0 for all 3 years,

TABLE 2-36

BASELINE FACILITY-LEVEL RATIO ANALYSIS
ALL MILLS

Ratio	Baseline Parameter 1985	1988	1989	Percent Variation
Gross Income Margin:				
Mean:	2.1%	1.8%	0.3%	87.9%
Median:	5.7%	11.6%	12.3%	53.2%
Return on Assets:				
Mean:	17.0%	31.0%	32.3%	47.6%
Median:	9.5%	17.3%	17.5%	45.9%
Current Ratio:				
Mean:	3.16	2.72	3.26	16.4%
Median:	1.85	1.84	1.81	1.7%
Net Working Capital:				
Mean ($000):	$5,275	$5,948	$5,392	11.3%
Median ($000):	$2,211	$2,778	$2,284	20.4%
Net WC/ Total Assets:				
Mean:	16.4%	12.0%	10.3%	37.2%
Median:	11.0%	9.8%	8.8%	20.5%

Notes: This table includes independent, single-facility, and multi-facility entities. There are 523 mills in the analysis.

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indicating that the typical facility had more assets than liabilities. The industry downturn actually started at the end of 1989 (DeKing et al., 1990); most facilities closed out 1989 with lower net working capital than in 1988. This pattern is also seen in the 1989 drop in net working capital/total assets. The percent variation is defined as the ratio of the difference between the maximum and minimum values to the maximum value. The measure provides an estimate of the variation in ratios seen during a business cycle.

Baseline financial ratios for the company or business entity are shown in Table 2-37. As expected, net income margin is smaller than the gross income margin in Table 2-36, but with the same business cycle pattern. The company's return on assets also is smaller because all costs are considered, and it also reflects the business cycle pattern. Current ratio and debt-to-asset ratio stayed very stable during this period, which might indicate that little can be learned from these ratios in the impact analysis. The difference between the mean and median times interest earned (TIE) is striking. Some companies have very small debts on their balance sheets and, therefore, very high TIE ratios, which skew the average up and away from the median. A similar phenomenon occurs with the net working capital.

Tables 2-36 and 2-37 indicate the cyclical nature of the pulp, paper, and paperboard industry. For this report, the fluctuations in financial ratios due to the business cycle are important to consider when assessing the impact of incremental pollution control costs. For all ratios that do not involve net working capital, impacts will be evaluated on a facility-by-facility basis, and the average and median impact will be reported (i.e., the mean change). In contrast, the incremental impacts for net working capital and net working capital/total assets were measured on a population basis (i.e., the change in the mean), because some mills have negative net working capital. Further reductions appear as positive changes and provide misleading results.

2.8 INTERNATIONAL COMPETITIVENESS OF THE PULP AND PAPER INDUSTRY

The 1980s marked a watershed in U.S. economic activity. The global dominance the U.S. industrial sector had enjoyed since the end of World War II was eroding quickly in the face of

TABLE 2-37

BASELINE BUSINESS ENTITY-LEVEL RATIO ANALYSIS
ALL COMPANIES

Ratio	Baseline Parameter 1985	1988	1989	Percent Variation
Net Income Margin:				
Mean:	1.8%	6.2%	4.7%	71.0%
Median:	4.2%	5.3%	5.0%	19.8%
Return on Assets:				
Mean:	4.6%	9.3%	8.0%	50.8%
Median:	5.8%	8.5%	6.5%	31.8%
Current Ratio:				
Mean:	3.55	2.48	2.43	31.6%
Median:	1.90	1.91	1.79	6.0%
Net Working Capital:				
Mean ($000):	$46,172	$70,231	$62,005	34.3%
Median ($000):	$5,584	$7,090	$5,841	21.2%
Net WC/ Total Assets:				
Mean:	20.3%	20.0%	18.2%	10.5%
Median:	18.3%	17.5%	13.2%	28.3%
Debt/Asset Ratio				
Mean:	51.5%	57.2%	58.4%	11.7%
Median:	50.2%	53.2%	54.4%	7.8%
Times Interest Earned:				
Mean:	45.5	34.2	21.1	53.8%
Median:	6.3	8.8	7.1	28.8%

Notes: Includes independent, single-facility, and multi-facility entities.
There are 196 companies in the analysis.

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increased international competition from Europe and Asia. Many businesses found themselves unprepared for a worldwide marketplace. The pulp and paper industry has succeeded in maintaining and enhancing its international performance level throughout this economic transition, as a result of both of the general capital and labor structure of U.S. pulp and paper mills, and of favorable economic conditions. This section reviews the factors contributing to the pulp and paper industry's advantageous position in the global market.

2.8.1 Foreign Trade Statistics

According to the *U.S. Industrial Outlook: 1993*, published by the U.S. Department of Commerce International Trade Administration, the trade deficit for the pulp and paper industry has been declining continuously over the past several years (ITA, 1993). In 1991, the trade deficit measured $1.1 billion; by 1992, the deficit had shrunk to $330 million. By adding to this total the export/import figures for wastepaper trade, the 1992 balance changes to a $260-million surplus. The paper and allied products industry witnessed a record high value of exports in 1992, shipping $10.4 billion of pulp, paper, and board products (excluding wastepaper) to U.S. trading partners. Export tonnage in 1992 exceeded 20 million metric tons for the first time in history. Wood pulp exports accounted for about 31 percent of the dollar total; printing and writing papers (including newsprint) brought in another 15 percent of this total, followed by linerboard (11 percent), boxboard (8 percent), and sanitary and all other converted products (almost 30 percent). In 1991, Canada, Japan, Mexico, Germany, and Italy purchased over 50 percent of all U.S. pulp, paper, and board exports (ITA, 1993). In that same year, over three-quarters of the paper imported to the United States came from Canada, which ships a significant, but diminishing, amount of newsprint to this country. Finland, Germany, Japan, and Brazil accounted for another 9 percent of U.S. imports (ITA, 1993).

The *U.S. Industrial Outlook* examines export data for the entire paper and allied products industry, which includes manufacturers investigated in this study, as well as converting mills that export products such as cigarette paper and books (AFPA, 1992b). The pulp, paper, and paperboard mills subject to the rulemaking have experienced equally large increases in exports,

as is shown in Tables 2-5, 2-9, and 2-13. Total exports grew from $2.4 billion in 1985 to nearly $6 billion in 1989. The reasons for this increase are discussed in the following section.

2.8.2 Global Competitiveness of U.S. Paper Industry

According to *Fortune* magazine, this country's forest products industry is one of two major U.S. industries whose dominant position in the world market is "not likely to erode significantly in the 1990s" (Kupfer, 1992). *Fortune* supports its argument with statistics released by the Organization for Economic Cooperation and Development, which indicate that U.S. forest products manufacturers' share of total production among facilities in Japan, Europe, and the United States has risen from 46 percent in 1980 to 49.3 percent in 1989 (Kupfer, 1992; OECD, 1992). The U.S. share of total world pulp and paper production points to similar dominance: in 1991, the United States produced 30 percent of the world's paper and paperboard and 35 percent of the world's wood pulp. U.S. production levels exceed the total pulp and paper output of the next four largest pulp- and paper-producing nations combined—Japan, Canada, Germany, and China (Storat, 1992).

The continuing success of U.S. pulp and paper manufacturers in the global marketplace can be attributed to a series of industry and market factors. First, the United States possesses vast natural reserves of trees and highly developed tree farming practices, resulting in steady and relatively inexpensive fiber sources. More important, however, the pulp and paper industry has managed to maintain a well-trained work force by investing billions of dollars since 1980 to boost productivity and to gain a foothold in new markets with new products (Kupfer, 1992). This high productivity, along with an industry operating rate that exceeds 90 percent, has resulted in low unit labor costs. In addition, by generating 56 percent of its own energy through incineration of manufacturing byproducts, the pulp and paper industry has relatively low energy costs.

On the market side, a favorable foreign currency exchange rate has buoyed U.S. exports of pulp and paper in recent years (ITA, 1993). In addition, several recently concluded trade agreements have improved the export market for U.S. pulp, paper, and board. The U.S.-Canada Free Trade Agreement (FTA), which commenced January 1, 1993, eliminates all paper industry

tariffs between the two signatories. In April 1992, Japan and the United States concurred on measures to help lower barriers to Japan's $27-billion paper market. Moreover, the General Agreement on Trade and Tariffs (GATT) and the North American Free Trade Agreement (NAFTA), if concluded, promise to enhance even further the international preeminence of the U.S. pulp and paper industry (ITA, 1993). At present, the rate of export growth to developing nations is more than double the rate to industrialized nations. Exports have become increasingly important to the paper industry since 1980; exports now account for about 8 percent of total U.S. pulp and paper sales.[9] With an increased focus on global markets among U.S. producers and continued economic growth in developing nations, U.S. pulp and paper exports should continue to increase throughout the 1990s (ITA, 1993).

2.8.3 Environmental Regulations and Considerations

The U.S. pulp and paper industry currently complies with three broad divisions of federal environmental regulations: water pollution, air pollution, and solid and hazardous waste. Each category is discussed below from the perspective of existing regulations, ongoing regulatory development activities, and nonregulatory initiatives that could affect the pulp and paper industry.

2.8.3.1 Water Pollution Control

From 1974 to 1986, EPA promulgated several regulations that establish national effluent limitations for conventional and some toxic water pollutants emitted from pulp and paper mills. These pollutants include BOD_5, TSS, pH, zinc, trichlorophenol (TCP), and pentachlorophenol (PCP). These limitations form the basis for the National Pollutant Discharge Elimination System (NPDES) permits that have been issued for pulp and paper facilities. Under these permits, facilities are required to meet numerical limits on releases of specific pollutants. For PCP, TCP,

[9]Survey data for 1989 indicate exports were 45 percent of market pulp shipments (see Tables 2-4 and 2-5), 2 percent of paper shipments (see Tables 2-10 and 2-11), and nearly 9 percent of paperboard shipments (see Tables 2-16 and 2-17).

and zinc, new source performance standards (NSPS) have also been established. Individual facility permits can reflect more stringent requirements based on state and regional water quality issues and guidance on specific pollutants (e.g., dioxin). Revised effluent limitations are part of the Agency's integrated rulemaking, which is the focus of this report's economic analysis.

2.8.3.2 Air Pollution Control

In 1978, under authority of the Clean Air Act (CAA), EPA promulgated NSPS to limit kraft pulp mills' emissions of particulates and reduced sulfur compounds (e.g., hydrogen sulfide, methyl mercaptan, dimethyl sulfide, and dimethyl disulfide). Revisions to these standards were adopted in 1986. CAA compliance is mandatory for all facilities that began construction or significant modification after September 24, 1976. The CAA rules contain numerical emission limitations and monitoring requirements for particulates and reduced sulfur compounds from specific kraft mill operations, including recovery furnaces, smelt dissolving tanks, digesters, brown stock washing systems, evaporators, and condensate stripper systems.

Under the Clean Air Act Amendments of 1990, EPA will promulgate emission limits for 189 hazardous air pollutants. As discussed in Section One, revised air emission standards are part of the integrated rulemaking for the pulp, paper, and paperboard industry.

2.8.3.3 Solid and Hazardous Waste Control

Solid and hazardous waste regulations affect pulp and paper mills insofar as they govern facility sludge disposal and land application sites. Under the terms of a 1988 consent decree (*EDF/NWF v. Thomas*, D.D.C. No. 85-0973, July 27, 1988), EPA announced in November 1991 that there was insufficient evidence of potential risk to justify regulation under the Resource Conservation and Recovery Act (RCRA) of landfill or surface impoundment disposal of bleached pulp and paper mill sludge. Under a separate consent decree (*EDF v. Reilly*, D.D.C. No. 89-0598), EPA is required to "promulgate a listing determination for sludges from pulp and paper mill effluent on or before the date 24 months after promulgation of an effluent guideline

regulation under the Clean Water Act for pulp and paper mills" (Id. at 10). The decree specifies, however, that a listing determination would not be required if the final rule for the effluent guideline revision is based on "the use of oxygen delignification, ozone bleaching, prenox bleaching, enzymatic bleaching, hydrogen peroxide bleaching, oxygen and peroxide enhanced extraction, or any other technology involving substantially similar reductions in uses of chlorine-containing compounds," (Id. at 10-11). Also in response to the 1988 consent decree, regulatory actions to control land application under the Toxic Substances Control Act (TSCA) were proposed in April 1991 and are still under development (EPA, 1993).

2.8.4 Environmental Regulations Affecting Foreign Competitors

U.S. environmental regulations often are compared with other countries' corresponding rules to gauge potential effects on American international competitiveness. Many pulp and paper industry representatives express concern that stringent effluent limitations could put U.S. firms at a disadvantage internationally because of increased costs of compliance. The environmental regulations faced by Canadian and some European manufacturers are examined below.

2.8.4.1 Canadian Regulations

The pulp and paper industry is the single, largest discharger of wastewater in Canada (Sjöblom, 1990). Canadian pulp and paper mills have confronted many of the same environmental issues U.S. mills face today. Canada's national environmental regulatory bodies have revised regulations governing BOD, TSS, acute toxicity, and environmental effects monitoring. These effluent regulations, which took effect on July 1, 1992, established the following guidelines: a monthly average per-facility BOD effluent limit of 7.5 kg/ton; a monthly average per-facility TSS limit of 11.25 kg/ton; stricter toxicity tests on local fish populations; and increased reporting and surveying of waterways. The Canadian government also forbids the sale and use of wood chips from wood treated with PCP in mills using chlorine and/or chlorine dioxide. In other regulatory activity, mills using a chlorine bleaching process are prohibited from

releasing final effluent that contains any measurable concentration of dioxin or furan. Canadian provinces have established chlorinated organics (adsorbable organic halides, or AOX) limits for pulp and paper mills which vary in stringency. In Quebec, for example, existing softwood pulp mills must comply with a 2.5 kg/ton AOX limit, while new softwood mills must release no more than 1.5 kg/ton. In Alberta, limits vary from mill to mill, but range from 0.3 kg/ton to 1.5 kg/ton (Pryke, 1992). In Ontario, a goal of 0.0 kg/ton AOX has been set for December 2002, with intermediate goals from 1.5 to 0.8 kg/ton (Bodien, 1993).

Atmospheric emission regulations have been promulgated by Canada's provinces for sulfur dioxide (SO_2), particulates, and total reduced sulfur (TRS), which includes a variety of sulfur-based emissions that cause odors. Canadian mills may not emit more than 200 to 300 parts per million (ppm) of SO_2, 5 to 70 ppm of TRS, and 3 to 10.5 kg/ton of particulates depending on the province and, in some cases, the age of the mill (Sjöblom, 1990).

2.8.4.2 European Regulations

Until 1989, regulatory issues were the driving force behind the development of more environmentally sound pulp and paper products and processes in Europe. In recent years, however, market forces have been the main source of pressure for manufacturers to improve the environmental performance of pulp and paper processes. Influenced by environmental groups, consumers—especially in Germany, Austria, and Switzerland—increasingly prefer products that contain recycled fibers and chemical pulps bleached with minimal quantities of chlorine chemicals. Pulp and paper manufacturers throughout the European Community and Scandinavia have responded quickly to meet changing demands (Malinen, 1992).

In many European countries, recycled fiber in products is becoming accepted and even required, and for many consumers, environmental friendliness overrides concerns about brightness. Demand for both ECF and TCF pulp products is increasing in Europe. Sulfite pulping of softwood predominates in Europe (OECD, 1992). A common nonchlorine pulping process in Scandinavia involves (1) achieving low lignin levels through improved cooking techniques, (2) oxygen delignification, (3) efficient washing to remove dissolved and suspended

organics and other impurities, (4) ozone delignification, and (5) peroxide bleaching (Malinen, 1992). In addition, the sulfite pulp process, which does not require chlorine bleaching to achieve brightness, dominates pulp production in Europe.

Table 2-38 summaries various AOX regulations for the pulp, paper, and paperboard industry. Salzhammergut in Austria and the Canadian province of Ontario have the strictest requirements—0.0 kg/ton AOX. The Austrian limit is currently in effect while the Ontario limit must be attained by the end of 2002. Several of the European countries vary the limits by the type of wood pulped (hardwood or softwood) or the pulping process (kraft or sulfite).

TABLE 2-38

JURISDICTIONS REGULATING AOX AS A WASTEWATER POLLUTANT (AS OF APRIL 1993)

AUSTRALIA	Australia issued guidelines in 1989 for new bleached eucalypt kraft pulp mills discharging to marine waters. These guidelines stipulate the following limitations on the discharge of AOX: — Maximum 24 hour average (based on rated production capacity): 2.5 kg/t[1] — Maximum 1 year moving average (based on actual production): 1.0 kg/t
CANADA	No Federal regulations for AOX, however, several provinces have regulated AOX as follows:
Alberta	Has no AOX regulations, however, all existing and new bleached kraft mills have AOX limitations in their licenses. These limitations range from 0.29 kg/t (annual average) for a new facility to 1.5 kg/t (monthly average) for existing facilities.
British Columbia	1.5 kg/t (monthly average) by 31 December 1995, and 0.8 kg/t by 31 December 2002, or 0.0 kg/t by 31 December 2000.[2]
Ontario[3]	1.5 kg/t (monthly average) by 31 December 1995. 1.93 kg/t (daily maximum) by 31 December 1995. 0.80 kg/t (monthly average) by 31 December 1999. 1.03 kg/t (daily maximum) by 31 December 1999. Goal of 0.0 kg/t by 31 December 20002.
Quebec	1.5 kg/t (monthly average) for hardwood by 31 December 1993. 2.5 kg/t (monthly average) for softwood by 31 December 1993. 1.0 kg/t (monthly average) for hardwood by 30 September 1995. 2.0 kg/t (monthly average) for softwood by 30 September 1995. 0.8 kg/t (monthly average) by 31 December 2000.
EUROPE	
Austria	One area of Austria, the Salzkammergut, has required the attainment of 0.0 kg/t by the year 1992.
Finland	2.0 kg/t (maximum annual average) for softwood by 1995. 1.0 kg/t (maximum annual average) for hardwood by 1995.
Germany	1.0 kg/t for sulfite mills.
Norway	2.0 kg/t for kraft mills. 1.0 kg/t for sulfite mills.

TABLE 2-38 (cont.)

Sweden	1.0 kg/t (annual average) by 1995 for softwood. 0.5 kg/t (annual average) by 2000 for softwood. 0.5 kg/t (annual average) by 1995 for hardwood. 0.3 kg/t (annual average) by 2000 for hardwood.
Helsinki Convention	Following a 15 February 1988 meeting of the Ministers of the Environment of the Baltic Sea Area, a proposal was worked out that all new sulfite mills must meet immediately and all existing chemical pulp mills must meet before the year 2000 the following emission standards: — Bleached kraft mills 2.0 kg/t — Bleached sulfite mills 1.0 kg/t
Paris Convention	The most recent Paris Convention meeting was held in London on January 17-19, 1989. At that meeting, Sweden presented the following proposal aimed at the reduction of chlorinated substances from the production of bleached pulp: 1. As of January 1, 1994, the discharge of chlorinated organic substances (AOX) should not, as an annual average, exceed the following values for each contraction party's total production of: — softwood kraft pulp bleached with chlorine chemicals 2 kg/t — hardwood kraft pulp bleached with chlorine chemicals 1 kg/t — sulfite pulp bleached with chlorine chemicals 1 kg/t 2. The annual average values for each mill should, as a minimum, be based on one analysis a month. Analysis should be made on representative 24 hours, unsettled samples.
JAPAN	The Japan Paper Association has established a goal of 1.5 kg/t for all bleached pulp mills to be achieved by the end of 1993.
UNITED STATES	No federal or state regulations for AOX prior to this rulemaking; however, several mills have been permitted for AOX as follows:
Oregon	Two bleached kraft pulp mills have been permitted at 1.5 kg/t (annual average) and 1.9 kg/t (monthly average) to be achieved by 15 November 1995.[4] The remaining bleached kraft pulp mill in Oregon, has been issued an order to achieve an annual average AOX of 1.5 kg/t by 31 December 1997.
Idaho	An existing facility was issued a permit with mass AOX limits based on 1.5 kg/t (annual average) and 1.9 kg/t (monthly average).

TABLE 2-38 (cont.)

Washington	Permit limits for bleached kraft pulp mill #1 are 1.5 kg/t[5] (annual average) and 1.9 kg/t (monthly average). Permit limits for bleached kraft pulp mill #2 are 1.3 kg/t (annual average) and 1.6 kg/t (monthly average) and must be achieved by 9 May 1996. Permit limits for a dissolving sulfite mill are 1.5 kg/t (annual average) and 1.9 kg/t (monthly average) and must be achieved by 10 December 1996.

Source: Bodien, 1993; McCubbin, 1992.

[1]All tons are bleached metric tons unless other wise noted.

[2]This alternative allows the discharger an exemption from meeting the 31 December 1995 requirements provided a plan is submitted to the director on or before 30 June 1992 for meeting the 31 December 1990 requirement.

[3]Draft regulations.

[4]The permit for one facility was issued to the city POTW.

[5]Limits for this mill based on unbleached metric tons of production.

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SECTION THREE

ECONOMIC IMPACT AND REGULATORY FLEXIBILITY ANALYSIS METHODOLOGY

The Agency is proposing effluent limitations guidelines and maximum achievable control standards (MACT) for the pulp, paper, and paperboard industry. The compliance options and regulatory alternatives evaluated by the Agency are summarized in Section 4.1. Compliance costs include both capital costs (such as equipment) and annual operating costs (such as labor and chemicals). Capital costs are one-time expenditures while incremental operating costs are incurred each year. Both types of costs generally increase the cost of production.

The economic analysis investigates the change in financial conditions caused by these additional costs. The first step in the process is to estimate what a business would actually pay to purchase, install, and operate the new pollution control equipment. The estimation of the cost—called the industry compliance cost—takes into account tax savings the business accrues through depreciation and other tax shields. The compliance cost estimates what the industry would pay to meet the new pollution control requirements. As such, it is the appropriate measure of cost with which to analyze industry impacts. The data, assumptions, and model used to estimate compliance costs for each facility are described in Section 3.1.

Two methodologies are used to examine the potential economic impacts of the compliance costs on the pulp, paper, and paperboard industry. The first method, described in Section 3.2, uses a financial model that focuses on individual facilities. The second method, described in Section 3.3, uses a market model that examines interactions among all the facilities. In Section 3.4, the models, their assumptions, and results are compared.

The Regulatory Flexibility Act requires an analysis of whether the potential impacts of proposed regulations fall disproportionately on small entities. Section 3.5 describes this study's definition of "small entities" and the methods used to examine economic impacts on these entities.

3.1 COMPLIANCE COST MODEL

The compliance cost model, also called the cost annualization model, estimates the cost actually incurred by the facility to upgrade its pollution controls. Figure 3-1 is an overview of the compliance cost methodology. Inputs to the model include the capital and annual costs of the pollution control equipment. The discount rate, also called the cost of money, is taken from the *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities, Part B: Financial Information* survey data. These inputs, in conjunction with financial assumptions, are used to calculate the cash outflows over time before and after tax shields.

There are several reasons why the capital and annual costs need to be annualized. First, the initial capital outlay should not be compared against the facility's income in the first year because the capital cost is incurred only once in the equipment's lifetime. The initial investment, then, should be spread out over the equipment's life. Second, money has a time value. A dollar today is worth more than a dollar in the future. The cost annualization model is defined in terms of 1989 dollars because 1989 is the most recent year for which financial data are available from the survey. Pollution control capital and annual costs, which were initially estimated in 1991 dollars, are deflated to 1989 dollars prior to projecting cash outflows. The cash flows are discounted to calculate the present value of the future cash outflows in terms of 1989 dollars. It is a way of evaluating what the business would pay in 1989 dollars for all initial and future expenditures. Finally, the model calculates the annualized cost for the cash outflow as an annuity that has the same present value as the cash outflow. The annualized cost represents the annual payment required by the business to finance the cash outflows and includes the cost of money or interest. The annualized cost is analogous to a mortgage payment that spreads the one-time investment in a home into a series of constant monthly payments. The annualized cost is inflated to 1991 dollars for presentation of the costs in the report and for comparability with the engineering cost data presented in the Development Document.

Section 3.1.1 discusses the data sources for inputs to the compliance cost model. Section 3.1.2 summarizes the financial assumptions for the model. Section 3.1.3 presents all steps of the model with a sample calculation.

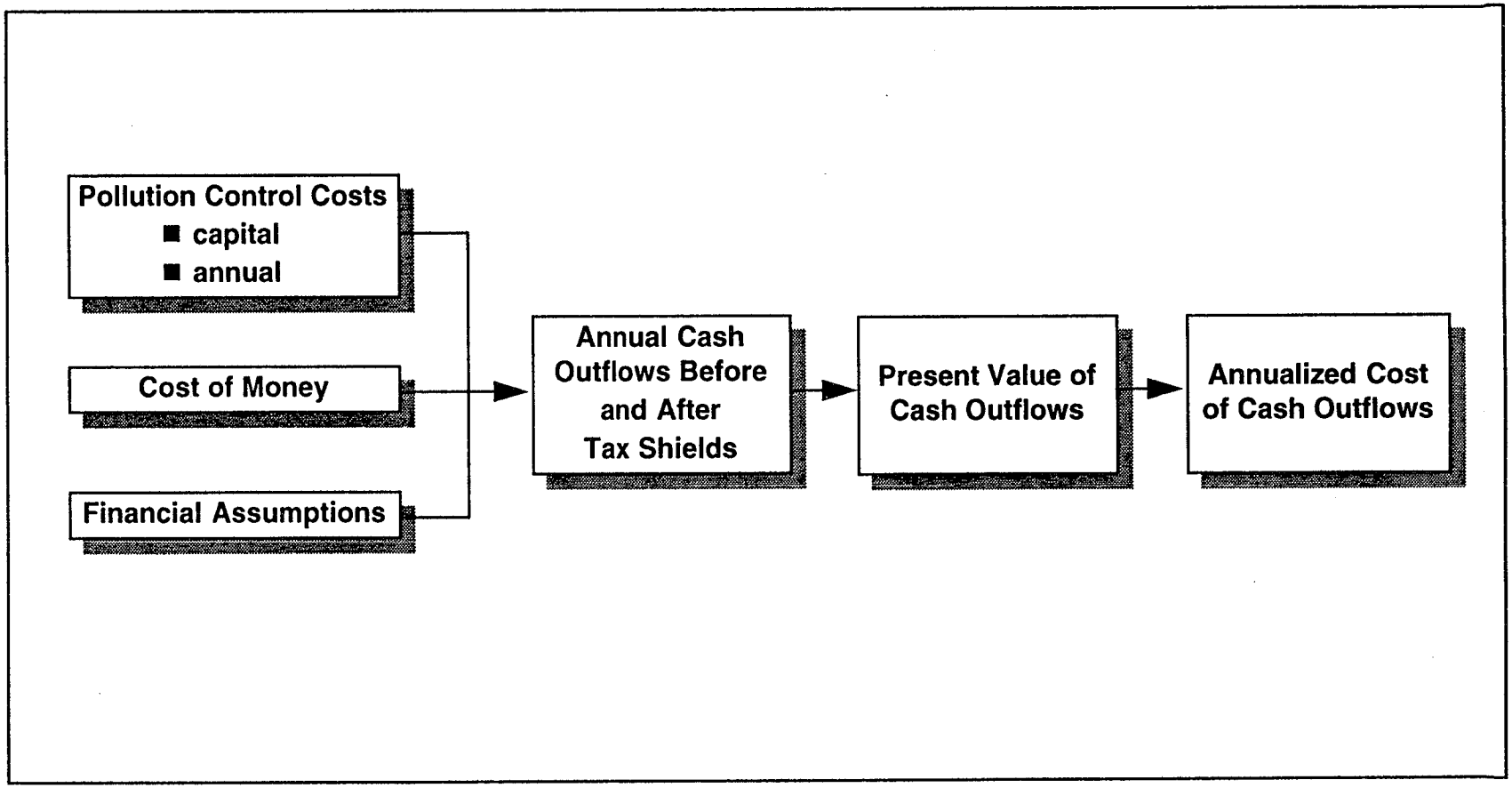

Figure 3-1. Overview of compliance cost methodology.

3.1.1 Input Data Sources

Table 3-1 illustrates the cost annualization model with fictitious data. The inputs and assumptions for the analysis are listed in the spreadsheet's top portion. The first input is the *survey identification* number for the facility analyzed. The second line is the number of the regulatory *option* or alternative for which the annualized costs are calculated.

The third and fourth lines are the option's *capital* and *O&M* costs, developed by the engineering staff. The capital investment is the initial investment to purchase and install the equipment. The capital cost is a one-time cost. The O&M cost is the annual cost of operating and maintaining the equipment.[1] O&M costs are incurred every year of the equipment's operation. These costs are provided in terms of 1991 dollars. They are deflated to 1989 dollars because the financial survey data are in 1989 dollars (see discussion above).[2]

The *life of the asset* is determined according to the Internal Revenue Code's classes of depreciable property. Fifteen-year property is assumed to have a class life of 20 to 25 years—a typical life span for the equipment considered in the costing analysis. For example, a 20-year lifetime for a recovery boiler is a reasonable estimate (see Development Document). According to the U.S. Master Tax Guide, 15-year property includes such assets as municipal wastewater treatment plants (CCH, 1991b, p. 329). Thus, for the purposes of calculating depreciation, most components of the capital cost for a pollution control option are assumed to be 15-year property. Section 3.1.2.3 discusses the effect of using another asset lifetime in the cost annualization calculation.

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[1]The engineering cost model provides three components used in the compliance cost model: total capital investment (TCI), annual noncapital fixed costs (GAC), and annual variable costs (VAC). Total capital investment is the cost of control device(s) or process equipment needed to meet the standard, including installation labor and materials. TCI is the capital cost used in the compliance model. GAC includes general and administrative overhead, property taxes, and property insurance. VAC includes operating and maintenance labor and materials, chemical usage, and energy costs associated with operating the control device(s) and process equipment. The compliance cost model uses the sum of GAC and VAC as its O&M cost.

[2]The deflation factor is 4615/4835—roughly 0.95—based on the change in the Engineering News Report Construction Cost Index from 1989 to 1991 (ENR, 1993).

TABLE 3-1
SAMPLE SPREADSHEET FOR ANNUALIZING COSTS

Inputs:		
Survey ID #:	1234	
Option Number:	OPTION Q	
	$1991	$1989
Initial Capital Cost ($000):	$100,000	$95,450
Annual Operation & Maintenance Cost ($000):	$8,000	$7,636
Equipment Lifetime (Class Life - yrs):	15	
Company-Specific Nominal Discount Rate:	0.13	
Expected Inflation Rate:	4.0%	
Real Discount Rate:	9.0%	
Marginal Income Tax Rates:		
Federal	34.00%	
State	6.75%	
Combined	40.75%	

Column 1	2	3	4	5	6	7	8
Year	Depreciation Rate	Depreciation For Year	Tax Shield From Depreciation	O&M Cost	O&M Tax Shield	Cash Outflow	Cash Outflow After Tax Shields
1	0.000%	$0	$0	$0	$0	$95,450	$95,450
2	10.000%	$9,545	$3,890	$7,636	$3,112	$7,636	$635
3	9.643%	$9,204	$3,751	$7,636	$3,112	$7,636	$774
4	9.272%	$8,850	$3,606	$7,636	$3,112	$7,636	$918
5	8.886%	$8,481	$3,456	$7,636	$3,112	$7,636	$1,068
6	5.655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325
7	5.655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325
8	5.655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325
9	5.655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325
10	5.655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325
11	5.655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325
12	5.655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325
13	5.655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325
14	5.655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325
15	5.655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325
16	5.655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325
Sum	100.00%	$95,450	$38,896	$114,540	$46,675	$209,990	$124,419
Present Value		$55,366	$22,562	$61,551	$25,082	$157,001	$109,357

Present Value of Incremental Costs:	$109,357
Annualized Cost:	$13,156

Notes: This spreadsheet assumes that a modified accelerated cost recovery system (MACRS) is used to depreciate capital expenditures.
All figures except the input capital and o&m are in $1989.
This schedule assumes that there is a one year period between construction and start-up.
If the company-specific discount rate is <5% or >19%, then an industry average figure of 13% is used.

The *discount rate* is used in calculating the present values of the cash flows. The discount rate represents an estimate of the facility's average cost of capital, i.e., what it will cost the facility to raise the money whether through debt (a loan), equity (sale of stock), or working capital (opportunity cost). Section 2.7 reviews the survey data regarding discount rates and the assumptions used for the cost annualization model. Where facility-specific data are available and where they are between 5 and 19 percent, the facility-specific data are used in the cost annualization model. Where no discount data are available or where the data are outside of the 5 to 19 percent range, the industry average discount rate of 13 percent is used in the model.

Since the cost annualization model is developed in terms of constant 1989 dollars, the discount rate must be adjusted for inflation before use in the model. Table 3-2 lists the average inflation rate for the years 1981 to 1991 as measured by the Consumer Price Index. An estimated average inflation rate of 4 percent is used in the cost annualization model to convert the nominal discount rate to a real discount rate.

The final inputs to the model are the federal and average state *tax rate*, which are used in determining the facility's tax shield or tax benefit. A business can offset taxable income both with incremental O&M costs and with the depreciation of the equipment itself. The federal tax rate used in the model is the marginal federal tax rate (the rate applied to corporate income above $335,000).[3] Table 3-3 lists each state's corporate income tax rate and calculates a national average state tax rate. The cost annualization model uses the average state tax rate because of the complexities in this industry; for example, a facility could be located in one state, while its corporate headquarters are located in a second state, and the corporation's holding company is located in a third state. Given the uncertainty over which state tax rate applies to a given

[3]Costs for all facilities must be annualized to obtain the industry compliance cost. Not all facilities, however, have sufficient information in the data base for the closure analysis. Facilities lacking such information could be mills that began operations after 1989, changed ownership after 1989, have assets carried only at the corporate level, or have financial information held only on a combined basis with another facility. For all facilities, the cost annualization model uses the 34-percent marginal federal income tax rate. The closure model adjusts tax rates used to determine post-tax earnings depending on whether the business is an S Corporation, a multifacility corporation, or a single-facility, independent operation.

TABLE 3-2
INFLATION RATE 1981-1991

Year	Consumer Price Index	Change
1981	90.9	
1982	96.5	6.2%
1983	99.6	3.2%
1984	103.9	4.3%
1985	107.6	3.6%
1986	109.6	1.9%
1987	113.6	3.6%
1988	118.3	4.1%
1989	124.0	4.8%
1990	130.7	5.4%
1991	136.2	4.2%
Average Inflation Rate		4.1%

Source: CEA, 1993, Table B-56.

TABLE 3-3
STATE CORPORATE INCOME TAX RATES

State	Corporate Income Tax Rate	Basis for States With Graduated Tax Tables
Alabama	5.00%	
Alaska	9.40%	$90,000+
Arizona	9.30%	
Arkansas	6.00%	$100,000+
California	9.30%	
Colorado	5.00%	
Connecticut	11.50%	
Delaware	8.70%	
Florida	5.50%	
Georgia	6.00%	
Hawaii	6.40%	$100,000+
Idaho	8.00%	
Illinois	4.00%	Plus Excise Tax
Indiana	4.50%	
Iowa	12.00%	$250,000+
Kansas	6.75%	
Kentucky	8.25%	$250,000+
Louisiana	8.00%	$200,000+
Maine	8.93%	$250,000+
Maryland	7.00%	
Massachusetts	9.50%	
Michigan	2.35%	
Minnesota	9.80%	
Mississippi	5.00%	$10,000+
Missouri	5.00%	
Montana	6.75%	
Nebraska	7.81%	$50,000+
Nevada	0.00%	
New Hampshire	8.00%	
New Jersey	9.42%	
New Mexico	7.60%	$1Million+
New York	9.00%	
North Carolina	7.00%	
North Dakota	10.50%	$50,000+
Ohio	8.90%	Based on Stock Value
Oklahoma	6.00%	
Oregon	6.60%	
Pennsylvania	12.25%	
Rhode Island	9.00%	
South Carolina	5.00%	
South Dakota	0.00%	
Tennesee	6.00%	
Texas	0.00%	
Utah	5.00%	
Vermont	8.25%	$250,000+
Virginia	6.00%	
Washington	0.00%	
West Virginia	9.30%	
Wisconsin	7.90%	
Wyoming	0.00%	
Average	6.75%	

Sources: Fortune Magazine, June 3, 1991, pg 22, Commerce Clearing House "State Tax Handbook", 1991

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facility's revenues, the average state tax rate is used in the cost annualization model for all facilities.

3.1.2 Financial Assumptions

The cost annualization model incorporates several financial assumptions:

- Depreciation method
- Timing between initial investment and operation
- Depreciable lifetime for the equipment
- Tax shields on interest payments

Each assumption, and the alternatives examined in making the assumption, is discussed in detail below.

3.1.2.1 Depreciation Method

The Agency examined three alternatives for depreciating capital investments:

- Modified Accelerated Cost Recovery System (MACRS)
- Straight-line depreciation
- Section 169 provision of the Internal Revenue Code

Modified Accelerated Cost Recovery System (MACRS) applies to assets put into service after December 31, 1986. MACRS involves the ability to write off greater portions of the investment in the early years. In contrast, the straight-line depreciation writes off a constant amount of the investment each year. MACRS offers companies an advantage over the straight-line method, since a company's income may be reduced under MACRS by a greater amount in

the early years when the time value of money is greater. Table 3-4 illustrates that although the absolute amount depreciated under each method is equivalent, MACRS provides a $1.9 million benefit owing to the timing differences in writing off the investment. The example in Table 3-4 uses a midyear convention for putting the equipment into operation, which assumes only 6 months of depreciation in the first year.

Section 169 of the Internal Revenue Code provides the option to amortize pollution control facilities over a 5-year period (IRS, 1988). Under this IRS provision, 75 percent of the investment could be rapidly amortized in a 5-year period using a straight line method. The 75-percent figure is based on the ratio of the allowable lifetime (15 years) to the estimated usable life (20 years) as specified in IRS Section 169, Subsection (f). Although the tax provision enables the facility to expense the investment over a shorter time period, the advantage is substantially reduced because only 75 percent of the capital investment can be recovered. Table 3-5 illustrates this tax provision using hypothetical costs. The present value of the tax shield from depreciation increases only slightly, from $22,562 (Table 3-1) to $22,694 (Table 3-5).[4]

Since the benefit of the provision is only slight and facilities might not be able to get the required certification to take advantage of it, this provision was not included in the cost annualization model. Its exclusion results in a more conservative estimate of the compliance costs. The benefit of using MACRS rather than the straight-line method for depreciation is clear; MACRS is the depreciation method used in the cost annualization model.

3.1.2.2 Timing Between Initial Investment and Operation

A business cannot begin to depreciate a capital investment before it goes into operation. While the midyear convention is frequently used when calculating depreciation (i.e., the equipment is operational halfway through its first year), it is not appropriate for this analysis. Approximately 1 year would be required to build and install most of the equipment considered in the regulatory alternative. Additional time might be required for design, permitting, and site

[4]These figures are expressed in thousands of dollars, as in the tables.

TABLE 3-4
DEPRECIATION METHODS
COMPARISON OF STRAIGHT LINE VS. MODIFIED ACCELERATED COST RECOVERY SYSTEM

Capital Cost ($000)	Discount Rate
$100,000	13.0%
Life (yrs)	
15	
Marginal Tax Rates:	
Federal	34.0%
State	6.8%
Overall	40.8%

Year	Depreciation For Year (MACRS)	Depreciation For Year Straight-Line	Tax Shield (MACRS)	Tax Shield Straight-Line
1	$5,000	$3,333	$2,038	$1,358
2	$9,500	$6,667	$3,871	$2,717
3	$8,550	$6,667	$3,484	$2,717
4	$7,700	$6,667	$3,138	$2,717
5	$6,930	$6,667	$2,824	$2,717
6	$6,230	$6,667	$2,539	$2,717
7	$5,900	$6,667	$2,404	$2,717
8	$5,900	$6,667	$2,404	$2,717
9	$5,910	$6,667	$2,408	$2,717
10	$5,900	$6,667	$2,404	$2,717
11	$5,910	$6,667	$2,408	$2,717
12	$5,900	$6,667	$2,404	$2,717
13	$5,910	$6,667	$2,408	$2,717
14	$5,900	$6,667	$2,404	$2,717
15	$5,910	$6,667	$2,408	$2,717
16	$2,950	$3,333	$1,202	$1,358
Sum	$100,000	$100,000	$40,750	$40,750
Present Value	$24,239	$19,576	$9,878	$7,977
Net benefit of using MACRS vs. SL (year 1 dollars)		$1,900		

SL_MACRS.WK3 24-Jun-93

TABLE 3-5
SPREADSHEET FOR ANNUALIZING COSTS USING SECTION 169 PROVISION

Inputs:		
Survey ID #:	1234	
Option Number	OPTION Q	
	$1991	$1989
Initial Capital Cost ($000):	$100,000	$95,450
Annual Operation & Maintenance Cost ($000):	$8,000	$7,636
Equipment Lifetime (Class Life - yrs):	15	
Company-Specific Nominal Discount Rate:	0.13	
Expected Inflation Rate:	4.0%	
Real Discount Rate:	9.0%	
Marginal Income Tax Rates:		
Federal	34.00%	
State	6.75%	
Combined	40.75%	

Column 1	2	3	4	5	6	7	8
Year	Depreciation Rate	Depreciation For Year	Tax Shield From Depreciation	O&M Cost	O&M Tax Shield	Cash Outflow	Cash Outflow After Tax Shields
1	0.000%	$0	$0	$0	$0	$95,450	$95,450
2	20.000%	$14,317	$5,834	$7,636	$3,112	$7,636	($1,310)
3	20.000%	$14,317	$5,834	$7,636	$3,112	$7,636	($1,310)
4	20.000%	$14,317	$5,834	$7,636	$3,112	$7,636	($1,310)
5	20.000%	$14,317	$5,834	$7,636	$3,112	$7,636	($1,310)
6	20.000%	$14,317	$5,834	$7,636	$3,112	$7,636	($1,310)
7	0.000%	$0	$0	$7,636	$3,112	$7,636	$4,524
8	0.000%	$0	$0	$7,636	$3,112	$7,636	$4,524
9	0.000%	$0	$0	$7,636	$3,112	$7,636	$4,524
10	0.000%	$0	$0	$7,636	$3,112	$7,636	$4,524
11	0.000%	$0	$0	$7,636	$3,112	$7,636	$4,524
12	0.000%	$0	$0	$7,636	$3,112	$7,636	$4,524
13	0.000%	$0	$0	$7,636	$3,112	$7,636	$4,524
14	0.000%	$0	$0	$7,636	$3,112	$7,636	$4,524
15	0.000%	$0	$0	$7,636	$3,112	$7,636	$4,524
16	0.000%	$0	$0	$7,636	$3,112	$7,636	$4,524
Sum	100.00%	$71,587	$29,172	$114,540	$46,675	$209,990	$134,143
Present Value		$55,690	$22,694	$61,551	$25,082	$157,001	$109,225

Present Value of Incremental Costs:	$109,225
Annualized Cost:	$13,140

Notes: This spreadsheet assumes that Section 169 of the Internal Revenue Code is used to depreciate capital expenditures.
All figures except the input capital and o&m are in $1989.
This schedule assumes that there is a one year period between construction and start-up.
If the company-specific discount rate is <5% or >19%, then an industry average figure of 13% is used.

preparation. The cost annualization model, therefore, assumes a 1-year delay from the initial capital expenditure to operation. As shown in Table 3-1, while the capital expenditure is listed in Year 1, depreciation and annual O&M costs are not listed until Year 2, assumed to be the first full year of operation. Assuming a 1-year delay also changes each year's depreciation rates. Table 3-6 shows the derivation of the depreciation rates used in the cost annualization model. As a result of the timing assumption, the present value calculation covers 16 years—the 1-year delay plus the 15-year depreciable lifetime for the equipment.

3.1.2.3 Depreciable Lifetime for the Equipment

An asset's depreciable life can differ from its actual life. The U.S. Master Tax Guide lists 15-year property as property with a class life of 20 years or more but less than 25 years. Municipal wastewater treatment plants are given as an example of 15-year property (CCH, 1991b, Section 1240). The pollution control equipment is considered in this analysis as 15-year property; however, the actual life could extend to 25 years. Under these circumstances, up to 10 years of O&M expenses would be excluded from the present value calculations. The effect of excluding such costs, however, would not be large, since in Year 16, a dollar is worth only $0.16 (assuming a 13-percent discount rate). Furthermore, by adding more years to the calculation, the annualized cost is lowered because even though O&M costs are incurred during the extra years, payments for the capital investment will be spread over a longer time period.

3.1.2.4 Tax Shields on Interest Payments

The cost annualization model does not consider tax shields on interest paid to finance new pollution control equipment. A facility could finance through a bank loan (debt), take money out of working capital, issue a corporate bond, or sell additional stock (equity shares). In any case, the present value analysis assumes a cost to the facility to use the money (the discount rate), whether that amount is paid as interest or is the opportunity cost of the internal funding. According to current tax law, if the facility finances the investment using debt, the associated interest expenses can be deducted, thereby reducing taxable income. The tax shield on the

TABLE 3-6
CALCULATION OF MACRS DEPRECIATION RATES

Assumptions:
Property goes into service at beginning of year
150% double declining balance (DB) method
15-year property
Assume $10,000 unadjusted basis
Switch to Straight-Line occurs in Year 5

Year	Years Remaining At Beginning Of Year	Straight-Line Rate	150% DB Rate On Adjusted Basis	Depreciation For Year	Adjusted Basis at Year End	150% DB Rate On Unadjusted Basis
		0.00%	0.00%		$10,000	
1	15	6.67%	10.00%	$1,000	$9,000	10.000%
2	14	7.14%	10.71%	$964	$8,036	9.643%
3	13	7.69%	11.54%	$927	$7,109	9.272%
4	12	8.33%	12.50%	$889	$6,220	8.886%
5	11	9.09%	9.09%	$565	$5,655	5.655%
6	10	10.00%	10.00%	$565	$5,089	5.655%
7	9	11.11%	11.11%	$565	$4,524	5.655%
8	8	12.50%	12.50%	$565	$3,958	5.655%
9	7	14.29%	14.29%	$565	$3,393	5.655%
10	6	16.67%	16.67%	$565	$2,827	5.655%
11	5	20.00%	20.00%	$565	$2,262	5.655%
12	4	25.00%	25.00%	$565	$1,696	5.655%
13	3	33.33%	33.33%	$565	$1,131	5.655%
14	2	50.00%	50.00%	$565	$565	5.655%
15	1	100.00%	100.00%	$565	$0	5.655%
Sum				$10,000		100.00%

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interest payments thus would reduce the annualized cost of compliance. It is not known what mix of debt and capital a facility will use to finance the cost of pollution control equipment. According to Table 3-7, which illustrates the effect of 100-percent debt financing, the annualized compliance cost would drop by approximately 4 percent due to tax shields on the interest payments. If the facility financed the entire investment out of working capital, there would be no associated tax benefit and the compliance cost should be calculated without interest tax shields. To maintain a conservative cost estimate, tax shields on interest payments are not considered in the cost annualization model.

3.1.3 Sample Cost Annualization Spreadsheet

In Table 3-1, the spreadsheet contains numbered columns that calculate the cost of the investment to the facility. The first column lists each year of the equipment's life span, from its installation through its 15-year depreciable lifetime.

Column 2 of Table 3-1 represents the portion of the capital costs that can be written off or depreciated each year. These rates are based upon the MACRS. Multiplying these rates times the capital cost gives the annual amount the facility may depreciate (Column 3). These amounts will be used to offset annual income. Column 4 shows the tax benefit provided from the depreciation expense—the overall tax rate times the depreciation amount for the year.

Column 5 of Table 3-1 is the annual O&M expense, a constant amount, except for Year 1 when no O&M costs are incurred because the equipment is not yet in service. The sixth column is the tax shield or benefit provided from expensing the O&M costs.

Column 7 lists the facility's total expenses associated with the additional pollution control equipment. Total expenses include capital costs, assumed to be incurred during the first year when the equipment is installed, along with each year's O&M expense. Column 8 lists the annual cash outflow minus the tax shields from the O&M expenses and depreciation, since the facility will recoup these costs as a result of reduced income taxes.

TABLE 3-7
SPREADSHEET FOR ANNUALIZING COSTS WITH INTEREST PAYMENTS

Inputs		
Survey ID #	1234	
Option Number	OPTION Q	
	$1991	$1989
Initial Capital Cost ($000)	$100.000	$95,450
Annual Operation & Maintenance Cost ($000)	$8.000	$7,636
Equipment Lifetime (Class Life - yrs)	15	
Company-Specific Nominal Discount Rate	0.13	
Expected Inflation Rate	4 0%	
Real Discount Rate	9 0%	
Marginal Income Tax Rates		
Federal	34 00%	
State	6 75%	
Combined	40.75%	

Financing:	
Amount financed	$95,450
Annualized	$11,483

Column 1	2	3	4	5	6	7	8	9	10
Year	Depreciation Rate	Depreciation For Year	Tax Shield From Depreciation	O&M Cost	O&M Tax Shield	Cash Outflow	Cash Outflow After Tax Shields	Interest Payments	Interest Payment Tax Shield
1	0 000%	$0	$0	$0	$0	$95,450	$95,450	$1,033	$421
2	10 000%	$9.545	$3,890	$7,636	$3,112	$7,636	$635	$1,033	$421
3	9 643%	$9 204	$3,751	$7,636	$3,112	$7,636	$774	$1,033	$421
4	9 272%	$8,850	$3,606	$7,636	$3,112	$7,636	$918	$1,033	$421
5	8 886%	$8,481	$3,456	$7,636	$3,112	$7,636	$1,068	$1,033	$421
6	5 655%	$5 397	$2,199	$7,636	$3,112	$7,636	$2,325	$1,033	$421
7	5 655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325	$1,033	$421
8	5 655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325	$1,033	$421
9	5 655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325	$1,033	$421
10	5 655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325	$1,033	$421
11	5 655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325	$1,033	$421
12	5 655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325	$1,033	$421
13	5 655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325	$1,033	$421
14	5 655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325	$1,033	$421
15	5 655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325	$1,033	$421
16	5 655%	$5,397	$2,199	$7,636	$3,112	$7,636	$2,325	$1,033	$421
Sum	100 00%	$95,450	$38,896	$114,540	$46,675	$209,990	$124,419	$16,535	$6,738
Present Value		$55,366	$22,562	$61,551	$25,082	$157,001	$109,357	$9,364	$3,816

Present Value of Incremental Costs	$109,357
Annualized Cost	$13,156
Annualized Interest Tax Shield	$459
Annualized Cost After Interest Tax Shield	$12,697

Notes This spreadsheet assumes that a modified accelerated cost recovery system (MACRS) is used to depreciate capital expenditures.
All figures except the input capital and o&m are in $1989.
This schedule assumes that there is a one year period between construction and start-up.
If the company-specific discount rate is <5% or >19%, then an industry average figure of 13% is used.

Column 8 shows the annual after-tax-shield cash outflows. The sum of the 16 annual payments is $124.4 million (1989 dollars). The present value of the payments is $109.4 million. The present value calculation takes into account the time value of money and is calculated as:

$$\text{Present Value of Cash Outflows} = \sum_{i=1}^{n} \frac{\text{cash outflow in Year i}}{(1 + \text{real discount rate})^{i-1}}$$

The exponent in the denominator is i-1 and not i because the real discount rate does not apply to the cash outflow in Year 1. The cell formula in Lotus is: initial cash outflow in Year 1 + @npv(real discount rate, cash outflows in Year 2 to Year 16). The present value of the cash outflows is used in the closure analysis to calculate the post-regulatory present value of future earnings for the facility (Section 3.2.1).

The present value of the cash outflows must be transformed into a constant, annual payment for use as the annualized facility compliance cost. The annualized cost is calculated as the 16-year annuity that has the same present value as the bottom line in Column 8. The annualized cost represents the annual payment required to finance the cash flows after tax shields. In essence, paying the annualized cost every year and paying the amounts listed in Column 8 for each year are equivalent. The annualized cost is calculated as:

$$\text{Annualized Cost} = \text{Present value of cash outflows} * \frac{\text{real discount rate}}{1-(\text{real discount rate} + 1)^{-n}}$$

where n is the number of payment periods.

In Lotus, the cell formula is: @pmt(present value of cash flows, real discount rate, 16). In this example, based on the capital investment of $100 million and annual O&M cost of $8 million (1991 dollars), the annualized cost is $13.2 million in 1989 dollars.

Note that the annualized cost can be determined in two ways. The first way is to calculate the annualized cost as the difference between the annuity value of the cash flows (Column 7) and the tax shields (Columns 4 and 6). The second way is to calculate the annuity value of the cash flows after tax shields (Column 8). Both ways yield the same value. The

annualized cost is used in calculating the compliance cost of the regulation and in the ratio analysis (Section 3.2.2).

The *social* cost of the regulation differs from the *compliance* cost. The compliance cost represents the cost to the industry, and takes into account cost savings due to tax shields. The federal government loses the money saved by industry through tax shields.[5] The cost to society includes the costs borne by the industry, as well as the cost borne by the federal government through lost tax revenues. The cost to society, therefore, is always higher than the cost to industry. Section 3.3 contains a more detailed discussion of social costs.

3.1.4 Cost Annualization Model and Total Cost Assessment

EPA, 1992a describes the Total Cost Assessment (TCA) approach for evaluating pollution prevention alternatives. TCA is comprehensive financial analysis of the life cycle costs and savings of a pollution prevention project. A TCA approach includes:

- Internal allocation of environmental costs to product lines or processes through full cost accounting.
- Financial analysis of direct and indirect costs, short- and long-term costs, liability costs, and less tangible benefits of an investment.
- Evaluation of project costs and savings over a long-time horizon, e.g., 10 to 15 years.
- Measures of profitability which capture the long-term profitability of the project, e.g., net present value and internal rate of return.

TCA approaches are being developed as alternatives to traditional financial analysis methods in order to capture and properly evaluate the long-term costs and savings inherent in pollution prevention activities.

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[5]The annualized cost to federal and state governments can be calculated as the difference between the annualized cost before and after tax shields (Table 3-1, columns 7 and 8).

The cost annualization model incorporates several features of a total cost assessment analysis, including:

- Long-time horizon (the annualization model uses a 15-year time frame).
- Short- and long-term costs.
- Cost savings due to reduced chemical usage, etc., which are included in the cost estimates prepared by the EPA engineers (see Development Document).
- Depreciation, taxes, inflation, and discount rate.
- The associated closure analysis (see next section), which uses the net present value of the investment calculated in the cost annualization model to evaluate the long-term impacts on profitability.

The economic analysis differs from the TCA approach in that it does not include a "liability avoided" component or an evaluation of the less tangible benefits of the regulation. There are insufficient data to estimate potential future liability costs for each facility. The exclusion of this parameter results in a more conservative analysis where potential impacts are not offset by avoiding future liability costs. A separate analysis and report compare the costs and benefits of the regulation.

3.2 FINANCIAL IMPACT ANALYSIS METHODOLOGY

There are two major components to the financial model methodology for estimating the economic impacts for the proposed rule:

- Facility closure analysis through the comparison of estimated salvage value, projected earnings, and regulatory costs (Section 3.2.1).
- Financial ratio analysis at the facility and company level to identify impacts short of closure (Section 3.2.2).

The closure analysis and the financial ratio analysis are facility and business entity specific. As such, both analyses are based on information gathered in the *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities, Part B: Financial Information* (EPA, 1991).[6]

Figure 3-2 is an overview of the financial model methodology. The present value of the pollution control options is calculated within the cost annualization model (Table 3-1). The closure model reduces the present value of pre-regulatory projected earnings by the present value of the pollution control option. The adjusted earnings for the facility are compared against its salvage value, and the likelihood of closure is evaluated. The closure model is discussed in more detail in Section 3.2.1.

Financial ratios are an accepted method for evaluating financial performance and health. Ratios are calculated with the financial data as presented in the survey. The ratios are then recalculated with the inclusion of the annualized cost of the pollution control option. Section 3.1 discusses the calculation of annualized costs. Ratio analysis is used to identify financial impacts on a facility that are not as severe as closure. Ratio analysis is also calculated at the business entity level to evaluate the impacts of a business needing to upgrade multiple facilities. Section 3.2.2 discusses the financial ratio analysis methodology.

3.2.1 Closure Model

A mill is assumed to close if long-term profits are worth less than closing the mill and selling its assets. One component of the economic analysis is estimating whether the costs of

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[6]A mill must meet three requirements to be in the closure and ratio analyses: it must be in the survey financial data base (QFIN Version 2), its assets must be carried at the facility level, and it must have reported financial records for the individual facility location. With respect to the third requirement, for a small number of survey respondents, two separate facilities had financial records maintained only on a combined basis. The facilities provided separate technical information, but only one combined report of financial information. To maintain comparability between the technical and financial data sets, both facilities are included in the financial data base, but one mill has no entries. For the purpose of economic analysis, the pollution control costs for both mills were added and compared to the assets and revenues for the combined facility. Approximately seven combination mills are in the closure analysis.

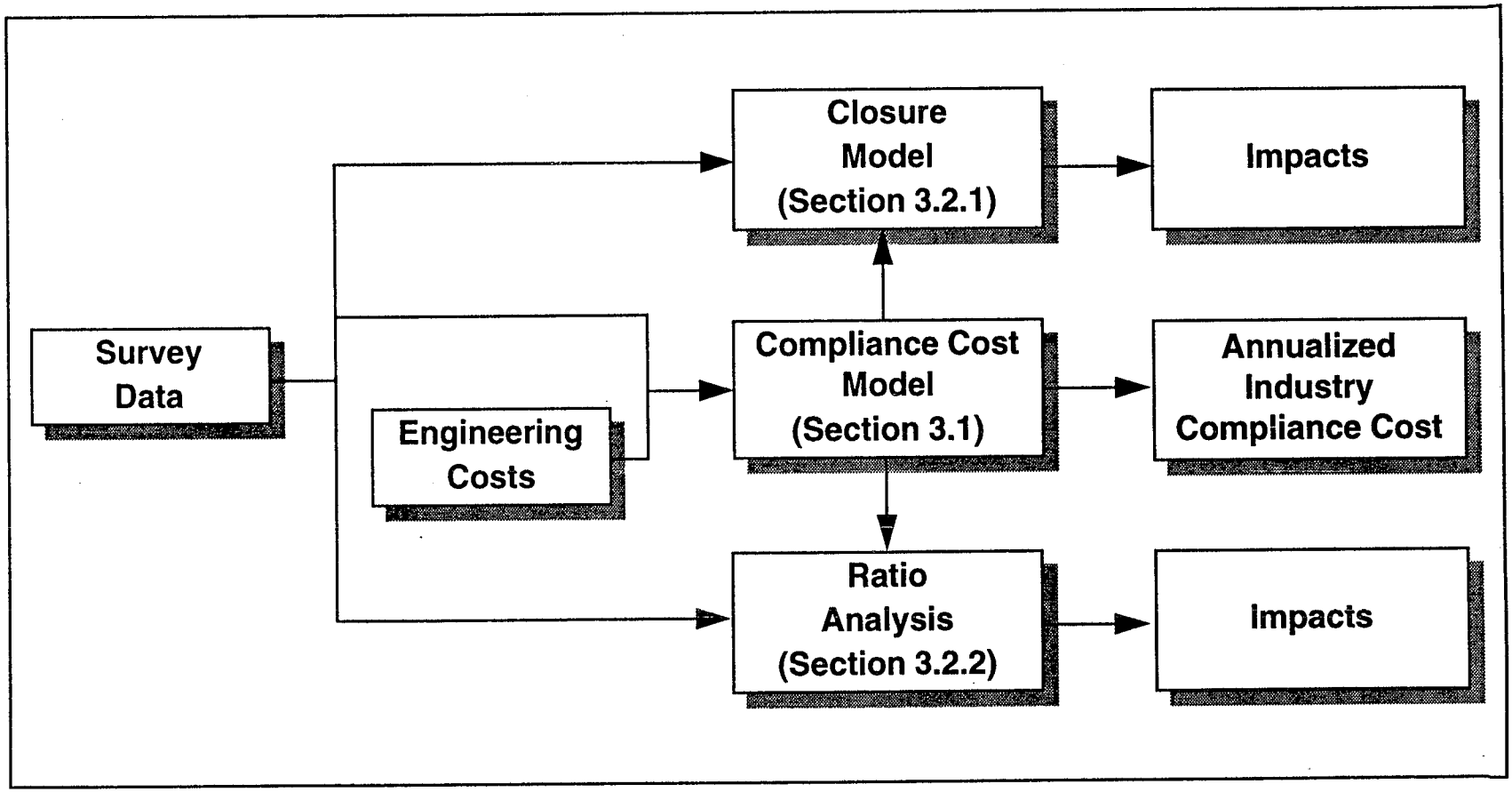

Figure 3-2. Overview of financial model methodology.

regulation are so great that an individual facility is no longer profitable. In addition to lost profits, closures could lead to secondary impacts such as:

- Losses in employment
- Losses in government tax revenues
- Adverse effects on small business
- Losses in paper or pulp production capacity, leading to:
  - Supply/demand adjustments and product pricing shifts
  - Negative impacts on the U.S. foreign trade account

Facility closures are estimated by comparing the mill's "salvage value" to the present value of its future earnings. The salvage value represents the expected amount of cash the owner would receive if the mill were closed and liquidated. The present value represents the value in current dollars of the expected stream of earnings that the mill can generate. If the salvage value of the mill is greater than the earnings the mill is expected to generate, then the owner presumably would liquidate the mill rather than operate it.[7] Figure 3-3 provides a schematic diagram of the methodology and components used in the closure analysis. Sections 3.2.1.1 and 3.2.1.2 describe the calculation of the salvage value and the present value of future earnings, respectively. Section 3.2.1.3 describes a sample closure analysis. Section 3.2.1.4 discusses the scoring methodology used to project closure, and Section 3.1.2.5 reviews the reasons mills could be identified as closures before any incremental pollution control costs are incurred (i.e., baseline closures).

[7]When a mill is liquidated for its salvage value, the Agency assumes that the mill no longer is operated; thus, closure-related impacts could result. In contrast, mills that are sold because a new owner presumably can generate a greater return are considered *transfers*. Transfers cause no closure-related impacts, even if the transfer was prompted by increased regulatory costs. Transfers are not estimated in this analysis.

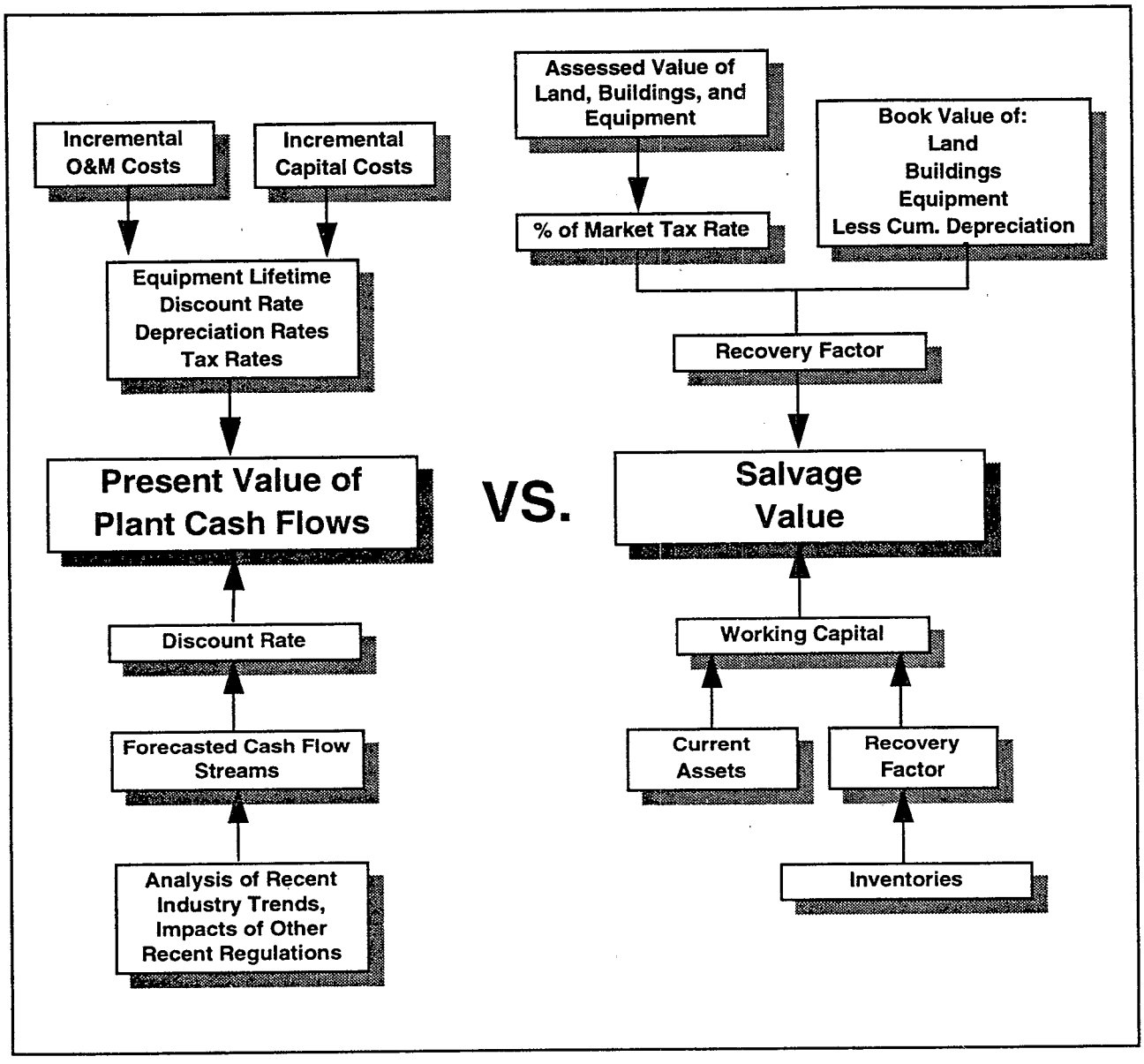

Figure 3-3. Overview of closure analysis methodology.

3.2.1.1 Salvage Value

The salvage value is calculated assuming the mill will be closed. Thus, assets are evaluated based not on their potential for contributing to operations, but only on their market value in a liquidation sale of plant and equipment. Salvage value is estimated assuming that all cash transactions are realized in the current year and that discounting is not required. In fact, many mills could face multiyear obligations that are not dismissed with mill closure. The salvage value is the net cash realized by the plant owner after all assets are sold and obligations are dismissed.

Salvage value includes the value of short-term (or current) assets and long-term and fixed assets. Short-term assets, defined as those assets not expected to be held beyond a year, include cash, short-term Certificates of Deposit, inventory, and other assets. Long-term assets include financial instruments expected to be held beyond a year and fixed assets of plant, equipment, and land.

Short-term assets held on mill balance sheets generally will be considered part of the mill's working capital and therefore are clearly part of the mill's asset base. Long-term financial assets, such as deferred bond expense, stocks, bonds, and intangibles, could be held on the balance sheet of either the mill or the parent company.[8] There is no method of determining what share of the long-term financial assets of a parent company or headquarters mill should be allocated to individual mills. These assets are also typically considered independent of normal mill working capital or mill operations. Timberlands are considered long-term investments that are essentially separate from the mill (i.e., they have value whether or not the mill continues to operate). Therefore, timberlands and long-term financial assets other than land, buildings, and equipment were excluded from the salvage value calculations. All other tangible assets (both

[8]The survey has separate sections for balance sheet information depending on whether the facility is part of a multifacility operation. An independent, single-facility company would be able to show a detailed balance sheet for the mill, while mills that belong to a multifacility company might have components held only at the corporate level, not at the facility level. Only those components allocated to a facility were included in the closure analysis.

short- and long-term) are included in the salvage value. The most recent data in the survey (1989) is used in the salvage value calculation.

Valuing Current Assets. Current assets include cash and near-cash financial assets, accounts receivable, and inventories. The valuation of these assets is based on their probable stability during an auction/liquidation process. Since cash and near-cash financial instruments would not decline in value in the event of liquidation, they would command their face value even in a distress sale. Accounts receivables and inventories (including both inventories of raw materials and finished products) are likely to decline in value to some degree depending on factors such as company and industry experience with bad debt problems, economic conditions, and the geographic proximity of potential purchasers of raw materials or finished products.

Current assets are carried at the mill level based on their original purchase cost or, in the case of finished goods, at the manufacturing cost. In valuing these assets, the Agency assumes that they are made up of two components: intangibles (e.g., cash, receivables, and short-term investments) and inventories (e.g., raw materials, supplies, fuels, work-in-progress, and finished goods). In the event that the facility is liquidated at an auction, these assets would be recovered at varying proportions of their book value.

Since intangible current assets are the most liquid, the Agency assumes they would be recovered at their face value. Unlike inventories, most intangible current assets would maintain their book value in the event of an auction. Some items, such as CDs and other short-term investments, actually are likely to appreciate in value compared to their cost as recorded on the books. Accounts receivable, however, could be worth less than their book value, depending on each mill's accounting practices for recognizing bad accounts. Overall, the Agency assumes that the book value of these assets accurately reflects their actual market value (i.e., they are valued at 100 percent in the salvage value calculations).

Inventories are not as marketable as the rest of current assets because of their unique or specialized purposes. In the event of liquidation, a mill would have to sell its inventories at a fraction of their recorded book value. For example, the demand for specialty items such as deinking chemicals would depend on the number of nearby deinking mills that use similar

processes. Such products likely could not be sold for what the mill paid to the chemical supplier. For this reason, the analysis values inventories by applying a recovery factor that represents the portion of book value expected to be recouped in a sale. A 40-percent recovery factor is used to calculate the salvage value of inventories. This recovery factor reflects the fact that many of the specialty supplies and unfinished products would have to be sold at a fraction of their book value, while basic commodities such as finished pulp and raw materials likely would maintain most of their value in the event of liquidation.[9]

Valuing Fixed Assets. Two approaches are used to estimate the value of the fixed or long-term assets at each facility: based on the tax assessment values and based on the book value of the fixed assets. Since neither method is always satisfactory, both are incorporated into the closure model.

Tax Assessments. Most of the mills pay local property taxes based on the assessed value of the mill's fixed assets. Questionnaire responses provide information about the 1989 assessed value of each facility's land, buildings, and equipment. The questionnaire also provides the percent of market value on which the tax assessment was based. Each facility's market value is calculated as the facility's assessed value divided by the percent of market value rate. A 20 percent recovery factor is applied to the result to reflect the fact that the assets would be liquidated at a fraction of their value.

Not all facilities could provide both tax assessments and percentage of market value. Questionnaire responses indicate several possible reasons:

- Some facilities were not assessed for tax purposes.
- Some assessments included nonmill assets.
- Some assessments bore no relationship to current market value of the assets.

[9]Companies might maintain their inventories under a "First In First Out" (FIFO) approach or under the "Last In First Out" (LIFO) approach. During inflationary periods, LIFO will tend to undervalue inventories, generally as a means of limiting tax liability. The survey did not ask the respondent to identify the inventory accounting system used; however, the system used is unlikely to create a significant difference in the analysis.

Book Value. An alternative approach for estimating the salvage value of each facility's fixed assets is according to the most recent balance sheet. The book value of the fixed assets (including the facility land, buildings and improvements, equipment, and machinery) can be calculated from the survey data. The book value is equal to the recorded cost less any accumulated depreciation. (As mentioned above, assets such as long-term investments and timberlands are excluded from this calculation.) Similarly to the tax assessment approach, a 20 percent recovery factor is applied to the book value of the fixed assets to reflect the liquidation value of those assets.

There are potential difficulties with using the book value of assets to estimate the salvage value of a mill. The book value understates the true value of some assets while overstating the value of others. For instance, a facility's land could have been purchased as long ago as the 19th century, and has since appreciated in value tremendously. Other assets, however, such as a cement settling tank, might have no market value, but could continue to carry a book value since they have not yet been completely depreciated.

Summary of Salvage Value Estimates. The Agency examined the estimated salvage values for the 317 mills that are expected to bear the costs of regulation and that can be analyzed in the closure model. For all of these mills combined, the book value approach led to a higher average salvage value than the tax assessment approach. When looking at individual mills, however, the tax assessment salvage value was higher than the book value in about 3 of 10 cases (Table 3-8).

Mill closure costs, which reduce the overall salvage value of the facility, are difficult to estimate even by mill executives. These costs can include pension administration, payout costs, and site cleanup prior to sale. These costs are not included in the salvage value estimate. As a result, the calculated salvage value could be high, which would make the mill more likely to be projected to close in the analysis. This approach leads to a conservative estimate of the number of mill closures.

In summary, the closure model relies on two estimates of salvage value for each facility:

- Tax assessment value of fixed assets plus short-term assets

TABLE 3-8
SUMMARY OF TECHNIQUES FOR DETERMINING SALVAGE VALUE

Parameter	Salvage Value (Thousands, 1989 Dollars) Average	Total	Percent of Time Salvage Value Estimation Approach Produced Greater Value
Assessment Approach:	$38,490	$10,854,209	29%
Book Value Approach:	$41,905	$13,032,453	71%

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- Book value of fixed assets plus short-term assets

The values of fixed assets and inventories are reduced by recovery factors to reflect liquidation values.

3.2.1.2 Present Value of Forecasted Earnings

The present value of each mill is its future stream of earnings in current dollars. The valuation assumes that the mill continues to be used for the manufacture of paper or pulp. The methodology uses recent earnings and other data to estimate future earnings, and then discounts the future stream to derive the present value. The components of this analysis include measuring earnings, establishing a time frame for the analysis, projecting earnings, discounting earnings, and incorporating the incremental costs of regulation. In addition, Subchapter S corporations require separate consideration because income is taxed at the rate for individuals, not corporations.

Definition of Economic Earnings. Two alternatives were examined to estimate the present value of future plant operations:

- Net income, calculated as revenues less manufacturing cost of goods sold; selling, general, and administrative expenses; depreciation; interest; and taxes.
- Cash flow, which equals net income plus depreciation.

Estimates of the present value generated from future plant operations generally are based on cash flow projections. Depreciation is added to net income because it reflects previous, rather than current, spending and does not actually absorb any portion of incoming revenues.

Net income figures also can be used to project the value of continued plant operations. This approach assumes that ongoing reinvestment in plant and equipment will be necessary and that in the long run, depreciation costs should be reflected as a charge against earnings (i.e., annual maintenance is not sufficient to ensure a mill's efficiency and capacity in the long run). This approach was chosen to reflect the continuing capital investment and expansion seen for the

majority of mills in the survey (see Section 2.4.4)—the more conservative indicator of the future value of continued plant operations. This approach, however, might overestimate the potential closures of newer plants, which would report higher depreciation figures (i.e., the required investment is overstated) and thus lower earnings. These facilities might appear less economically viable than they actually are in such an analysis.

In the closure model, the present value of future earnings is calculated based on *net income*. For independent facilities, earnings generated from long-term investments are not included. These revenues (identified in survey responses) are considered to be independent from the mill's paper and pulp production. Furthermore, since the assets generating these revenues are excluded from the salvage value calculation, their earnings should not be included on the opposite side of the closure equation.

Time Frame for Analysis. The capital expenditures associated with additional pollution control for the pulp and paper industry are depreciated over a 15-year lifetime in the cost annualization model (see Section 3.1.1). The same time frame is used for the present value analysis.

Earnings Forecast. Three methods are used to forecast future earnings. All three methods are based on the 1985, 1988, and 1989 data collected in the survey and all use the same general set of assumptions and procedures:

- No cost pass-through. The mill is assumed to be unable to raise prices to recoup incremental pollution control costs. It is as if there is a foreign supply waiting at the U.S. border; if domestic mills raise their prices, imports will flood into the domestic market.
- No growth. The mill is assumed to be running at or near capacity and significant growth is considered unlikely without a major capacity addition.
- Constant 1989 dollars. Data from 1985 and 1988 are inflated using the change in the Consumer Price Index (see Table 3-2).

- Earnings for 1986 and 1987. Earnings from 1985, 1988, and 1989 were regressed to estimate 1986 and 1987 earnings. If no 1985 data were available, the earnings were set to zero for that year.[10]

- Tax rate applied, if necessary, to obtain after-tax earnings. For facilities that are part of multiple-facility companies, earnings are estimated as revenues minus costs. These amounts are adjusted to after-tax earnings using tax rates for corporate income shown in Section 2 of the questionnaire for the business entity. For independent facilities, net income is taken from the income statement and does not need to be adjusted. For S-Corporations, after-tax earnings are estimated using personal tax rates.[11]

The three forecasting methods can be summarized as follows:

- Simple Cycle
  - Peak year of cycle is 1989, based on industry data.
  - Data for 1985 to 1989 are repeated in mirror image to provide cycle.
  - Advantage: Stays closest to survey data, retains cyclical nature of industry.
  - Disadvantage: Does not account for what happened in 1990 and 1991, at least not on an industry-wide basis.

- Moving Average
  - Data for 1990 and 1991 are generated by scaling 1989 earnings based on industry-wide decline rates.
  - Data for 1992 to 2011 generated as a 7-year moving average.
  - Advantage: Data for 1990 and 1991 incorporate more information than simple cycle method.
  - Disadvantage: Moving average dampens industry cycle.

- Modified Cycle
  - Data for 1990 and 1991 are generated by scaling 1989 earnings based on industry-wide decline rates.

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[10]Where 1985 earnings were available in the survey data, about half the entries were positive and half were negative (i.e., the facility suffered a loss). Thus, in the absence of survey data , a value of zero is a reasonable estimate of 1985 revenues for a facility.

[11]A facility's operating losses, like earnings, are reduced by the tax shield. The owner may use the operating loss to offset income from another facility or carry the loss forward to offset income generated in the future. For mills owned by multifacility companies, the closure model selects a federal tax rate based on the parent's marginal income tax rate. If the parent shows a loss, logic implies a 0-percent tax rate. The fact that a parent company has net losses should not imply that a mill's earnings are tax-free. The closure model uses a marginal federal tax rate of 34 percent for mills whose parent shows a net loss. The 34-percent bracket was the most representative for companies in the closure analysis.

- Data for 1985 to 1991 are repeated for 1992 to 1998 and from 1999 to 2005.
- Advantage: Data for 1990 and 1991 incorporate more information than simple cycle method, retains cyclical nature of industry.
- Disadvantage: Sharp shifts are seen between cycles; could be interpreted as sharp management action to correct the mill's financial performance.

These forecasting methods reflect both smoothed and unsmoothed approaches to modeling the cyclical nature of the paper and pulp industry.[12] In the moving average and modified cycle methods, earnings for 1990 and 1991 are scaled from 1989 data using the industry-wide decline in profits shown in Mies et al., 1992. Decline rates used in the calculations are 30.7 percent (for 1990) and 28.0 percent (for 1991).

Figure 3-4 illustrates the three forecasting methods. The survey data are the points shown for 1985, 1988, and 1989 (Figure 3-4, right side). The data for 1986 and 1987 are obtained by regressing the 1985, 1988, and 1989 data. These five values form the basis for the forecasted values (Figure 3-4, left side).

For the simple cycle, the value for 1988 is repeated for 1990, 1996, 1998, 2004, and 2008. The forecasted sequence has two peaks, 1997 and 2005, and two low points, 1993 and 2001. The data for 1990 and 1991 are the same for the moving average and modified cycle approaches—both are scaled by the industry decline rates. The moving average approach rapidly smooths the fluctuations of the business cycle to a near-horizontal line. The modified cycle has timing differences from the simplified cycle—there are two peaks, 1996 and 2003, but three low points, 1992, 1999, and 2006. While Figure 3-4 illustrates a typical pattern seen in the survey data, a wide range of possible patterns exist. Because of the uncertainty about the choice of forecasting models and potential outcomes, a methodology was developed to incorporate all three forecasting methods in the closure analysis (Section 3.2.1.3).

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[12]Other parameters, such as gross domestic product and population, are not included in the forecasting model because they are measured on a national basis while the forecasts are done on a facility basis. For example, a population increase may lead to increased paper demand, but the mill cannot increase its output beyond its capacity.

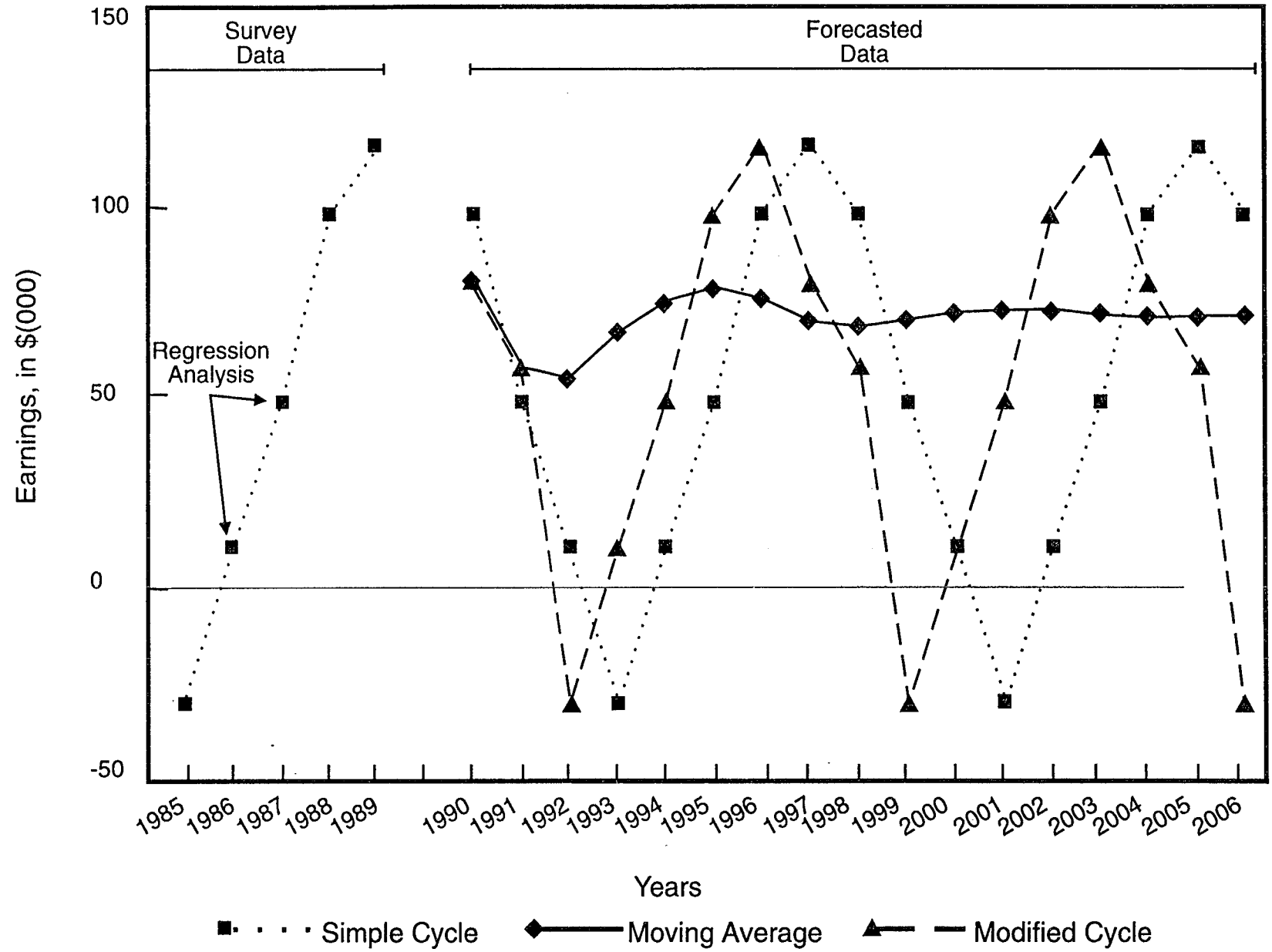

Figure 3-4. Forecasting methods.

Discounting. The final step in estimating each mill's baseline present value is to discount the earnings stream back to current dollars. This step does not adjust the stream for inflation,since the earnings projections are in real terms. Thus, the discount rate used for discounting must be a real discount rate, obtained by subtracting the estimated annual rate of inflation (see Table 3-2) from the nominal discount rate. The same requirement used in the cost annualization model (i.e., the discount rate must be between 5 and 19 percent) is used in the calculating the present value of future earnings.

Summary of Forecasting Earnings. In summary, three estimates of earnings are used in the closure model:

- Moving average
- Simple cycle
- Modified cycle

The Agency examined the present value of future earnings as calculated by the three forecasting methods for the 317 mills that are estimated to bear regulatory costs and are in the closure analysis. Table 3-9 summarizes the results. The moving average method results in the highest average present value and, in more than half the cases, the highest present value for an individual mill. This result is expected because the moving average dampens out the business cycle (see Figure 3-4). For almost all the remaining cases, the simple cycle method results in the highest present value for an individual mill. The modified cycle results in the highest present value for a mill in only 1 percent of the cases. The modified cycle method also has the lowest average present value.

The three forecasting methods produce average present values of future earnings that are within 13 percent of each other. For specific facilities, the estimates can show a wider variation. Since the determination of whether a facility is likely to close is a comparison of the salvage value and value of future earnings, the choice of a forecasting method may affect whether the facility of projected to close. The choice of a forecasting method may also change the closure determination if there is very little margin between the salvage value and post-regulatory future

TABLE 3-9
SUMMARY OF TECHNIQUES FOR DETERMINING FORECASTED EARNINGS

Parameter	Present Value of Forecasted Earnings (Thousands, 1989 Dollars) Average	Total	Percent of Time Forecasting Method Produced Highest Estimate
Simple Cycle:	$160,503	$51,039,796	62%
Moving Average:	$154,255	$49,052,970	37%
Modified Cycle:	$142,026	$45,164,127	1%

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earnings. For these reasons, the closure analysis incorporates all three forecasting methods in the evaluation of facility closure.

3.2.1.3 Sample Closure Analysis

Table 3-10 cross-references the data used in the closure analysis with the survey data. Figures 3-5a and 3-5b are an annotated printout of the closure model based on hypothetical data. When actually used, however, the closure model output closely resembles Figures 3-5a and 3-5b, and contains facility-specific confidential information.

In Figure 3-5a, the section labeled "A" contains input variables for the calculation. The estimated inflation rate is based on the change in the Consumer Price Index from 1981 to 1991 (Table 3-2). The company-specific discount rate is taken from survey data. The average discount rate is calculated from the survey data based on company discount rates that fall between 5 and 19 percent. The next line shows the nominal discount rate used in the present value calculations. The real discount rate is calculated as the nominal discount rate minus inflation. Recovery factors for inventories and fixed assets are given as 40 and 20 percent, respectively. The company tax structure is used to identify which set of tax rates should be used to calculate after-tax income. In the example, the facility's tax rate is based on the income level of the company that owns the mill. For an independent facility, the net income does not need to be adjusted for taxes. For an S Corporation, personal income tax rates are used (CCH, 1991a). The average state tax rate is added to federal tax rate to provide the combined effective tax rate for the mill.

Two methods were used to calculate the salvage value of a mill: tax assessment and book value. Salvage values for the mill are calculated in Section B of Figure 3-5a. (Note that all values are expressed in thousands of dollars.) The salvage value of currents assets is: $30,000 + ($62,000 x 40%) = $54,800. Under the tax assessment method, the mill's salvage value is $36,000, which is 20 percent of its market value, $180,000. The book value of the mill is the sum of the book value for the individual components minus the cumulative depreciation ($6,500 +

TABLE 3-10
COMPONENTS USED IN THE CLOSURE ANALYSIS

Description	Location in Questionnaire		SAS File Member Name	
	Multifacility	Independent	Multifacility	Independent
SALVAGE VALUE COMPONENTS:				
1989 Book Value of Current Assets	57a	45a	B3C	B3B
1989 Book Value of Inventories	57b	45b	B3C	B3B
1989 Assessed Value of Fixed Assets	77d	77d	B3D	B3D
Percent of Market Value	78	78	B3D	B3D
1989 Book Value of Land	58e	46d	B3C	B3B
1989 Book Value of Buildings	58g	46f	B3C	B3B
1989 Book Value of Equipment	58h	46g	B3C	B3B
1989 Cumulative Depreciation	58j	46k	B3C	B3B
1989 Book Value of Other NC Assets	58i	46h-j	B3C	B3B
EARNINGS COMPONENTS:				
Independents:				
Net Income				
1985		16k		B2B
1988		19k		B2B
1989		22k		B2B
Other Income:				
1985		16b		B2B
1988		19b		B2B
1989		22b		B2B
Multis:				
Revenues				
1985	65 (1985)		B3D	
1988	65 (1988)		B3D	
1989	65 (1989)		B3D	
Manufacturing Costs				
1985	68		B3D	
1988	71		B3D	
1989	74		B3D	
Non-Manufacturing Costs				
1985	69a		B3D	
1988	72a		B3D	
1989	75a		B3D	
Company Discount Rate	13	35	B2A	B3A

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CONFIDENTIAL BUSINESS INFORMATION

CLOSURE MODEL Survey ID#: 1234 Class: BAT run date: 28-Jun-93

ALL FIGURES IN THOUSANDS OF DOLLARS

A INPUT VARIABLES:

Inflation Rate (1990-2011):	4.0%
Co.-Specific Discount Rate (Nom.):	14%
Avg. Discount Rate (Nominal):	13.0%
Nominal Discount Rate:	14.0%
Real Discount Rate:	10.0%
Inventory Recovery Factor:	40.0%
Fixed Asset Recovery Factor:	20.0%
Company Tax Structure:	1
Taxable Income (Corp. Parent):	800,000
Federal Income Tax Rate:	34.0%
Avg. State Income Tax Rate:	6.8%
Combined Eff. Income Tax Rate:	40.8%

Federal Corp.Tax Table:

Taxable Income ($000)	Average Effective Tax Rate
$0	15.0%
$50	16.7%
$75	20.4%
$100	28.3%
$335	34.0%

Federal Personal Tax Table:

Taxable Income ($000)	Average Effective Tax Rate
$0	15.0%
$20	21.5%
$47	30.5%
$98	31.0%

(1=Multi; 2=Independent; 3=S-Corp.)
(what if '85 income is in different bracket than '88 & '89)

B SALVAGE VALUE:

CURRENT ASSETS:

1989 Cash:	30,000
1989 Inventories:	62,000
Total:	$54,800

FIXED ASSETS:

Tax Assessed Value:

	Assessed Value	Assessment Rate	Market Value	Recoverable Value
Total (b077D):	180,000	100%	$180,000	$36,000

Book Value:

1989 Land:	6,500
1989 Buildings:	62,000
1989 Equipment:	820,000
Less Cum. Deprec.:	310,000
Total:	$578,500
Recoverable Value:	$115,700

TOTAL SALVAGE VALUE OF MILL:

Using Tax Assessments:	$90,800
Using Book Value:	$170,500

Need to examine notes sections to see if assessment rates vary for real assets vs. fixed assets.

Figure 3-5a. Closure analysis model—Inputs and salvage value using hypothetical data.

PRESENT VALUE:

C

PAST EARNINGS ($1989):
Corporate Tax Structure: Multi-Facility Co.

		Pre-Tax	Post-Tax
Earnings	1985	(50,000)	($29,625)
Earnings	1988	120,000	$71,100
Earnings	1989	150,000	$88,875
Estimated Earnings	1986	$4,615	$2,735
Estimated Earnings	1987	$56,154	$33,271

Regression Output:

Constant	-1.02E+08
Std Err of Y Est	15689.291
R Squared	0.9894203
No. of Observations	3
Degrees of Freedom	1
X Coefficient(s)	51538.462
Std Err of Coef.	5329.3871

FORECASTED EARNINGS:

Year	Cycle	Avg.	Cycle2
1985	($29,625)	($29,625)	($29,625)
1986	$2,735	$2,735	$2,735
1987	$33,271	$33,271	$33,271
1988	$71,100	$71,100	$71,100
1989	$88,875	$88,875	$88,875
1990	$71,100	$61,590	$61,590
1991	$33,271	$44,345	$44,345
1992	$2,735	$38,899	($29,625)
1993	($29,625)	$48,688	$2,735
1994	$2,735	$55,253	$33,271
1995	$33,271	$58,393	$71,100
1996	$71,100	$56,577	$88,875
1997	$88,875	$51,964	$61,590
1998	$71,100	$50,588	$44,345
1999	$33,271	$51,480	($29,625)
2000	$2,735	$53,278	$2,735
2001	($29,625)	$53,933	$33,271
2002	$2,735	$53,745	$71,100
2003	$33,271	$53,081	$88,875
2004	$71,100	$52,581	$61,590
2005	$88,875	$52,669	$44,345
2006	$71,100	$52,967	($29,625)
2007	$33,271	$53,179	$2,735
2008	$2,735	$53,165	$33,271
2009	($29,625)	$53,055	$71,100
2010	$2,735	$52,957	$88,875
2011	$33,271	$52,939	$61,590
BASELINE PRESENT VALUE:	$266,861	$416,898	$288,859

D

SUMMARY:

		Assessment:	$90,800		Salvage Value: Book:	$170,500		
Regulatory Option	PV of Incremental Reg. Costs	Cycle $266,861	Mov. Avg. $416,898	Mod Cycle $288,859	Present Value: Cycle $266,861	Mov. Avg. $416,898	Mod Cycle $288,859	Closures
Baseline	$0	0	0	0	0	0	0	0
Option 2	850	0	0	0	0	0	0	0
Option 3	2,500	0	0	0	0	0	0	0
Option 4	5,000	0	0	0	0	0	0	0
Option 5	10,000	0	0	0	0	0	0	0
Option 6	25,000	0	0	0	0	0	0	0
Option 7	50,000	0	0	0	0	0	0	0
Option 8	75,000	0	0	0	0	0	0	0
Option 9	100,000	0	0	0	1	0	0	1
Option 10	150,000	0	0	0	1	0	1	2
Option 11	226,000	1	0	1	1	0	1	4

Figure 3-5b. Forecasted earnings and closure score using hypothetical data.

$62,000 + $820,000 - $310,000 = $578,500). Liquidation value is 20 percent of the book value: $115,700. The total salvage value for the mill is:

- Tax assessment = $54,800 + $36,000 = $90,800
- Book value = $54,800 + $115,700 = $170,500

Earnings are forecasted in Section C of Figure 3-5b. The first three lines list the earnings for 1985, 1988, and 1989 as taken from the survey. The three pretax values are regressed, and the values for 1986 and 1987 are calculated. Because the example mill part of a multifacility company, the earnings (revenues minus costs) must be adjusted to posttax earnings. The present value is calculated for each of the forecasted earnings streams using the discount rate in Section A.

The simple cycle uses data from 1985 to 1989 in mirror-image fashion, as indicated by the brackets. There are two peaks, 1997 and 2005, and two low points, marked by dots at 1993 and 2001. For the moving average and modified cycle, the data for 1990 and 1991 are scaled using industry decline factors. The moving average is calculated on a 7-year basis (i.e., the value for 1992 is the average for 1985 through 1991. The modified cycle repeats the values for the 1985-1991 period. There are two peaks, 1996 and 2003, and three low points, marked by dots at 1992, 1999, and 2006.

Section D of Figure 3-5b summarizes the results of the closure analysis. Each row, beginning with the one entitled "Baseline," represents a regulatory alternative or option. The present value of the incremental regulatory cost for each option is calculated with the cost annualization model (Section 3.1, Table 3-1). With two methods of estimating salvage value (book and tax assessment) and three methods of estimating the present value of future earnings (simple cycle, moving average, and modified cycle), there are six ways to evaluate facility closure. The post-regulatory earnings are calculated by subtracting the present value of incremental regulatory costs from the present value of projected earnings. For example, under Option 9, the present value of the post-regulatory earning is $266,861 - $100,000 = $166,861 for the simple cycle method of projecting earnings. This value is greater than the salvage value as calculated by the tax assessment method ($90,800) but lower than the salvage value as calculated by book value

($170,500). A mill that is determined not to close under a particular combination is given a score of 0 for that combination. A mill that is determined to close under a particular combination is given a score of 1 for that combination. The scores are then totaled for all combinations. Under Option 9, the simple cycle/tax assessment combination has a score of 0, while the simple cycle/book value combination has a score of 1. The right-hand column sums the entries for all six earnings projections/salvage value combinations to provide a closure score. The closure score for a given facility, then, can range from 0 (no closure under any combination) to 6 (closures under all combinations).

3.2.1.4 Scoring Method for Projecting Facility Closure

The last step in the closure analysis is to evaluate when a mill would be considered a closure. The closure score for a mill can range from 0 to 6. As mentioned earlier, there could be difficulties with a particular mill's data or estimation methods. For this reason, the mills with closure scores of 1 or 2 are not considered closures. A score of 4 or higher in the closure model is considered a facility closure. A score of 4 or higher results from the salvage value exceeding the post-regulatory projected earnings under at least two forecasting methods and both methods of estimating salvage value. Under these circumstances, the Agency assumes the mill would close. In the example given in Figure 3-5d, the mill experiences adverse financial impacts beginning with Option 9, but is not considered a closure until Option 11.

For mills with no tax assessment salvage value, however, a score of 3 predicts closure. A mill with a score of 3 would have scored 1 for every combination of forecasting method and book value for salvage value estimate, and the Agency assumed that, if a tax assessment were available, the mill would be likely to close under at least one forecasting method/tax assessment for salvage value combination.

3.2.1.5 Baseline Closures

A baseline closure is a mill that fails the salvage value test before the addition of incremental pollution control costs. Section 2.4.5 of the industry profile identified a category of mills that is likely to appear as baseline closures. These are "captive" mills—mills that exist to serve other facilities under the same ownership. In the entire mill population, between 46 and 51 mills reported that over 90 percent of all pulp, paper, and paperboard revenues were from transfers to other facilities under the same ownership. In addition to these captive mills, between 56 to 60 mills indicated that 90 percent or more of their revenues from one product (pulp, paper, or paperboard) were from transfers to other facilities under the same ownership. Over half of the mills indicated they transferred some product to other facilities under the same ownership during the survey period.

Since many of the transfers are done at cost, these captive and near-captive mills would show little, if any, profit. If the captive mills have any salvage value, they could be deemed closures before the addition of incremental pollution control costs. In actuality, these mills would not close but would raise the transfer prices for their products to meet the incremental costs of pollution control; they should not be considered as closures due to the incremental cost of regulation.

Of the 338 mills estimated to bear incremental costs in this rulemaking, data were available to perform the closure analysis on 317. About 84 of these 317 mills are considered baseline closures. Nearly 40 percent of the baseline closures (31 mills) show anywhere from 1 to 3 years of losses. Fourteen mills show only minimal profits. (The earnings for these mills might be more favorable if we examined cash flow rather than net income.) Sixteen mills are considered "captive" mills. Fifteen mills had high salvage values because of their large amounts of cash. (Current assets, other than inventory, are valued at 100 percent while all other components in the salvage value are reduced by a recovery factor.) These mills are unlikely to close even though the salvage value exceeds the present value of future earnings.

In other words, the industry profile identified a category of mills likely to appear as baseline closures before the closure analysis was performed. Given the widespread practice of

transferring product to other mills under the same ownership, low earnings may be a frequent phenomenon in the survey data. The methodological choice of analyzing net income rather than cash flow for projected earnings also results in low earnings projections. The analysis of the baseline closure results also identified a small number of mills whose large cash positions led to high salvage values, which in turn, resulted in the mills considered as baseline closures. In summary, a mill could be a baseline closure for a wide range of reasons. The projection of baseline closures is consistent with the industry structure as seen in the survey data and the methodology chosen for the financial analysis. The objective of the closure analysis, however, is to examine the impacts of additional pollution control costs on the pulp and paper industry. To examine impacts, only the incremental closures (i.e., beyond baseline) are counted because these closures can be attributed solely to the incremental costs of compliance.

3.2.2 Ratio Analysis

Financial ratios represent an accepted method for evaluating financial performance and health. For example, investors and lenders often use ratios to determine whether a firm is creditworthy. Managers use ratios to help build strategies for capital investment, mergers and acquisitions, pricing, or any other decision that could affect the firm's financial structure. Similarly, in an investigation of regulatory compliance costs, ratio analysis can provide insight into how additional pollution control requirements will affect the financial structure of mills. In contrast to the closure model discussed in Section 3.2.1, financial ratio analysis identifies economic impacts on facilities and companies that are less severe than closure.

In ratio analysis, standard financial data are translated into statistics that allow for comparison of the health of reporting entities or groups of entities. Financial health comparisons are based on profitability, leverage, liquidity, and other relevant characteristics.

Pulp and paper firms might make capital expenditures and incur annual operating and maintenance costs associated with additional levels of pollution control. These investments, which might not contribute to product quality or output level, could adversely affect their financial structure. The magnitude of such impacts depends on the size of the investment

required, the size of the firm, and the method of financing. Furthermore, the size of the investment, or the cost of compliance, is often a function of the products produced, the current equipment and processes used, and the new level of control required.

Data gathered in the survey are used to develop a financial profile of the industry's facilities and firms. The cost of additional pollution control is then combined with the balance sheet information under two alternative financing options (i.e., long-term debt and working capital). A pre- and post-regulation ratio analysis of the facilities and companies is used to compare the financial health of the firms before regulation and under alternative regulatory options.

3.2.2.1 Financial Ratios

To derive an accurate financial profile of the industry, a variety of financial ratios are used. Several measures of economic impacts often must be examined to obtain a clear picture of the regulation's potential effects. The ratios to be used in the analysis cover three basic aspects of the financial structure and health of a facility or firm:

- Profitability
- Leverage
- Liquidity/solvency

Profitability Ratios. Profitability ratios measure the company's ability to make a profit relative to the size of its sales, stockholders investment (equity), and capital investments (assets). Examples of profitability ratios include net income margin, return on equity, and return on assets.

Net Income Margin. Net income margin measures the percentage of sales revenue that is converted into profit. Net income, for this analysis, will be calculated as earnings after interest and taxes. This ratio is a good indicator of profitability to use when comparing the regulatory

effects on prices. For instance, knowing that a firm converts $0.22 of every $1.00 in sales to profit helps assess its ability to absorb additional pollution control costs without a price increase. The larger the margin, the greater the facility's ability to absorb increased costs and still remain profitable. This ratio will be calculated from survey data at the business-entity level and, for independent single-facility entities, at the facility level.

Return on Assets. Return on assets (ROA) measures the firm's efficiency in using assets to generate profits. An ROA of 18 percent indicates that $0.18 in profit is generated for every $1.00 in assets. ROA reflects differences in leverage as well as in profitability because high interest payments to finance assets can result in lower taxes.[13] ROA is used in the analysis because it can be calculated for both the facility level and the business level.[14]

Leverage Ratios. Leverage measures the level of debt a firm uses to finance its operations. Investment in additional pollution control equipment could affect a firm's leverage if additional debt is taken on to finance pollution control equipment. The reduction in leverage due to investment in pollution control could affect the firm's financial flexibility. In general, a highly leveraged firm has less flexibility to ride out a market downturn; similarly, it would not have the resources to take advantage of opportunities for upgrading, expansion, or acquisition.

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[13]The Agency considered using return on equity (ROE) in the financial analysis. ROE measures how effectively the company creates value for the equity holders. An ROE of 18 percent indicates that for every $1.00 of equity invested in a firm's assets, $0.18 of net income is generated. This ratio measures the firm's efficiency in using invested money to generate profits. ROA and ROE highly correlated, i.e., they tend to move together, (see Brealy ~~and Myers~~, 1984, pp. 580). Using both variables would not provide much additional information. Because equity information needed to calculate ROE is generally not held at the facility level and because equity information for common shareholders only is not available for most organizations, the Agency did not use ROE in the financial analysis.

[14]At the business entity level, ROA is calculated as net income/total assets. At the facility level, it is calculated as (revenues - manufacturing costs - nonmanufacturing costs)/total assets, because taxes and interest are rarely kept at the facility level. Technically, interest tax shields should be removed from cash flows and an average of assets from the beginning of the year to yearend should be used when calculating ROA values. Since neither parameter is available from the survey, however, these adjustments are not included. The analysis focuses on the change in the ratio due to incremental pollution control costs, rather than fine-tuning the baseline estimates.

Instead, such a firm would be committed to making interest payments on its debt, thus minimizing outlays for ongoing operations or expansions.

Times Interest Earned. The times interest earned (TIE) ratio measures the amount of interest payments a firm must make in relation to its cash flows. The TIE ratio is calculated as follows:

TIE = [Earnings before interest and taxes (EBIT) + depreciation] ÷ interest expense

For example, a firm with a TIE ratio of 5.0 has cash flows sufficient to cover a five-fold increase in interest expense.

Debt Ratio. The debt ratio, as calculated in this analysis, is the proportion of total debt to total assets. Total debt will be calculated as the sum of all liabilities. This ratio is a common indicator of the degree to which debt is used to finance the assets of the company.

Considered in conjunction with one another, these two ratios provide a good picture of a firm's leverage. A firm with an above-average debt ratio, for example, might be very profitable and thus have a high TIE ratio. In this case, the high level of debt might present no problems. Conversely, a low debt ratio might make a firm appear healthy; but if it also has a low TIE ratio, problems could arise when the firm incurs additional debt.

Liquidity/Solvency Ratios. The third group of ratios assesses firm liquidity and near-term solvency. They describe a firm's ability to meet its short-term financing needs using its own short-term resources. Liquidity can affect a firm's ability to raise capital, since lenders are concerned with a borrower's ability to meet payments on a day-to-day basis. The liquidity of pulp and paper manufacturers should be examined, since any use of current assets to finance pollution control equipment, or the operation of that equipment, could significantly reduce liquidity.

Current Ratio. The current ratio, calculated as the proportion of current assets to current liabilities, indicates whether a firm can cover its current obligations using its available cash or

liquid assets. Firms opting to finance pollution control equipment with working capital could see their current ratio decline dramatically. Easy to calculate, this ratio provides a very common and accurate tool with which to assess the impacts of the proposed regulations.[15]

Net working capital. Net working capital is the difference between current assets and current liabilities, and represents the amount of cash or liquid assets that a firm or facility has available for short-term operations. If pollution control costs are paid by internal funding, net working capital will be affected.

Net working capital to total assets. Dividing net working capital by total assets creates a ratio to evaluate the potential for future investment compared to past investment.

Summary. Table 3-11 displays the seven financial ratios discussed above and shows how each is calculated. A preliminary selection of these ratios for consideration in this analysis was made based on their potential usefulness in evaluating the effects of the proposed regulations. Together, these ratios will provide insight into the three key aspects of firms' and facilities' financial structure—profitability, leverage, and liquidity. The asterisks used in Table 3-11 signify whether the ratio is affected by debt-financing, working capital-financing, or both.

Two sets of financial ratio analysis are performed in this study for different levels in the business hierarchy—the facility level and the business entity level. The business entity level is the level above the facility level at which separate financial data is generated (e.g., corporate divisions or subsidiaries). Both sets of analyses are based on survey data.

The survey provides a financial profile of the industry in 1985, 1988, and 1989 to characterize the industry through several recent years. These years include a very poor year in the pulp, paper, and paperboard industry (1985), and a healthy year for the industry (1989)—a

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[15] The Agency considered using the quick ratio in the financial analysis. The quick ratio is similar to the current ratio, but excludes inventories from the calculation of current assets. Current ratios are more commonly reported on financial summaries (S&P, 1992), and that tradition is followed here.

TABLE 3-11
FINANCIAL RATIOS INCLUDED IN THE PAPER, PULP, AND PAPERBOARD ECONOMIC IMPACT ANALYSIS

	Financial Ratio	Calculation
Profitability Ratios:		
	• Net Income Margin	Net Income/Sales Revenue
	• Return on Assets	Net Income/Total Assets
Leverage Ratios:		
	• Times Interest Earned	(EBIT + Depreciation)/Interest Expense
+	• Debt Ratio	Total Debt/Total Assets
Liquidity Ratios:		
	+ Current Ratio	Current Assets/Current Liabilities
	+ Net Working Capital	Current Assets-Current Liabilities
	+ Net Working Capital/Total Assets	(Current Assets-Current Liabilities)/ Total Assets

Notes: EBIT refers to earnings before interest and taxes.
Net Income refers to earnings after interest and taxes.
Owner's Equity refers to the difference between total assets and total liabilities.
Total Debt refers to total liabilities.
+ Indicates a ratio which could be directly affected by working capital approach to financing of required pollution control investments.
• Indicates a ratio which could be directly affected by debt approach to financing of required pollution control investments.
All ratios could be indirectly affected by either method of financing pollution control equipment.

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low point and a high point in the market cycle. (DeKing et al., 1990 and Mies et al., 1992 discuss the cyclical nature of the pulp, paper, and paperboard industry.) Thus the analysis will characterize recent variations in financial structure in the context of normal, recent business conditions. The cost annualization model and engineering cost data are incorporated in the facilities'/firms' balance sheets under the alternative financing options. These two profiles (before and after regulatory costs are incurred) are used to examine the potential effects of the proposed regulations on the firms and facilities. In particular, the Agency searches for any significant impacts that might exceed those seen in the industry's natural cycle.

3.2.2.2 Facility-Level Ratio Analysis

The ratio analysis is performed at the facility level to examine the potential regulatory impacts on individual plants, particularly to flag and assess impacts less severe than closure. Independent facilities, for whom the facility, business entity, and corporate levels are identical, are examined only at the business entity level (see Section 3.2.2.3).

Some multifacility companies do not carry all financial components necessary for a complete ratio analysis at the facility level. For example, for facilities that carry interest only at the business entity or corporate level, a TIE ratio cannot be calculated. More than half of the facilities do not carry noncurrent liabilities on the facility books, making it difficult to calculate a meaningful return on equity. The return on sales or income margin can still be calculated. Since many expenses are not carried at the facility level (e.g., income taxes, pension expenses, and other corporate expenses), the ratio represents more of a gross income margin. The ratios examined at the facility level are:

- Gross Income Margin. (Mill revenues - manufacturing costs - nonmanufacturing costs)/ mill revenue. Depreciation expense is included in the nonmanufacturing costs. For the incremental impacts, the annualized cost is also subtracted from revenues.

- Return on Assets. Gross income, as calculated above, as a percentage of total mill assets. The incremental impacts on this ratio were examined by decreasing the gross income by the annualized cost, and increasing the asset base by the capital investment required for each option.

- Current Ratio. Current assets/current liabilities. The incremental impacts were analyzed after the annualized cost for each option was taken out of current assets.

- Net Working Capital. Current assets - current liabilities. Incremental impacts were examined by subtracting the annualized cost for each option.

- Net Working Capital/Total Assets. Net working capital, as calculated above, as a percentage of total mill assets. For the incremental impacts, the net working capital was adjusted for the annualized cost and the total assets were adjusted for the new capital equipment needed under each option.

Net working capital and net working capital/total assets are included to examine both the incremental impacts on liquidity (working capital as a proportion of mill assets), as well as the mill's overall ability to finance the annual cost of regulation. Table 3-12 cross-references the data in the survey with the components of the facility-level financial ratio analysis.

3.2.2.3 Business-Entity-Level Ratio Analysis

The ratio analysis performed at the business-entity level investigates the impacts of aggregated costs on the company. If an entity operates five paper facilities, the ratio analysis must incorporate the costs expected to be borne by all five facilities. In other words, while added pollution control costs might not force any of the mills to close, the aggregate costs for several mills might severely affect the company's financial health. The business entity is defined in the survey as the level closest to the facility for which complete financial data are available. Table 3-13 cross-references the survey data and the business-entity-level financial ratio analysis.

A ratio analysis is not planned at the corporate parent level, i.e., whatever owns the business entity. Higher up the corporate hierarchy, the impacts become more diluted because of an increased asset base. For single-establishment firms, ratio analysis at the facility level, business-entity level, and the corporate level would coincide.

TABLE 3-12
COMPONENTS NEEDED FOR FINANCIAL RATIOS
FACILITY-LEVEL ANALYSIS

	Location of Data in 1990 National Census Part B: Financial and Economic Information					
	Independently Owned			Multi-Facility Company		
	1985	1988	1989	1985	1988	1989
Asset Related:						
Current Assets	37c	41c	45c	49c	53c	57c
Total Assets	38n	42n	46n	50m	54m	58m
Liability Related:						
Current Liabilities	39a	43a	47a	51a	55a	59a
Total Liabilities	39a+39b	43a+43b	47a+47b	51a+51c	55a+55c	59a+59c
Income Statement Related:						
Sales Revenues	16a	19a	22a	65	65	65
Earnings Before Interest and Taxes (EBIT)	16h	19h	22h	NA	NA	NA
Interest Expense	16i	19i	22i	NA	NA	NA
Taxes	16j	19j	22j	NA	NA	NA
Manufacturing Costs	NN	NN	NN	68	71	74
Non-Manufacturing Costs (w/depreciation)	NN	NN	NN	69a	72a	75a
Net Income	16k	19k	22k	65-(68+69a)	65-(71+72a)	65-(74+75a)
Depreciation	16f	19f	22f	69b	72b	75b

Notes:NA Not available.
Income statement related data for facilities owned by multi-facility companies may not be accurate since items such as taxes and interest may or may not be carried on the facility's books.

NN Not necessary.
This information is not needed for the ratio analysis, since more accurate data can be obtained from Section 2 of the questionnaire.

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TABLE 3-13
COMPONENTS NEEDED FOR FINANCIAL RATIOS
BUSINESS-ENTITY LEVEL ANALYSIS

	Location of Data in 1990 National Census Part B: Financial and Economic Information					
	Independently Owned *			Multi-Facility Company		
Component	1985	1988	1989	1985	1988	1989
Asset Related:						
Current Assets	See Table 3			15a	18a	21a
Total Assets				15d	18d	21d
Liability Related:						
Current Liabilities				15e	18e	21e
Total Liabilities				15h	18h	21h
Income Statement Related:						
Sales Revenues				16a	19a	22a
Earnings Before Interest and Taxes (EBIT)				16h	19h	22h
Interest Expense				16i	19i	22i
Taxes				16j	19j	22j
Net Income				16k	19k	22k
Depreciation				16f	19f	22f

Notes: * Components for independents are the same as the facility components found in Table 3-12.

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3.2.2.4 Baseline Results

Baseline results are based on the financial ratios and their change due to the business cycle before the addition of incremental pollution control cost. After the ratios are calculated for each facility and/or business entity, the average and median values are calculated. Table 3-14 presents the summary results for the facility-level ratio analysis for 1985, 1988, and 1989.[16] Both the median and mean value are presented because of the variability in the ratios; median values are much less sensitive to outliers. The median 1985 gross income margin and return on assets values indicate how poor a year it was; these ratios are almost half the values for 1989. The current ratio, on the other hand, remains above 1.0 for all 3 years, indicating that the typical facility had more assets than liabilities. The industry downturn actually started at the end of 1989 (DeKing et al., 1990); most facilities closed out 1989 with lower net working capital than in 1988. This pattern is also seen in the drop in net working capital/total assets for 1989.

Baseline financial ratios for the company or business entity are shown in Table 3-15. As expected, net income margin is smaller than the gross income margin seen in Table 3-14, but with the same business cycle pattern. Return on assets also is smaller for the company because all costs are considered, and it also shows the business cycle pattern. Current ratio and debt to asset ratio stayed very stable during this period, which might indicate that little can be learned from these ratios in the impact analysis. The difference between the mean and median times interest earned (TIE) is striking. Some companies have very small debts on their balance sheets and therefore have very high TIE ratios, which skew the average upwards and away from the median. A similar phenomenon occurs with the net working capital.

Tables 3-14 and 3-15 indicate the cyclical nature of the pulp, paper, and paperboard industry. For this report, the fluctuations in financial ratios due to the business cycle are

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[16]The first pass in the analysis revealed several outliers with large and negative values for current assets. Closer investigation revealed that all outlying mills apportioned most of their liabilities to an intercompany account that did not distinguish between current and noncurrent liabilities. All of these intercompany liabilities were recorded as current. These large values affected the current ratio and the net working capital estimates for the entire population. For these mills, the intercompany account was excluded from the estimate of current liabilities. This change did not affect the median net working capital.

TABLE 3-14

BASELINE FACILITY-LEVEL RATIO ANALYSIS
ALL MILLS

Ratio	Baseline Parameter 1985	1988	1989	Percent Variation
Gross Income Margin:				
Mean:	2.1%	1.8%	0.3%	87.9%
Median:	5.7%	11.6%	12.3%	53.2%
Return on Assets:				
Mean:	17.0%	31.0%	32.3%	47.6%
Median:	9.5%	17.3%	17.5%	45.9%
Current Ratio:				
Mean:	3.16	2.72	3.26	16.4%
Median:	1.85	1.84	1.81	1.7%
Net Working Capital:				
Mean ($000):	$5,275	$5,948	$5,392	11.3%
Median ($000):	$2,211	$2,778	$2,284	20.4%
Net WC/ Total Assets:				
Mean:	16.4%	12.0%	10.3%	37.2%
Median:	11.0%	9.8%	8.8%	20.5%

Notes: This table includes independent, single-facility, and multi-facility entities. There are 523 mills in the analysis.

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TABLE 3-15

BASELINE BUSINESS ENTITY-LEVEL RATIO ANALYSIS
ALL COMPANIES

Ratio	Baseline Parameter 1985	1988	1989	Percent Variation
Net Income Margin:				
Mean:	1.8%	6.2%	4.7%	71.0%
Median:	4.2%	5.3%	5.0%	19.8%
Return on Assets:				
Mean:	4.6%	9.3%	8.0%	50.8%
Median:	5.8%	8.5%	6.5%	31.8%
Current Ratio:				
Mean:	3.55	2.48	2.43	31.6%
Median:	1.90	1.91	1.79	6.0%
Net Working Capital:				
Mean ($000):	$46,172	$70,231	$62,005	34.3%
Median ($000):	$5,584	$7,090	$5,841	21.2%
Net WC/ Total Assets:				
Mean:	20.3%	20.0%	18.2%	10.5%
Median:	18.3%	17.5%	13.2%	28.3%
Debt/Asset Ratio				
Mean:	51.5%	57.2%	58.4%	11.7%
Median:	50.2%	53.2%	54.4%	7.8%
Times Interest Earned:				
Mean:	45.5	34.2	21.1	53.8%
Median:	6.3	8.8	7.1	28.8%

Notes: Includes independent, single-facility, and multi-facility entities.
There are 196 companies in the analysis.

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important to consider when assessing the impact of incremental pollution control costs. For all ratios that do not involve net working capital, impacts will be evaluated on a facility-by-facility basis, and the average and median impact will be reported (i.e., the mean change). In contrast, the incremental impacts for net working capital and net working capital/total assets were measured on a population basis (i.e., the change in the mean). This is because some mills have negative net working capital. Further reductions appear as positive changes and provide misleading results.

3.2.3 Associated Impacts

3.2.3.1 Direct Impacts

The closure analysis is facility-specific and impacts associated with mill closure are based on survey information. Direct, or primary, impacts such as job losses, revenue losses, and export losses are all calculated based on specific mill closures. The direct impacts associated with a specific regulatory alternative or option are estimated by summing the losses for all facilities projected to close.

3.2.3.2 Secondary Impacts

Any positive or negative economic activity can have a ripple effect on the local and regional economy. Whether it be the start-up of a factory, the introduction of a public spending program, or reductions in export sales at a local manufacturing plant, changes in economic activity influence the welfare of the surrounding region through inter-industrial relationships and impacts on households. A factory closing, for example, would not only decrease sales of local and regional raw material suppliers, but could also reduce the sales of local merchants through lowered employment and earnings in the area.

The U.S. Department of Commerce, Bureau of Economic Analysis, has developed a Regional Input-Output Modeling System (RIMS II) that aims to quantify these ripple effects for

over 500 different industries in all regions of the nation (DOC, 1992). RIMS II is based on an accounting framework called an input-output (I-O) table, which shows—for each industry—the inputs purchased from and outputs sold to other industries and households in the region.

National-level I-O multipliers from RIMS II for SIC codes 261 (pulp mills), 262 (paper mills), and 263 (paperboard mills) are used to estimate total impacts from projected mill closures. Impacts estimated by these multipliers include both direct and indirect impacts, that is, they include the impacts described in Section 3.2.3.1. The final-demand multiplier for output (Table 3-16) represents the total dollar change in output for each dollar change in industry output; e.g., every $1 change in pulp output results in a $3.52 change in total output. The final-demand multiplier for employment is the total change in jobs for each $1,000,000 change in output (Table 3-16). For example, a loss of $1,000,000 in paper shipments results in a loss of 27.2 jobs. This employment loss includes the loss in jobs estimated by the facility closure, i.e., it includes both direct and indirect job losses. The multiplier is based on 1989 data, as is the survey data (Pigler, 1993).

The financial model analysis estimates the loss in the value of shipments associated with facility closures. The loss in the value of shipments estimated by the facility closures is the input to the analysis of secondary and community effects.

3.2.3.3. Loss in Federal and State Tax Revenues

Tax shields that lower costs to the industry represent a loss in tax revenues to state and federal governments. The difference between pre-tax and post-tax annualized costs represent the potential loss in income to the governments.

TABLE 3-16

RIMS II MULTIPLIERS FOR THE PULP, PAPER, AND PAPERBOARD INDUSTRIES

Industrial Category	Final-demand multipliers	
	Output (dollars per dollar)	Employment (jobs per $1,000,000)
Pulp Mills	3.5183	29.7
Paper Mills	3.2303	27.2
Paperboard Mills	3.3589	28.2

Source: Pigler, 1993.

3.3 MARKET IMPACT ANALYSIS METHODOLOGY

Implementing regulations to control air and water pollutants from pulp and paper manufacturers will affect the costs of production in the U.S. pulp and paper industry. The costs of the regulations will vary across the many different mills in the industry, depending on the production processes currently employed. Mill-level production responses to these additional costs will determine the market impacts of the regulations. Specifically, the cost of the regulations may induce some mills, or product lines within mills, to close or to change their current level of production. These choices affect, and in turn are affected by, the market price for market pulp, paper, and paperboard products.

A variety of approaches may be used to quantify and evaluate economic impacts; they reflect a variety of underlying paradigms. The market impact model applies standard microeconomics concepts to model the supply of pulp, paper, and paperboard products and the impacts of the regulations on production costs and facility output decisions. The three main elements of the analysis are regulatory effects on the manufacturing facility, market responses, and facility-market interactions. For a more comprehensive and technically detailed discussion of the market impact analysis methodology and model, please see Appendix A of this report.

3.3.1 Market Impact Model Concepts

3.3.1.1 Facility-Level Effects

At any point in time, the costs that a firm faces can be classified as either unavoidable (sunk) or avoidable[1]. In the former category, we include costs to which the firm is committed and that must be paid regardless of any future actions of the firm. The second category, avoidable costs, describes any costs that are foregone by ceasing production. These costs can be further refined to distinguish between costs that vary with the level of production and those that are independent of the production level. For example, production factors such as labor, materials, and capital (except in the short run) vary with the level of output, whereas expenditures for

facility security and administration may be independent of production levels but avoidable if the facility closes down.

Figure 3-6 illustrates the derivation of a facility supply function for a market pulp, paper, or paperboard product from the classical U-shaped structure of production costs with respect to output. The horizontal axis, q/t, represents output per period and the vertical axis, $/q, represents the cost per unit of output. Let AVAC be the facility's average variable (avoidable) cost curve and ATAC the average (avoidable) cost curve for producing the product. The vertical distance between ATAC and AVAC is the per-unit average cost of nonvariable avoidable costs, and it approaches zero as the number of units of output increases. MC is the marginal cost of producing paper, paperboard, or market pulp, which intersects AVAC and ATAC at their respective minimum points. All these curves are conditional on input prices and the technology in place at the facility.

The facility supply function is the section of the marginal cost curve bounded by the quantities q^m and q^M. q^M is the largest feasible production rate that can be sustained at the facility given the technology and other fixed factors in place, regardless of the output price. Quantity q^m is the minimum economically feasible production rate determined by the minimum of the AVAC curve, which coincides with the price p^m. Suppose the market price of paper is less than p^m. In this case, the firm's best response is to close the facility and not produce paper because $P < AVAC$ implies that total revenue would be less than variable costs if the facility operated at the associated output levels below q^m.

Now consider the effect of the proposed regulatory control costs. These control costs fall into one of two categories: avoidable variable and avoidable nonvariable. We characterized these proposed costs as avoidable because a firm can choose to cease operation of the facility and thus avoid incurring the costs of compliance. The variable control costs include the O&M costs of the controls, and the nonvariable costs include compliance capital equipment.

The effect of these additional costs is illustrated in Figure 3-7. The facility's AVAC and MC curves shift upward (to AVAC′ and MC′) by the per-unit variable compliance costs. In addition, the nonvariable compliance costs increase total avoidable costs and thus the vertical

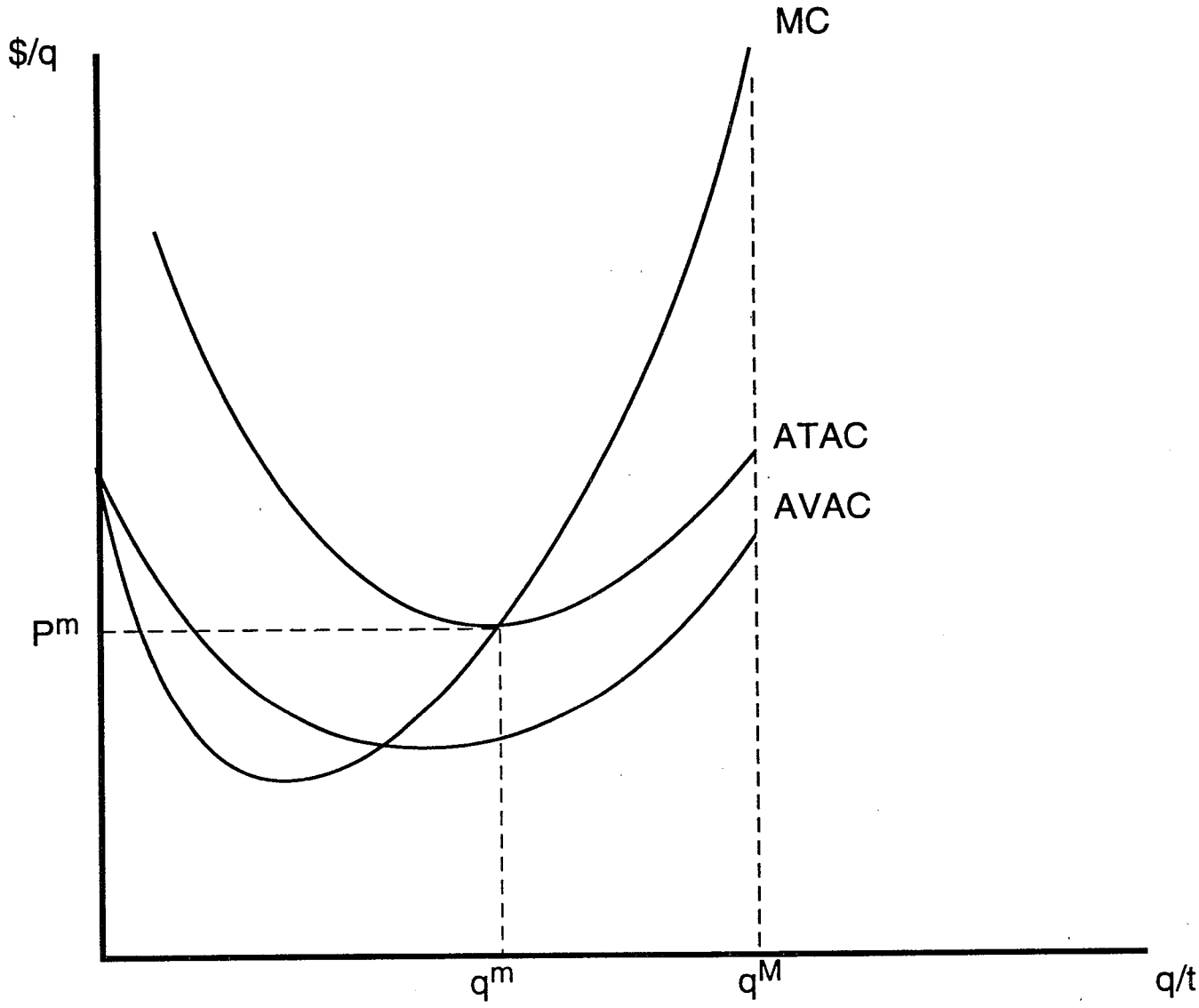


Figure 3-6. Facility cost curves.

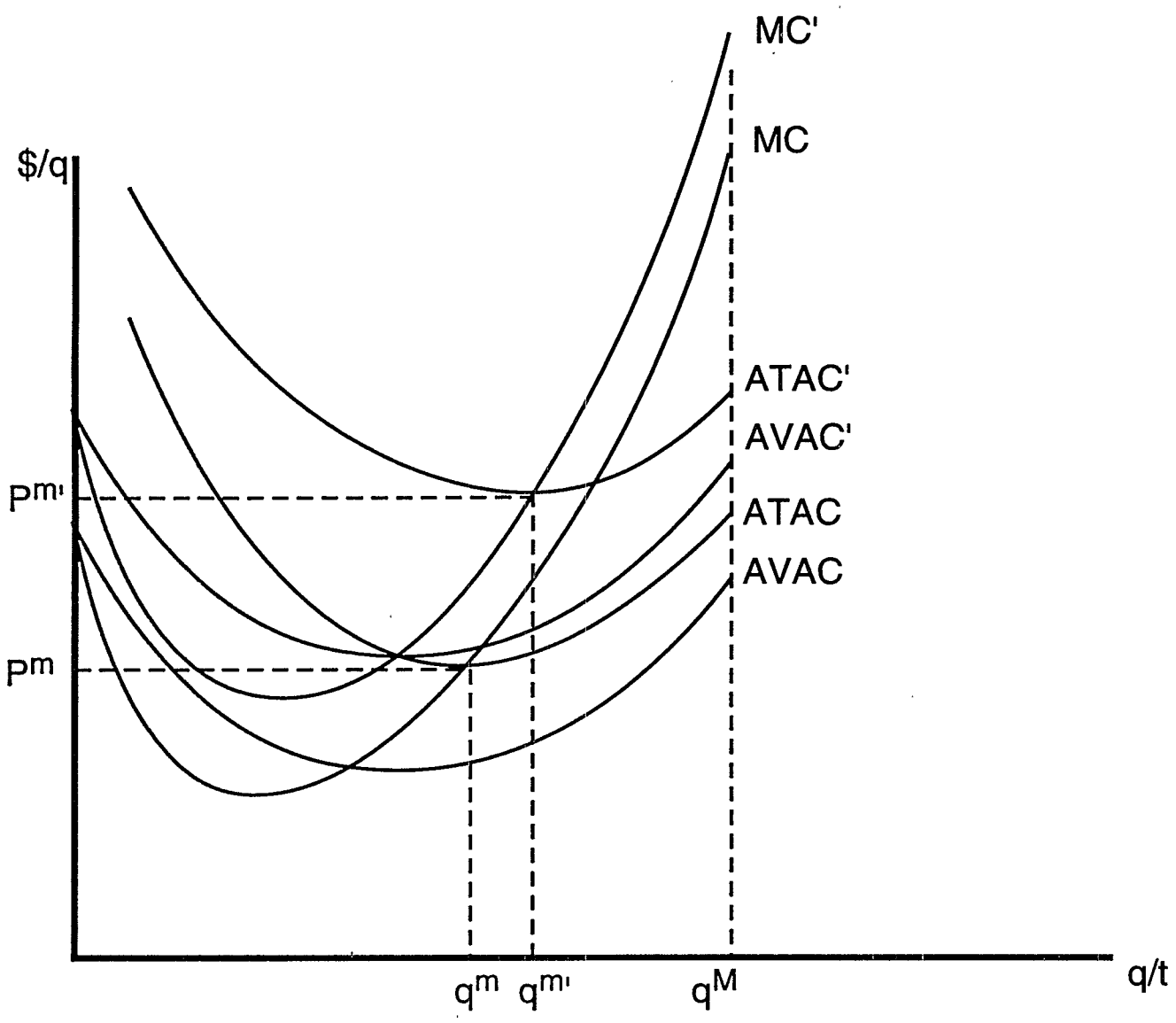


Figure 3-7. Effect of compliance costs on facility supply function.

distance between ATAC′ and AVAC′. The facility's supply curve shifts upward with marginal costs, and the new (higher) minimum operating level ($q^{m\prime}$) is determined by a new (higher) $p^{m\prime}$.

Now consider the effect of compliance costs on the derived demand for inputs at the regulated facility. Paper and paperboard manufacturing facilities are market demanders of pulp. We can employ a similar neoclassical analysis to the one above to demonstrate the effect of compliance costs on the demand for the market pulp input. Figure 3-8 illustrates the paper and paperboard manufacturing facility demand function for market pulp. Each point on the derived demand curve equals the firm's maximum willingness to pay for the corresponding marginal input. This is typically referred to as the input's value of marginal product (VMP), which is equal to the price of the output (P) less the per-unit compliance costs (c) times the input's "marginal physical product" (MPP), which is the incremental output attributable to the incremental input. Ignoring any effect on the output price for now, an increase in per-unit compliance costs due to the regulations will lower the VMP of all inputs by the unit amount of the additional compliance costs, leading to a downward shift in the derived demand curve in section a of Figure 3-8 from D_y to D'_y.

The paper and paperboard manufacturing facility demand curve for market pulp is downward sloping in this example, indicating that the marginal physical product of market pulp diminishes as more is used to produce paper and paperboard, and substitution possibilities exist with other inputs. This model assumes that the input-output relationship between the market pulp and the final paper and paperboard product is strictly fixed, not only by product specification but also by constant efficiency of use at all input levels. Therefore, the VMP of the market pulp is constant and the derived demand curve is horizontal with the constant VMP as the vertical intercept, as shown in section b of Figure 3-8.

3.3.1.2 Market-Level Effects

Consider the relationship depicted in Figure 3-9 between the markets for a single paper or paperboard product, Q_x, and a market pulp input, Q_y. Q_y, along with other inputs, such as labor, energy, and chemicals, is used in the production of Q_x. We assume that prices for the

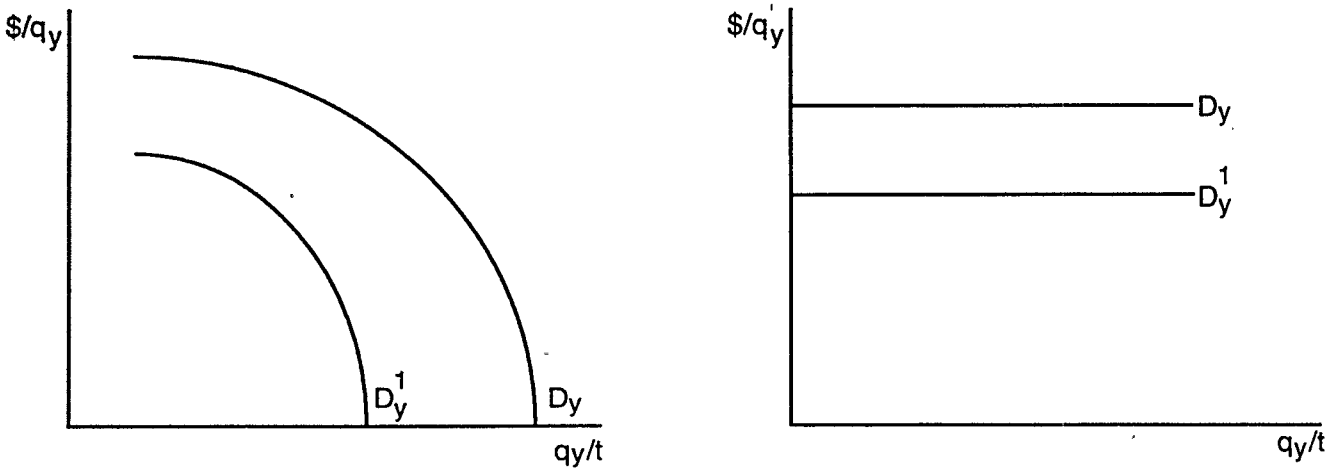
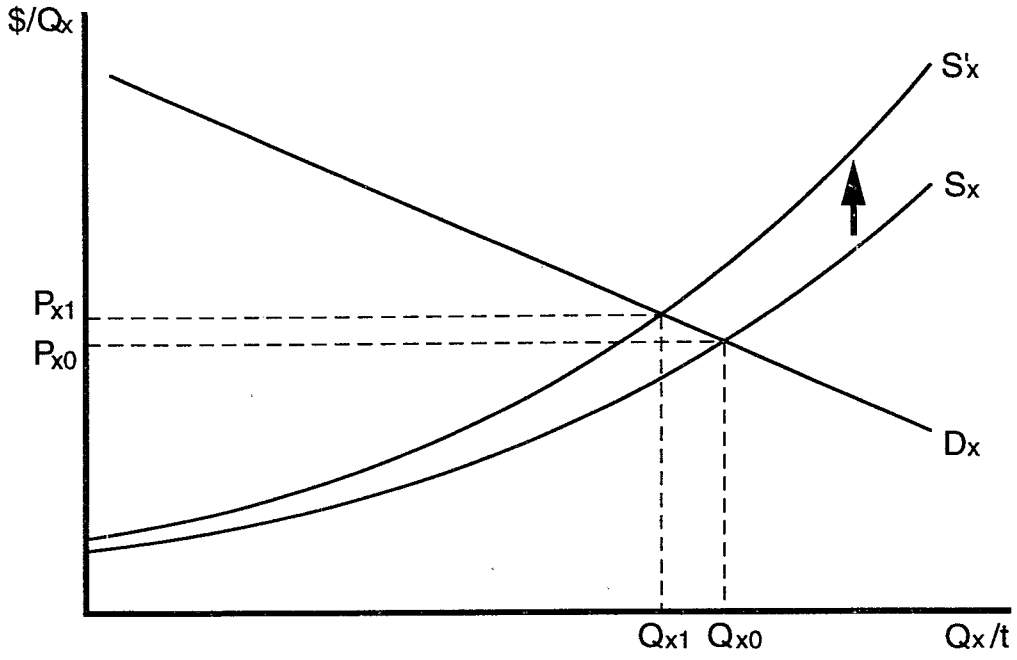
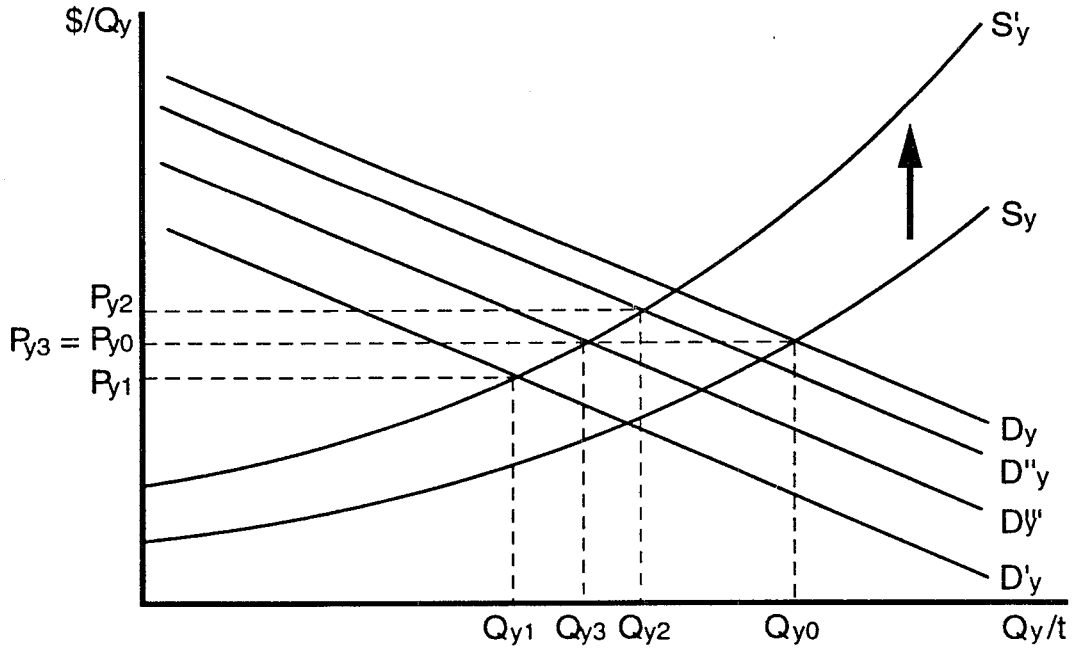


Figure 3-8. Effect of compliance costs on derived demand for market pulp at regulated facility.



(a) Market for Paper or Paperboard Product, Q_x



(b) Market for Pulp, Q_y

Figure 3-9. Market equilibria with and without compliance costs.

respective commodities are determined in competitive markets (i.e., individual facilities have negligible power over the market price of the commodities and thus take the price as "given" by the market). Under perfect competition, market prices and quantities are determined by the intersection of market supply and demand curves. A market supply curve is the sum of all facility supply curves, and a market demand curve is the sum of the demand curves for all demanders of the commodity. The demanders of paper or paperboard product, Q_x, are final product consumers, and the demanders of market pulp, Q_y, are the individual facilities that purchase market pulp for producing paper and paperboard products. Without the proposed compliance costs, the market quantity and price of paper or paperboard product, Q_x (Q_{x0}, P_{x0}), are determined by the intersection of the market demand curve (D_x) and the market supply curve (S_x), and the market quantity and price of market pulp, Q_y (Q_{y0}, P_{y0}), are determined by the intersection of the market demand curve (D_y) and market supply curve (S_y).

Imposing the regulations increases the costs of producing pulp and, thus, paper and paperboard, shifting the market supply function for both commodities upward to S'_x and S'_y, respectively. The supply shift in the market for paper and paperboard products causes the market quantity of each to fall to Q_{x1} and the market price to rise to P_{x1} in the new equilibrium. In the market for pulp, the drop in the market quantity is unambiguous; however, the direction of the change in the market price can only be determined if we know the relative magnitudes of the demand and supply shifts. If the downward demand effect dominates, the price will fall (e.g., P_{y1}); if the upward supply effect dominates, the price will rise (e.g., P_{y2}); and if the effects just offset each other, the price remains unchanged (e.g., $P_{y3} = P_{y0}$).

The sign (positive or negative) of the effect of these market adjustments on commodity prices and quantities is summarized in Figure 3-10; the magnitude of these effects is estimated by the market impact model. The supply shifts for market pulp, paper, and paperboard cause the market price to rise and market quantity to fall for these commodities at the new equilibrium. However, the downward shift in the demand curve for market pulp will have an offsetting effect on price, leaving the total effect ambiguous, while exacerbating the effect on quantity, resulting in an even lower quantity produced. In both cases, the producers that are unaffected by the regulations receive the higher price for their products without the associated increase in compliance costs and thus increase their production levels.

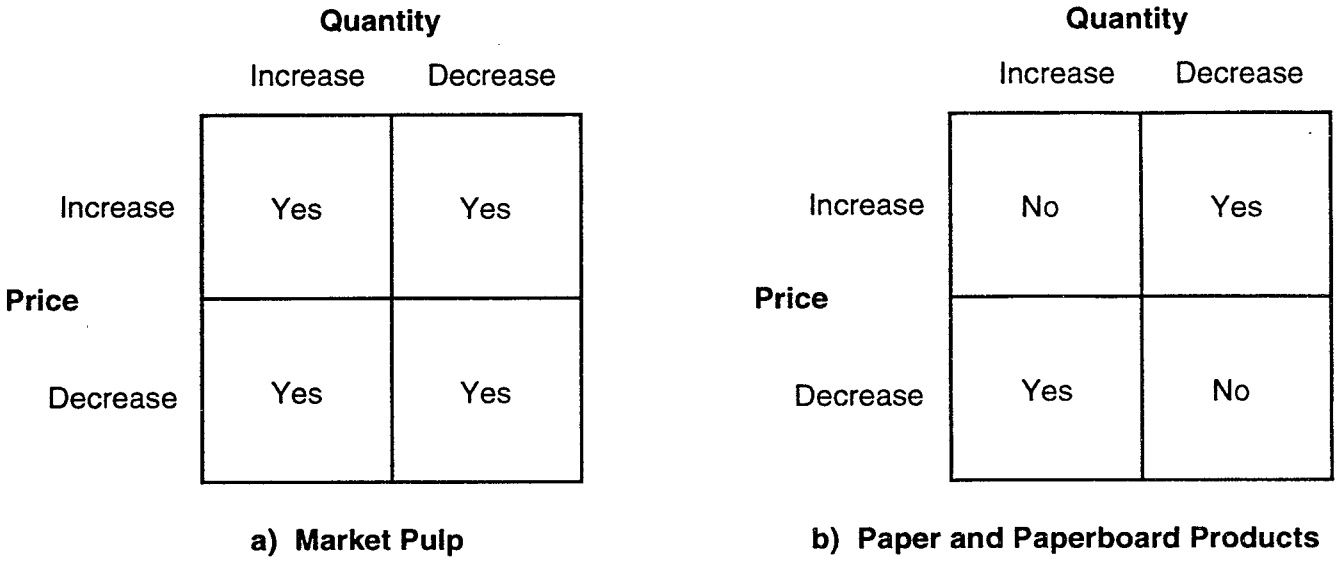


Figure 3-10. Market adjustments for market pulp, paper, and paperboard products.

3.3.1.3 Facility-Level Response to Control Costs and New Market Prices

In evaluating the market effects for pulp, paper, and paperboard products, we must distinguish between the initial effect of the regulations and the net effect after all markets have adjusted. Initially all affected facilities' supply curves for market pulp, paper, and paperboard shift upward by the unit variable costs of the regulation. As a result, all affected facilities' derived demand curves for market pulp shift downward by the unit variable control costs. However, the upward shift in the industry supply curves for paper and paperboard pushes up the prices of those commodities, which subsequently raises the VMP of the market pulp and, thus, puts upward pressure on the derived demand for that commodity. In general, the initial upward shift in supply at the facility will be greater than the subsequent increase in market price so that the mill reduces supply of market pulp, paper, or paperboard. The initial downward shift in demand will typically dominate the subsequent upward shift so that the net shift is downward and the mill reduces demand for market pulp. However, determining which shift dominates for a particular mill is difficult: it depends on the relative magnitude of the facility-specific unit variable costs of the regulation and the changes in market prices.

Given changes in market prices and costs, mills will elect to either:

- Continue to operate, adjusting production and input use based on new revenues and costs, or
- Close the facility if expected revenues do not exceed total avoidable costs.

This decision can be extended to the multiproduct facility where product lines may be closed if product revenues are less than product-specific avoidable costs, and the entire facility may be closed if total expected revenues from all products (market pulp, paper, and paperboard) do not exceed facility-specific avoidable costs.

This approach to modeling the facility closure decision is based on conventional microeconomic theory. It compares the ATAC—which includes all cost components that fall to zero when production discontinues—to the expected postregulatory price. Figure 3-7 illustrates

this comparison. If price falls below the ATAC, total revenue would be less than the total avoidable costs. In this situation, the owner's cost-minimizing response is to cease production.

An additional aspect of the facility-level impacts is the quantity adjustments. Changes in costs will change producers' output rates. However, some of this effect is mitigated when prices are increased. Of course, facility and product-line closures directly translate into quantity reductions. However, the output of operating facilities also will change as will supply from foreign sources. Affected facilities that continue to produce may increase or decrease their output levels depending on the relative magnitude of the unit variable control costs and the changes in market prices. Unaffected facilities will not face an upward shift in their product supply curves, so their response to higher product prices is to increase production. This response is illustrated in Figure 3-11 as an upward movement along the facility's supply curve for the product. Foreign producers, which do not incur higher production costs because of the regulations, will respond in the same manner as these unaffected U.S. mills.

3.3.2 Operationalizing the Market Impact Model

To estimate the economic impacts of the regulations, we operationalized the competitive market model of the pulp and paper industry outlined in the previous subsections. The model incorporates the facility-specific information on production obtained from the EPA's *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities* (EPA, 1991) and model parameters characterizing domestic and foreign (export) demands as well as foreign supply (imports). The model incorporates these data sources to provide an empirical characterization of the U.S. pulp and paper industry and product markets for a base year of 1989. We chose this base year of analysis because it is the last year for which facility-specific production and technical data were available from the *National Census* (EPA, 1991) and for which supporting economic data were readily available.

The model analyzes market adjustments for 31 paper and paperboard product markets and 6 market pulps by employing a process of *tatonnement* whereby prices approach equilibrium through successive correction—modeled as a Walrasian auctioneer. Integrated facilities and

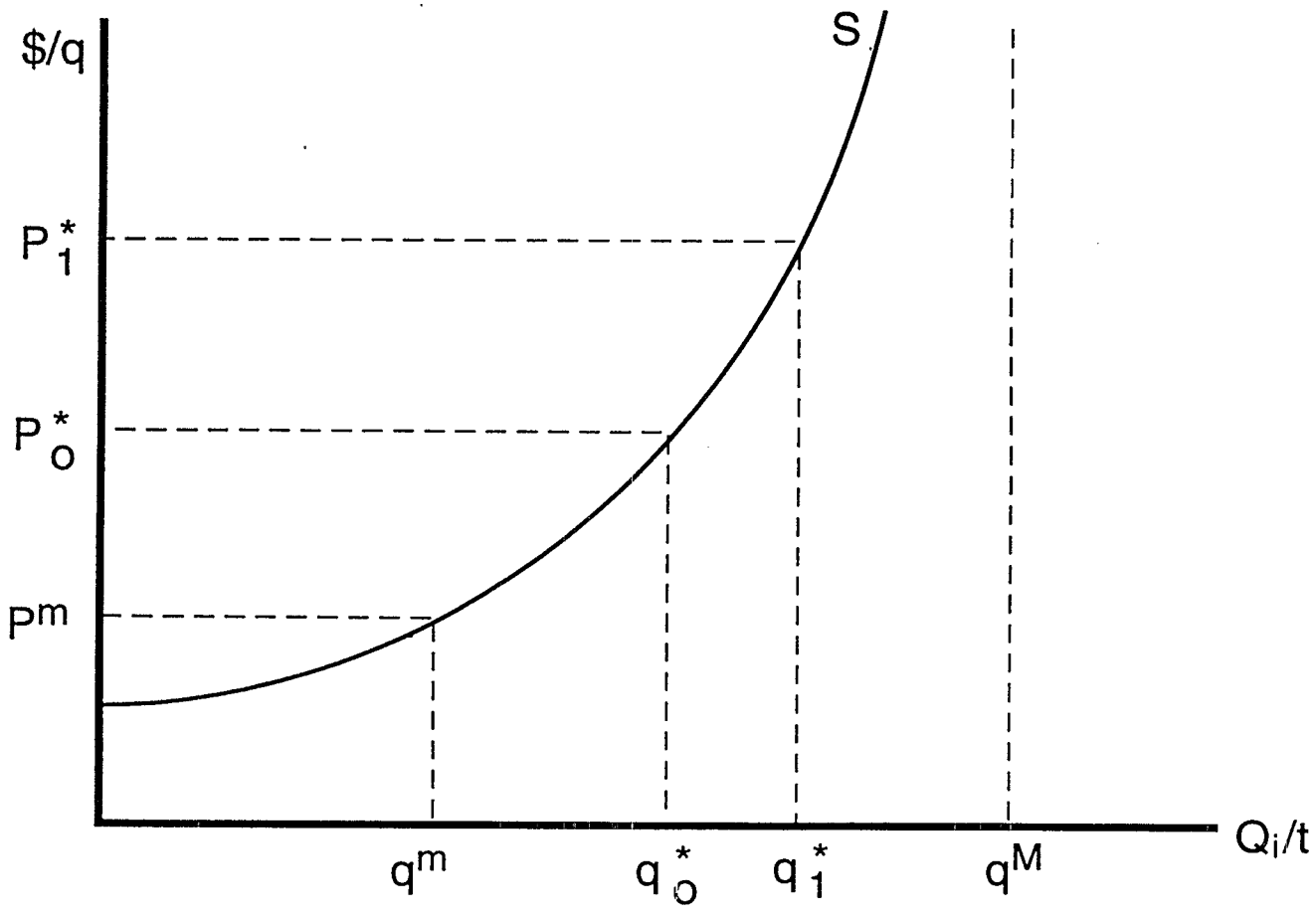


Figure 3-11. Movement along the product supply function.

paper-making facilities constitute those facilities supplying final paper products; the pulp mills and those integrated mills involved in the market for pulp, either as a supplier or demander, constitute those facilities included in the model for market pulps. The model also includes a foreign trade sector with which to assess the impact of international trade responses on market outcomes and vice versa.

To implement this model, we identified commodities and facilities to be included in the analysis, specified the supply and demand side of the market and associated response parameters, specified the foreign trade sector and provided the corresponding response parameters, incorporated demand and supply specifications into a market model framework, and evaluated market adjustments due to imposing regulatory compliance costs and estimated the impacts.

3.3.2.1 Model Dimensions

Clearly the analysis must account for all marketable commodities involved in producing pulp and paper, as well as all suppliers of these commodities. Figure 3-12 illustrates the modeled interactions between commodities and producers. The first marketable product is pulp, either bleached or unbleached; the second marketable product is the final paper or paperboard product. The model analyzes the market adjustments for 6 market pulps and 31 paper and paperboard products. All of these products are consumed and produced domestically, as well as traded internationally. Therefore, domestic producers export some pulp and paper products to other countries, and foreign producers supply their products to U.S. markets.

The pulp and paper industry is characterized by both nonintegrated and vertically integrated mills. Nonintegrated mills include pulp mills that produce market pulp as well as paper mills that purchase market pulp to produce paper and paperboard products. Vertically integrated mills rely mostly on their own production of pulp to produce paper and paperboard products. Those vertically integrated mills without enough internally produced pulp are also demanders of market pulp, and those that produce an excess supply of pulp are suppliers of market pulp. We modeled the production from 566 pulp, paper, and paperboard manufacturing facilities, including 28 pulp mills, 303 paper mills, and 235 integrated mills.

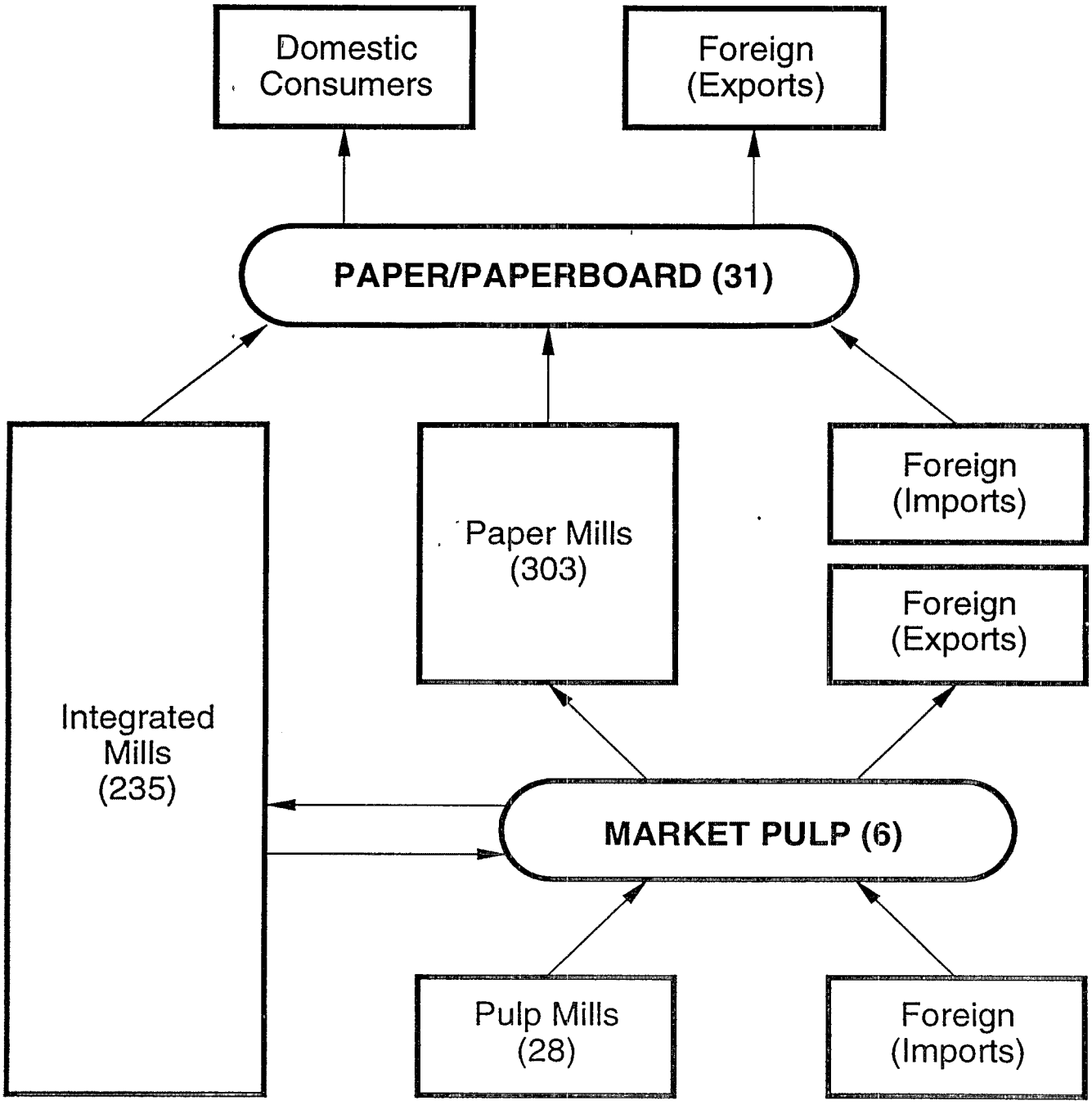


Figure 3-12. Interactions between commodities and producers.

3.3.2.2 Commodities

EPA's *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities* identifies the 566 mills existing in 1989 that may be affected, either directly or indirectly, by the air and water pollution regulations. The detailed production data obtained from this source on each mill form the basis for characterizing the commodities included in the model. Table 3-17 lists the products with a description of each product and its product code.

The *National Census* identifies 42 product markets to analyze—33 final paper and paperboard products and 9 pulp products. However, *National Census* data on facility-level production indicate no U.S. production of either "other shipping sack" (product code 32) or "hardboard" (product code 52) in 1989. Therefore, the markets for these two product groups are not included in the model.

Although some of the pulp product categories provided by the *National Census* distinguish between bleached and unbleached pulps, not all pulp categories have this distinction. Consequently, as shown in Table 3-18, the pulp product categories were expanded to 17 to account for bleached and unbleached versions of each pulp by matching the pulp category with pulp process codes from the *National Census*. Bleached and unbleached pulps were categorized using *National Census* data on the fiber source indicated by the pulp process codes and the percentage of the fiber that is bleached and unbleached. Distinguishing the pulp products by these features—pulping process and bleaching—is particularly important because the regulations are aimed primarily at chemical pulping and bleaching. Thus, the model includes 17 pulp inputs into the production of paper and paperboard.

Some subsets of the 17 pulps described above are sold on the market (i.e., market pulps). A number of the pulp inputs are only produced at integrated facilities for in-house production of paper and paperboard products and are consequently not marketed. In addition, some of these pulps are traded in very small quantities by a small number of suppliers; therefore, data were insufficient to derive prices for some of these market pulp products. The U.S. Department of Commerce's *Current Industrial Reports: Pulp, Paper, and Board* does not contain data on value of

TABLE 3-17

PULP, PAPER, AND PAPERBOARD PRODUCTS

Product (Code)[a]	Product Description
Pulp	
Special alpha and dissolving woodpulp (1)	Chemical pulp from wood and other fibers with a very high alpha cellulose content, readily adaptable for uses other than paper and paperboard making.
Sulfate-bleached (2) Sulfate-unbleached (3)	Made from an alkaline pulp manufacturing process that cooks chips in a pressure vessel using a liquor of primarily sodium sulfide and sodium hydroxide with sodium sulfate and lime being used to replenish these chemicals in recovery operations (also kraft).
Sulfite-bleached (4) Sulfite-unbleached (5)	Made from acid pulp manufacturing process that cooks chips in a pressure vessel using a liquor composed of calcium, sodium, magnesium, or ammonia salts of sulfurous acid.
Groundwood-bleached (6) Groundwood-unbleached (7)	Slurry produced by mechanically abrading fibers from barked logs through forced contact with the surface of a revolving grindstone. Used as newsprint and publication paper.
Thermomechanical-bleached (8) Thermomechanical-unbleached (9)	Pulp made by presteaming chips and reducing them into their fiber components during an initial mechanical treatment in refiners under elevated temperature and pressure. Subsequent refining done at atmospheric pressure.
Semichemical-bleached (10) Semichemical-unbleached (11)	Lower quality pulp made by cooking fibrous materials in a neutral sodium sulfite-sodium carbonate liquor followed by a final separation of the fiber using unpressurized mechanical means.
Defibrated or exploded-bleached (12) Defibrated or exploded-unbleached (13)	Pulp made by thermomechanical process in which woodchips are pretreated with a chemical, usually sodium sulfite, either prior to or during presteaming as an aid to subsequent mechanical processing in refiners.
Secondary-bleached (14) Secondary-unbleached (15)	Any type of paper- and paperboard-making fiber obtained from wastepapers and other used, reclaimable fiber sources.
Cotton and rag pulp-bleached and unbleached (16)	Pulp made from rags or cotton linters by a conventional cooking process with lime and sodium hydroxide, followed by refining and bleaching.

TABLE 3-17 (cont.)

Product (Code)[a]	Product Description
All other fiber, n.e.c. (17)	Pulps other than wood such as pulp of fibrous vegetable material (e.g., straw, reed, bagasse, bamboo, etc.); or synthetic and semi-synthetic sources (e.g., glass, fiberglass, rayon, nylon, combinations).
Paper	
Newsprint (20)	Light, inexpensive grade made largely from mechanical pulps and some unbleached sulfite or other chemical pulps.
Uncoated groundwood paper (21)	A higher grade than newsprint that is smoother and brighter and used in newspaper inserts, catalogs, paperback books, and directories.
Clay-coated printing and converted paper (22)	Printing and converting papers that contain a layer of coating material, such as clay or pigment, in combination with an adhesive.
Uncoated free sheet (23)	Contains no more than 10% mechanical pulps, including most grades of business paper (forms, bond, stationary, tablet, envelope, xerox, and computer paper, and cover and text grades used in printing).
Bleached bristols (24)	High-quality cardboards used for products such as index tags, cards, file folders, and postcards.
Cotton fiber writing paper and thin paper (25)	Papers in which cotton or other nonwood fibers comprise 25% or more of the total (e.g., bond, ledget, specialty papers [also, rag]).
Unbleached kraft packaging and industrial converting paper (26)	Various types of paper used for industrial or commercial purposes, such as wrapping papers, bag and sack stock, specialty papers.
Special industrial paper, except specialty packaging (27)	Special industrial papers such as photographic sensitizing paper, blotting paper, filter paper.
Tissue (28)	Light, fairly transparent, strong, absorbable, easily disposable paper, characterized by its gauze-like texture, made from mainly bleached kraft and sulfite pulps. Used for sanitary products.
Wrapping (30)	Grade of nonsanitary tissue, all M.G. and M.F. wrapping papers, treated and untreated butcher papers, and miscellaneous wrapping.

TABLE 3-17 (cont.)

Product (Code)[a]	Product Description
Shipping sack (31)	Paper made mainly from sulfate or soda, unbleached or bleached woodpulp characterized by toughness and strength, used in the manufacture of shipping sacks.
Other shipping sack (32)	Rope and combination kraft and rope shipping sack paper.
Other bag and sack (33)	All other kraft wrapping paper made mainly from sulfate or soda, used in the manufacture of grocery bags and bags other than shipping sacks.
Other bag and sack paper for conversion (34)	Used for conversion in liquor, millinery, notion, or other variety bags.
Waxing stock (35)	Packaging paper with weight over 29.4 g/m^2.
Other (36)	Other packaging and industrial converting paper such as asphalting and creping stocks, coating and laminating, gummed, twisting and spinning stocks (weight over 29.4 g/m^2).
Specialty packaging (37)	Packaging paper of weight not more than 150g/m^2.
Glassine, greaseproof, and vegetable parchment (38)	Papers made from pure chemical woodpulp or from mixtures of chemical woodpulp, cotton fiber pulp, treated by highly hydrated or hand beaten to render the resulting paper resistant to oil, grease, and water.
Paperboard	
Unbleached kraft (40)	High-strength paperboard made from sulfate pulp, usually with a naturally brown color from unbleached pulp.
Semichemical paperboard (41)	Made from semichemical pulp, mostly used for corrugating medium, which forms the inner, fluted layer of cardboard and corrugated containers.
Recycled paperboard (42)	Made from a combination of recycled fibers from various grades of paper stock, used for folding boxboard; core, can, and tube grades, corrugating medium; and gypsum linerboard.
Wet machine board (43)	Paperboard manufactured using a paper machine consisting essentially of a wire-covered cylinder rotating in a vat of pulpstock on which a mat of varying thickness is formed by drainage, such as binder's board and shoe board.

TABLE 3-17 (cont.)

Product (Code)[a]	Product Description
Construction paper (50)	Heavy paper used for watercolor and crayon artwork, made in various colors primarily from groundwood pulp.
Hardboard (51)	Paperboard made resistant to water and ink penetration by exposure to high degree of sizing treatments.
Insulating board (52)	Paperboard used for insulating electric cables.
Bleached linerboard (60)	Kraft paperboard used to line or face corrugated coreboard to form shipping boxes and various other containers.
Folding carton type board (61)	Type of boxboard made of bleached chemical woodpulp and used in the manufacture of "folding type" containers that are formed, filled, and closed by the user.
Milk carton board (62)	Special grade of bleached boxboard capable of being converted into containers for milk, cream, and other beverages.
Heavyweight cup and round nested food container (63)	Bleached paperboard used in the manufacture of cups and other nested cylindrical containers, used for hot and cold drinks and in packaging moist, liquid, and oily foods.
Plate, dish, and tray stock (64)	Bleached paperboard, hard-sized for moisture resistance and strength qualities.
Bleached paperboard for miscellaneous packaging (65)	Paperboard for miscellaneous packaging purposes such as nonfolding board for shipping cases and set-up boxboard.
Other solid bleached board (66)	Single-ply, homogeneous types of paperboards, made from the same stock throughout the sheet structure, including paperboard for moist, oily, and liquid foods.
Molded pulp products (70)	Products including fruit and vegetable packs and egg cartons.

[a]For all products termed bleached or unbleached: bleaching is the process of chemically treating fibers to reduce or remove coloring matter so that the pulp is improved in terms of whiteness or brightness; unbleached is produced without being treated with bleaching agents.

TABLE 3-18

PULP PRODUCTS, PRODUCT CODES, AND PROCESS CODES

Pulp Product	Pulp Product Code	National Census Process Code[a]
Special alpha and dissolving woodpulp	1	A, D
Sulfate-bleached	2	C, W
Sulfate-unbleached	3	C, W
Sulfite-bleached	4	B
Sulfite-unbleached	5	B
Groundwood-bleached	6	H, J
Groundwood-unbleached	7	H, J
Thermomechanical-bleached	8	G
Thermomechanical-unbleached	9	G
Semichemical-bleached	10	E
Semichemical-unbleached	11	E
Defibrated or exploded-bleached	12	I, F
Defibrated or exploded-unbleached	13	I, F
Secondary-bleached	14	K, L, M, N, O, P, R, S, T, U, Y, Z
Secondary-unbleached	15	K, L, M, N, O, P, R, S, T, U, Y, Z
Cotton and rag pulp-bleached and unbleached	16	V
All other fiber, n.e.c.	17	Q, X, SS

[a]Process codes taken from Subappendix Table AA-1.

product shipments and quantity of product shipped for a number of pulps because of disclosure concerns. Thus, the model analyzes only six market pulps for which good information was available:

- Special alpha and dissolving woodpulp
- Bleached sulfate
- Unbleached sulfate
- Bleached sulfite
- Bleached secondary fiber
- Unbleached secondary fiber

3.3.2.3 Domestic Supply of Pulp, Paper, and Paperboard

In this model, facilities are classified as either integrated or nonintegrated, and nonintegrated mills are broken down further into pulp mills and paper mills. Each type of facility has a different decision to make regarding production of pulp, paper, and paperboard, so we model the production decisions at each type of facility accordingly.

Integrated mills must determine optimal output given the market prices for all paper products they produce, which will determine the amount of internal pulp to produce. Excess supply of pulp will spillover into the market, while excess demand will cause the facility to demand market pulp. For nonintegrated paper mills, the market prices for pulp inputs and final paper and paperboard outputs will determine the optimal level of output to produce, and then, the corresponding market pulp to purchase. For pulp mills, the price of market pulp will determine the optimal supply of market pulp. The market supply of pulp is the sum of supply from all market pulp suppliers, and the market demand for pulp is the sum of demand from all market pulp demanders. The same is true for paper and paperboard products.

Mills have the ability to vary output in the face of production cost changes. To allow for mills to vary output in the face of regulatory control costs, the model uses facility-specific, upward-sloping supply curves for each product. The model employs supply functions for pulp and paper products that are derived from a generalized Leontief technology with the assumption of no substitutability across final products (i.e., cross-price elasticity of supply equal to zero for all mill outputs). The specification also restricts production to a fixed-proportion relationship between paper and pulp—that is, each unit of paper product requires a fixed number of units of pulp input. This fixed-proportions relationship implies that the firm's profit function, supply functions, and derived demand functions depend on product output price and market pulp input prices only insofar as they depend on net price. Further, we assumed that the variable proportions input combines with pulp according to a generalized Leontief technology, which is not fixed proportion.

The upward-sloping product supply curve for each facility is econometrically estimated by ordinary least squares (OLS) using facility-specific data on production from the *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities* and market prices obtained from U.S. Department of Commerce data. The supply curves are specified over a productive range with an upper bound given by facility production capacity and a lower bound given by the facility's minimum economically viable output level.

3.3.2.4 Incorporating Regulatory Control Costs

The starting point for assessing the impact of the regulations on the markets for pulp and paper products is to incorporate the mill-level regulatory compliance costs. The compliance costs for each mill are estimated by Agency engineers and include the total capital investment, the annual general and administrative costs, and the annual operating and maintenance costs (variable costs).

The primary challenge of incorporating regulatory control costs into the model structure is to appropriately assign variable production costs to the pulp products directly affected by the incidence of control costs. In some cases this assignment is straightforward, such as the case of

bleach plant process changes or the case of bleach plant process vent controls. In these cases, the variable costs are shared by each bleached pulp product produced by the affected process. Other cases are not as straightforward, such as the case of secondary wastewater treatment controls. Because the costs of these controls are not readily attributable to any specific production area of the mill, the costs are assumed to be shared by all pulp products produced at the mill. The result of assigning variable costs to the pulp products produced by each mill is a mill-specific, per-unit production cost change for each of the 17 pulp products.

The second challenge of incorporating regulatory control costs into the model structure is to calculate the annual nonvariable cost of regulation-imposed controls. The annual nonvariable control costs are determined from the net present discounted value (NPDV) of the stream of annual cash outflows, where the cash outflows are the total capital investment and the annual general and administrative costs. The length of the stream of cash outflows corresponds to the average depreciable life of the capital investment, which is estimated as 15 years, and the costs are discounted using the facility-specific discount rate reported in the *National Census* (which averages around 12 percent). The annual nonvariable control cost is then computed by annualizing the NPDV over the lifetime of the investment at the facility-specific rate of discount. The annual nonvariable control costs enter the model at the facility level, while the per-unit variable control costs enter at the product level for all facilities affected by the regulations.

3.3.2.5 The Facility's Product-Level Supply Decisions

The production decisions at the three types of facilities—integrated paper mills, nonintegrated paper mills, and pulp mills—are affected differently by the variable costs of control (i.e., the annual O&M costs). These direct costs are borne by pulp producers, both suppliers of pulp to the market and to integrated mills that produce and consume their own pulp. Because of the direct costs of control, market pulp prices will rise, leading to indirect costs borne by nonintegrated paper mills and integrated paper mills who purchase market pulp. The nonvariable control costs do not directly affect product-level supply decisions except in the case of facility closure, where supply is reduced to zero.

For integrated mills, the variable costs of control associated with onsite production of pulp will be borne at the level of paper and paperboard production. These costs are expressed per unit of pulp and can be transmitted up to the paper product through the input ratios. Integrated mills will be indirectly affected by increases in the price of market pulp inputs. These increases in pulp prices are transmitted through the purchased input ratios. Nonintegrated paper mills may not be directly affected by the control costs, but they will be indirectly affected through the changes in the prices of market pulp inputs to paper production. Pulp mills will be directly affected by the regulatory control costs, which enter the supply decision as a net price change to pulp producers.

3.3.2.6 Facility Closure Decisions

The facility may not always find complying with the regulation feasible and thus may shut down the pulp and paper manufacturing operation because it is no longer profitable. Thus, a facility's optimal choice could be to produce zero output (i.e., close the facility). The model defines the sufficient condition for production at the mill as non-negative net earnings before interest, depreciation, and taxes (EBIDT). EBIDT is defined as the annual difference between postregulatory production revenues less postregulatory production costs, including the variable and nonvariable costs of compliance. The closure decision as defined here does not include an annualized value for the liquidation opportunity cost, which is equivalent to assuming that the opportunity cost is offset by the costs of closing the facility.

3.3.2.7 Domestic Demand For Pulp And Paper Products

Market Pulp. The market impact model does not specify an exogenous demand function for market pulps because that demand is derived from the paper supply decisions at the integrated and paper mills. Therefore, once the paper and paperboard production decisions at each mill have been made, the mill-specific, purchased input ratios for each market pulp will determine the domestic demand for each market pulp. Internal consumption of pulp is determined by mill-specific, onsite input ratios for each pulp input. These on-site input ratios

also form the basis for transmitting the variable compliance costs expressed per unit of pulp produced at the mill to per-unit variable compliance costs at the level of paper and paperboard products. We derived the mill-specific, purchased input ratios for each market pulp and the mill-specific, onsite ratios for each pulp input from technical production data reported in the *National Census*. We assumed these ratios to be constant throughout the analysis, thereby restricting each mill to produce paper and paperboard products with the same combination of fiber sources, in the same relative amounts, both before and after imposing the regulations.

The model assumes the integrated mills that met all pulp input needs through onsite production in 1989 will not be active on the markets for pulp and will continue to satisfy all pulp requirements internally after imposing the regulation. Thus, these mills are neither suppliers nor demanders in the markets for pulp. However, the model does account for the interaction of those integrated facilities that were active in the pulp markets during 1989, by specifying supply relationships for market pulp suppliers, or by specifying purchased pulp input ratios for market pulp demanders.

Paper and Paperboard Products. The market impact model uses an exogenous demand function for paper and paperboard products. The function is consistent with a constant elasticity demand curve. The function was econometrically estimated, producing an elasticity of demand. The demand elasticity measures the proportional change in quantity demanded given a proportional change in price. Economic theory suggests that the elasticity is negative (i.e., a rise in price should induce a reduction in quantity demanded, all else equal). The absolute value of a product's demand elasticity measure is often compared to a benchmark value of 1. An absolute value greater (less) than 1 indicates that demand is elastic (inelastic) with respect to price.

3.3.2.8 Modeling the Foreign Sector

The importance of including a foreign sector in the economic model is highlighted by the significant level of international trade of products manufactured by facilities in the U.S. pulp and paper industry. Section Two of this report provides detailed information on the extent of foreign

supply of pulp and paper products to the U.S. (imports) and foreign demand for U.S.-produced pulp and paper products (exports).

The market model specifies general functions for the foreign supply and demand for each market pulp, paper, and paperboard product. These functions incorporate estimates of the elasticities of foreign supply and foreign demand, which determine the responsiveness of foreign trade flows to changes in domestic product prices. These elasticities were numerically computed, rather than econometrically estimated, because domestic elasticity estimates are believed to understate the price responsiveness of trade flows. Where foreign trade is a relatively minor component of U.S. consumption or production, elasticities imply that regulation-induced price changes may generate large proportional changes in imports and exports. But these changes may not be so large in absolute value, given the small initial values of foreign trade. Price-taking in world markets should dampen the price effects of regulation in U.S. markets because theoretically large potential import supplies are available at the "world" price, and U.S. producers are not able to significantly raise the price of exports on world markets.

3.3.3 Determining Market Equilibria

The market impact model evaluates the supply and demand in each pulp, paper, and paperboard product market. Recall that the market supply of pulp is the sum of supply from U.S. mills plus foreign supply. In similar fashion, the market supply of paper and paperboard products is the sum of supply from all paper and paperboard producers, including foreign suppliers. Recall also that the market demand for pulp is the sum of derived demand for market pulp across all U.S. mills plus foreign demand. In similar fashion, the market demand of paper and paperboard products is the sum of demand from all paper and paperboard consumers, including foreign demand.

In the market impact model, each type of facility, integrated or nonintegrated, makes a supply decision. The model is set into motion when facilities face increased production costs due to compliance, which cause the facility-specific production responses. The cumulative effect of these responses leads to a change in the market price that all producers (affected and

unaffected) and consumers face, which leads to further responses by producers (affected and unaffected) as well as consumers and thus new market prices, and so on. The new postregulatory equilibria is the result of a series of iterations between producer and consumer responses and market adjustments, until a stable market price arises where total market supply equals total market demand.

The process for determining equilibrium prices (and outputs) is modeled as a Walrasian auctioneer. The auctioneer calls out a price for each product and evaluates the reactions by all participants (producers and consumers, both foreign and domestic), comparing quantities supplied and demanded to determine the next price that will guide the market closer to equilibrium (i.e., market supply equal to market demand). The model employs an algorithm to simulate the auctioneer process and find a new equilibrium price and quantity for all 37 pulp and paper product markets simultaneously. The model is governed by decision rules that ensure the auctioneer process will converge to an equilibrium. The result of this approach is a vector of post-compliance product prices that equilibrates supply and demand for all product markets.

3.3.4 Postregulatory Impact Estimates

The market model equilibria results can be summarized as both market-level and facility-level impacts. Market-level results include adjustments in product prices, market-level production quantity changes, changes in international trade flows, and changes in aggregate economic welfare as measured by changes in consumer and producer surpluses.

Facility-level impacts include an evaluation of the pre-tax postregulatory compliance cost, product-line and facility closures, and changes in production, production costs, and EBIDT. In addition, the model computes changes in employment attributable to the changes in output at each mill. These output changes are due to product-line and facility closures as well as adjustments in production at mills that continue to operate under regulation. Workers' dislocation costs associated with industry-wide job losses are also calculated based on the one-time willingness to pay to avoid an involuntary unemployment episode.

3.4 RELATIONSHIP BETWEEN FINANCIAL AND MARKET IMPACT ANALYSIS METHODOLOGIES

The financial and market models provide related investigations of the potential impacts of increased pollution control costs. The financial model, clearly the more conservative of the two approaches, incorporates the following conservative assumptions and approaches:

- No cost pass-through. The mill is not allowed to raise prices to recoup increased pollution control costs. This is tantamount to assuming an inexhaustible supply of imports to keep domestic prices from rising.
- No growth. The mills are assumed to be operating at or near capacity. No growth can occur without the costs of expansion.
- Net income, rather than cash flow, to estimate earnings.
- Comparison of the net present value of future earnings against the salvage value to determine closure.
- Calculations of impacts only for those mills expected to incur pollution control costs.

The financial model focuses only on the facility. Results from the financial model predict mill closures and show how such closures will affect employment, revenue, and exports.

In contrast, the market approach uses an econometric model to estimate the impacts of additional pollution control costs on the pulp, paper, and paperboard industry. The market model can be distinguished from the financial model based on the following:

- Facilities may incorporate price increases to cover added pollution control costs.
- A mill may adjust output along product lines to maximize profits.
- Nonpulp, paper, or paperboard revenues are included in earnings estimates.
- Cash flow is used as a measure of earnings.
- A mill is closed only if revenues do not exceed total avoidable costs (i.e., the salvage value of the mill is not estimated).

- All mills in the industry are included in the market model.
- Imports affect market-level price and quantity changes.

Based on these differences, a mill is more likely to remain open in the market model, and the market model could show impacts for mills estimated to bear no costs for pollution control. (For example, a paper producer might not be able to sustain production if the price of input pulp increases while the prices for the final product do not.) The price increases calculated in the market model cannot be incorporated in the financial model because they are based on mill closures and product line shifts that occur as the model moves toward equilibrium. Employment impacts are estimated from mill closures and output changes in the market model.

The results of the financial model and market model, then, will differ. The financial model is likely to show consistently greater impacts from the regulations than the market model and possibly a different set of closure mills. Each approach has its own strengths and weaknesses. Using both models, however, yields the full range of possible impacts associated with the rulemaking.

3.5 REGULATORY FLEXIBILITY ANALYSIS METHODOLOGY

The Regulatory Flexibility Act (RFA) came into effect on January 1, 1981 (EPA, 1992b). A goal of the act is to establish a mechanism to provide policymakers with information on how regulatory options affect small entities. The intent is to ensure that the chosen regulatory alternative does not have undue or disproportionate impacts on small entities. The Agency has developed guidelines for implementing the Regulatory Flexibility Act (EPA, 1992b).

3.5.1 Definition of Small Entity

RFA Section 601 states "For the purpose of this chapter...(3) the term 'small business' has the same meaning as the term 'small business concern' under section 3 of the Small Business Act, unless an agency, after consultation with the Office of Advocacy of the Small Business

Administration and after opportunity for public comment, establishes one or more definitions of such terms what are appropriate to the activities of the agency....." (EPA, 1992b, Appendix A). The U.S. Small Business Administration issues definitions of "small businesses" in Code of Federal Regulations, Title 13, Part 121. For pulp, paper, and paperboard mills (SIC codes 2611, 2621, and 2631, respectively), the standard is 750 employees. A small entity, therefore, is defined as a business entity with less than 750 employees.

3.5.2 Alternate Definitions of Small Entity

RFA Section 601 allows an agency to establish alternative definitions for a small entity. The rulemaking focuses on individual facility performance with respect to meeting increased pollution control requirements. For this reason, two sets of definitions are developed—one on a company basis (for consistency with the Small Business Administration definition), and one on a facility basis (in keeping with the basis for the rulemaking).

For two reasons, the basis for the alternate definitions is the number of employees, both production and nonproduction.[17] The first reason is that the number of employees is the Small Business Administration basis for defining small entities for this industry. The second is that other ways to define a small entity (e.g., assets or shipments) did not appear to provide any advantage over the number of employees (see Section 2.4.2.1 for a more detailed discussion).

The distribution of the number of employees by facility indicates a substantial number of facilities with 125 or fewer employees (Figure 2-10). In keeping with the intent of the RFA, a three-tiered subdivision was developed for this rulemaking:

- Very small - 0 to 125 employees
- Small - 126 to 750 employees
- Large - more than 750 employees.

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[17]If a facility closes, both production and nonproduction employees will lose their jobs; hence the definition is based on all employees.

Taken together, the very small and small categories for the company correspond to the Small Business Administration definition of a small business entity for the pulp and paper industry. The additional definitions allow a more detailed examination of smaller entities.

3.5.3 Financial Impact Analysis of Small Entities

3.5.3.1 Summary Information for Small Entities - Facility Definition

Table 3-19 indicates that 35 percent of the facilities fall in the very small category; nearly half are in the small category; and the remaining 16 percent are in the large category. As anticipated, when a facility is independently owned, there is a much greater likelihood for it to be a very small facility. Nearly two-thirds of the independently-owned facilities are in the very small category. Only four percent of the independently-owned facilities are in the large category. The remaining mills are in the small category. In contrast, about half of the mills that are part of multifacility organizations are in the small category, and nearly two of every five are large facilities.

Table 3-20 summarizes the distribution of employees, shipments, and exports among the regulatory flexibility categories. Large facilities represent only 16 percent of the mill population, yet they account for over half the employees, 42 to 51 percent of the shipments, and 49 percent of the exports. Very small facilities account for about 6 percent of employees, 4 to 6 percent of shipments (value and tons, respectively), but less than 2 percent of the value of exports.

Table 3-21 examines the facility-level ratio analysis by size category. The average gross income margin for small facilities is negative for all 3 years in the survey. In 1985, at least 25 percent of the mills showed negative gross income margins. This dropped to at least 10 percent of the mills for 1988 and 1989. An investigation of outliers revealed such occurrences as a facility that stated in the comments section it was a captive mill that transferred all its production at cost while the actual data indicate that the transfer price did not cover costs, and a mill that claimed only 10 percent of its revenues were from pulp, paper, or paperboard. The negative

TABLE 3-19

COUNTS OF INDEPENDENT AND MULTI-FACILITY MILLS
BY REGULATORY FLEXIBILITY CATEGORY - FACILITY DEFINITION

Size Based on Employment	Independently Owned	Percentage	Multi-Facility Group	Percentage	All Mills	Percentage
Very Small (0 - 125 Employees)	34	64	148	31	182	35
Small (126 - 750 Employees)	17	32	239	51	256	49
Large (> 750 Employees)	2	4	84	18	86	16
Total	53	100	471	100	524	100

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Note: Only 524 facilities are included because some mills are dummy mills, have changed ownership since 1989 and therefore didn't have information for the questionnaire, have begun production since 1989, or had contractor-supplied labor.

TABLE 3-20

REGULATORY FLEXIBILITY CATEGORIES - FACILITY DEFINITION
(1989 DATA)

Facility Category	Mills		Employees		Shipments				Exports	
	Number	Percent	Number	Percent	Tons	Percent	Value ($000)	Percent	Value ($000)	Percent
Very Small (0 - 125 Employees)	182	34.7%	13,630	6.2%	4,919,637	5.7%	$2,521,977	4.3%	$99,493	1.7%
Small (126 - 750 Employees)	256	48.9%	91,966	41.7%	45,372,710	52.3%	$26,412,033	45.1%	$2,891,979	49.4%
Large (> 750 Employees)	86	16.4%	114,895	52.1%	36,419,405	42.0%	$29,595,176	50.6%	$2,862,478	48.9%
Total	524	100.0%	220,491	100.0%	86,711,752	100.0%	$58,529,186	100.0%	$5,853,950	100.0%

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Notes
Only 524 facilities are included because some mills are dummy mills, have changed ownership since 1989 and therefore didn't have information for the questionnaire, have begun production since 1989, or had contractor-supplied labor.

TABLE 3-21

BASELINE FACILITY-LEVEL RATIO ANALYSIS
REGULATORY FLEXIBILITY CATEGORIES - FACILITY DEFINITION

Ratio	Category	Baseline Value 1985	1988	1989	Percent Variation
Mean					
Gross Income Margin	Very Small	3.1%	7.3%	7.4%	59.0%
	Small	-0.2%	-7.7%	-11.1%	-4588.5%
	Large	7.0%	18.4%	18.8%	62.6%
	All	2.1%	1.8%	0.3%	87.9%
Return on Assets	Very Small	30.7%	29.7%	39.9%	25.4%
	Small	9.6%	34.8%	30.3%	72.3%
	Large	13.0%	22.6%	23.0%	43.6%
	All	17.0%	31.0%	32.3%	47.6%
Current Ratio	Very Small	4.72	3.46	3.83	26.8%
	Small	2.62	2.51	3.32	24.4%
	Large	2.15	2.03	2.08	5.6%
	All	3.16	2.72	3.26	16.4%
Net Working Capital ($000)	Very Small	$1,195	$1,475	$1,037	29.7%
	Small	$2,733	$4,916	$3,445	44.4%
	Large	$19,098	$17,629	$19,716	10.6%
	All	$5,275	$5,948	$5,392	11.3%
Net Working Capital/ Total Assets	Very Small	21.5%	17.7%	15.2%	29.4%
	Small	15.8%	9.8%	7.7%	51.0%
	Large	9.1%	6.9%	7.9%	24.2%
	All	16.4%	12.0%	10.3%	37.2%
Median					
Gross Income Margin	Very Small	5.7%	6.8%	8.2%	30.6%
	Small	5.4%	14.6%	13.2%	62.7%
	Large	8.0%	19.4%	20.2%	60.3%
	All	5.7%	11.6%	12.3%	53.2%
Return on Assets	Very Small	11 1%	11.3%	16.6%	33.5%
	Small	7 8%	20.6%	18.1%	62.4%
	Large	10.5%	18.4%	18.1%	42.8%
	All	9 5%	17.3%	17.5%	45.9%
Current Ratio	Very Small	2 09	1.98	1.88	9.8%
	Small	1.82	1.81	1.75	3.7%
	Large	1 71	1 77	1.76	3.2%
	All	1 85	1 84	1.81	1.7%
Net Working Capital ($000)	Very Small	$667	$709	$628	11.5%
	Small	$2,926	$4,434	$4,224	34.0%
	Large	$13,593	$17,652	$19,084	28.8%
	All	$2,211	$2,778	$2,284	20.4%
Net Working Capital/ Total Assets	Very Small	19 1%	18 2%	12.9%	32.3%
	Small	9 9%	10 2%	8.7%	14.3%
	Large	6 1%	6 6%	6.1%	7.4%
	All	11 0%	9 8%	8.8%	20.5%

Notes: Includes independent, single-facility, and multi-facility entities.
There are 523 mills in the analysis.

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value seen for the average gross income margin is an example where data for the ratio analysis will vary dramatically between the facility level and the business entity level. These data also indicate that there will be a large number of mills that are projected to close before the addition of incremental pollution control costs.

The median gross income margin and median return on assets indicate that very small facilities had more favorable business conditions in 1988 and 1989 than in 1985; the improvement was less than was seen for small and large facilities. For small facilities, the median return on assets nearly tripled from 1985 to 1988. The median current ratio remains stable for all categories for all survey years. The median current ratio for very small facilities is consistently slightly higher than for the other categories. A very small facility may need a higher current ratio in order to have a sufficient amount of working capital to finance day-to-day operations. The distinction between the categories is most apparent in the median amount of net working capital. Small facilities have about four times the amount of net working capital as very small facilities while large facilities have between four to five times the net working capital as small facilities. Net working capital forms the highest percentage of total assets for very small facilities and the smallest percentage for large facilities.

3.5.3.2 Summary Information for Small Entities - Business Definition

Table 3-22 indicates that 32 percent of the business entities fall in the very small category; another 42 percent are in the small category; and the remaining 26 percent are in the large category. The distribution among size categories is the same for independent operations because the facility and business entity coincide; nearly two-thirds of the independently-owned facilities are in the very small category. In contrast, only one of every five non-independent companies are in the very small category. For non-independent businesses, 46 percent are in the small category and the remaining 34 percent are in the large category. Using only the Small Business Administration definition for small entity, large entities account for 26 percent of the population.

Table 3-23 summarizes the distribution of employees, shipments, and exports among the regulatory flexibility categories on a company basis. Large companies represent only 26 percent

TABLE 3-22

COUNTS OF INDEPENDENT AND MULTI-FACILITY MILLS
BY REGULATORY FLEXIBILITY CATEGORY - BUSINESS DEFINITION

Size Based on Employment	Independently Owned	Percentage	Non-Independently Owned	Percentage	All Mills	Percentage
Very Small (0 - 125 Employees)	34	64	29	20	63	32
Small (126 - 750 Employees)	17	32	66	46	83	42
Large (> 750 Employees)	2	4	49	34	50	26
Total	53	100	144	100	196	100

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Note: This analysis includes 196 companies. Three companies are not included because they have begun production since 1989 or had contractor-supplied labor.

TABLE 3-23

REGULATORY FLEXIBILITY CATEGORIES - BUSINESS DEFINITION
(1989 DATA)

Company Category	Companies		Employees		Shipments				Exports	
	Number	Percent	Number	Percent	Tons	Percent	Value ($000)	Percent	Value ($000)	Percent
Very Small (0 - 125 Employees)	63	32.1%	4,197	1.9%	1,361,956	1.6%	$695,040	1.2%	$39,508	0.7%
Small (126 - 750 Employees)	83	42.3%	27,010	12.2%	9,369,963	10.8%	$5,748,242	9.8%	$756,824	12.9%
Large (> 750 Employees)	50	25.5%	189,284	85.8%	75,979,833	87.6%	$52,085,904	89.0%	$5,057,618	86.4%
Total	196	100.0%	220,491	100.0%	86,711,752	100.0%	$58,529,186	100.0%	$5,853,950	100.0%

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Notes:
This analysis includes 196 companies Three companies are not included because they have begun production since 1989 or had contractor-supplied labor.

of the population, yet they account for 86 percent of the employees, 76 to 88 percent of the shipments, and 87 percent of the exports.

Table 3-24 examines the ratio analysis by size category based on business entities. The patterns seen in the data are similar to those seen at the facility level (Table 3-20). The average net income margin for very small entities is negative in 1985, while large entities had a margin of nearly 6 percent. The data for all ratios indicate that the industry downturn had begun by the end of 1989; 1988 tends to be the better year. This is consistent with the observations of other industry analysts (DeKing et al., 1990).

The distinction between the size categories is most apparent when we compare the median net working capital and net working capital-to-total assets. Very small companies have about $1 million in net working capital, yet this forms between 25 to 40 percent of its total assets. Small companies have about $5 to $9 million in net working capital, but this forms only between 15 to 20 percent of its total assets. The median amount of net working capital for a large company ranges from $60 to $100 million over the survey period. Although this is nearly 60 to 100 times the amount of net working capital for a very small entity, it forms only 8 to 10 percent of the total assets for the company. The median values for the other ratios—net income margin, return on assets, current ratio, debt-to-assets, and times interest earned—show far less stratification among the categories.

3.5.4 Market Impact Analysis of Small Entities

The results of the market impact model can be used to evaluate the impact of the proposed regulations on groups of small and large facilities and small and large companies. The market impact model provides facility-level impacts that are mapped to company-level data to estimate impacts on companies. For the purpose of evaluating market impact analysis results small facilities are defined as 126 to 750 employees, and very small facilities are defined as less than 125 employees. In addressing small business impacts at the company level, the SBA size standards will be employed. Thus, the company-level analysis will consist of a large category, defined as greater than 750 employees, and a small category, defined as less than 750 employees.

TABLE 3-24

BASELINE BUSINESS ENTITY-LEVEL RATIO ANALYSIS
REGULATORY FLEXIBILITY CATEGORIES - BUSINESS DEFINITION

Ratio	Category	Baseline Parameter 1985	1988	1989	Percent Variation
Mean					
Net Income Margin	Very Small	-1.0%	5.5%	3.5%	118.5%
	Small	1.2%	6.2%	4.7%	81.4%
	Large	5.6%	7.2%	6.1%	22.1%
	All	1.8%	6.2%	4.7%	71.0%
Return on Assets	Very Small	6.9%	10.4%	10.7%	35.9%
	Small	1.5%	9.0%	6.3%	83.8%
	Large	6.5%	8.6%	7.3%	24.0%
	All	4.6%	9.3%	8.0%	50.8%
Current Ratio	Very Small	7.04	3.16	3.17	55.1%
	Small	2 16	2.44	2.29	11.2%
	Large	1.87	1.75	1.72	7.8%
	All	3 55	2.48	2.43	31.6%
Net Working Capital ($000)	Very Small	$2,825	$2,714	$2,416	14 5%
	Small	$40,820	$62,349	$51,501	34.5%
	Large	$100,924	$165,886	$155,766	39.2%
	All	$46,172	$70,231	$62,005	34.3%
Net Working Capital/ Total Assets	Very Small	34 3%	29 1%	26.3%	23.5%
	Small	16 3%	19 7%	17 4%	17.6%
	Large	11.1%	9 4%	9.2%	17.2%
	All	20.3%	20.0%	18.2%	10.5%
Debt/Asset Ratio	Very Small	43.4%	53.6%	53 9%	19.5%
	Small	58 0%	61 1%	62.7%	7.5%
	Large	50.9%	55.9%	57 7%	11.9%
	All	51.5%	57.2%	58 4%	11 7%
Times Interest Earned	Very Small	25 0	14 3	28 8	50.5%
	Small	40 5	35 1	~ 15 1	62 9%
	Large	65 7	47 7	22 8	65 3%
	All	45 5	34 2	21 1	53 8%
Median					
Net Income Margin	Very Small	4 0%	3 7%	3 8%	9 1%
	Small	4 3%	4 6%	3 2%	30 5%
	Large	4 1%	7 2%	6 4%	42 6%
	All	4 2%	5 3%	5 0%	19 8%
Return on Assets	Very Small	6 9%	9 2%	8 4%	24 9%
	Small	5 4%	6 8%	5 2%	22 8%
	Large	5 4%	8 9%	6 7%	38 7%
	All	5 8%	8 5%	6 5%	31 8%
Current Ratio	Very Small	2 66	2 32	2 08	22 0%
	Small	1 83	2 03	1 82	10 5%
	Large	1 69	1 64	1 57	7 2%
	All	1 90	1 91	1 79	6 0%
Net Working Capital ($000)	Very Small	$973	$89[illegible]	$1 037	13 9%
	Small	$5 569	$6 491	$6 472	34 4%
	Large	$60 427	$69 230	$100 400	39 8%
	All	$5 584	$[illegible] 090	$5 84[illegible]	21 2%
Net Working Capital/ Total Assets	Very Small	39 8%	29 8%	25 1%	36 9%
	Small	18 0%	19 3%	15 4%	20 3%
	Large	10 3%	9 1%	8 1%	21 1%
	All	18 3%	17 5%	13 2%	28 3%
Debt/Asset Ratio	Very Small	35 7%	52 9%	54 [illegible]%	34 1%
	Small	50 7%	53 3%	56 [illegible]%	10 3%
	Large	51 6%	52 6%	49 7%	5 5%
	All	50 2%	53 2%	54 4%	7 8%
Times Interest Earned	Very Small	5 3	6 3	5 2	17 4%
	Small	6 6	6 9	4 7	32 0%
	Large	6 3	10 9	11 1	43 7%
	All	6 3	8 8	7 1	28 8%

Notes Includes independent single-facility and multi-facility entities
There are 196 companies in the analysis

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The terms facility, establishment, plant, and mill are synonymous in this analysis and refer to the physical location where products are manufactured. Likewise, the terms company and firm are synonymous and refer to the legal business entity that owns one or more facilities.

3.5.4.1 Facility-Level Analysis

In the case of the pulp and paper industry, small businesses will probably incur an economic impact because all facilities react to the regulation-driven changes in market prices resulting in changes in facility-level revenues, costs, and earnings before interest, depreciation, and taxes (EBIDT). The market impact model analysis generates information that can be used to assess these impacts. Measures of economic impact on which an analysis at the facility-level is based should reflect changes in operating status and employment, changes in revenues, costs, and EBIDT, and the relative size of the regulatory costs to baseline revenues, costs, and EBIDT.

The facility-level analysis includes the following impact measures:

- Percentage of small mills predicted to close with the regulation versus the percentage of large mills
- Distribution of predicted employment changes with the regulation across small and large mills
- Percentage change from baseline in product revenues, total costs of production, and EBIDT for small versus large mills
- Annual compliance costs (annualized capital and annual operating) as a percentage of total revenues and total costs of production for small versus large mills, and
- Annual compliance costs (annualized capital and annual operating) as a percentage of EBIDT for small versus large mills.

The baseline values for revenues, costs, and EBIDT at the facility level are determined from the baseline data in the market impact model, and the percentage changes due to the regulation are obtained after imposing the regulatory costs and allowing markets to adjust.

Baseline Facility Size Distribution. Table 3-25 indicates that 85.2 percent of the facilities fall in the small combination group, while the remaining 14.8 percent are in the large category. Within the small combination group, small facilities account for 54 percent and very small facilities the remaining 46 percent. As expected, a facility is more likely to be in the small combination group when it is independently owned and operated as opposed to when it is part of a multifacility group. Almost 97 percent of the independently owned facilities are in the small combination group, while only 3 percent are in the large category. Alternatively, roughly 83 percent of the mills that are part of multifacility groups are part of the small combination group, and over 17 percent are categorized as large.

Facility Employment. As shown in Table 3-26, industry production and non-production employment estimates for 1989 are almost evenly divided across small combination group and large facilities. Small combination group facilities employ roughly 49 percent of industry workers, while the remaining 51 percent of the industry's workforce is employed at large facilities. Within the small combination group, small facilities account for over 85 percent, while very small facilities account for the remaining 15 percent. Facilities that are part of a multifacility group employ the vast majority of the estimated 217,628 production and non-production employees, accounting for over 90 percent of this total. As expected, independently owned and operated facilities account for a very small percentage, only 9 percent, of employment. Employment changes associated with regulating the industry are determined by the facility-level responses in the market impact model. The changes in employment result from both mill closures and production changes at mills continuing to operate with the regulations.

Product Revenues, Production Cost, and Earnings Before Interest, Depreciation and Taxes (EBIDT). Additional indicators of the severity of the economic impact on small facilities include the changes in product revenues, total costs of production, and EBIDT. All facilities in the market impact model react to the regulation-driven changes in market prices--deciding whether to produce and, if so, at what level. These reactions to the market outcomes result in changes in facility-level revenues, variable production costs, and EBIDT. Comparing the distributional changes in facility-level revenues, costs, and EBIDT across small and large facilities indicates whether any disproportional impact exists across these populations because of regulation.

TABLE 3-25

INDEPENDENT AND MULTIFACILITY MILLS BY SIZE: 1989 BASELINE VALUES

Size based on employment	Independently owned		Multifacility group		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
Small Combination Group (<750)	94	96.9	388	82.7	482	85.2
Small (<750 & >125)	44	45.4	217	46.3	261	46.1
Very Small (≤125)	50	51.5	171	36.4	221	39.1
Large (>750)	3	3.1	81	17.3	84	14.8
Total	97	100.0	469	100.0	566	100.0

Source: EPA survey.

TABLE 3-26

EMPLOYMENT OF INDEPENDENT AND MULTIFACILITY MILLS BY SIZE: 1989 BASELINE VALUES

Size based on employment	Independently owned		Multifacility group		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
Small Combination Group (<750)	17,698	83.3	88,701	45.2	106,399	48.9
Small (<750 & >125)	14,391	67.7	76,109	38.8	90,500	41.6
Very Small (≤125)	3,307	15.6	12,592	6.4	15,899	7.3
Large (>750)	3,549	16.7	107,680	54.8	111,229	51.5
Total	21,247	100.0	196,381	100.0	217,628	100.0

Source: EPA survey.

Annual Compliance Costs. The relative severity of the regulations can also be measured by comparing the ratios of annual compliance costs to total revenues, total costs, and EBIDT across small and large facilities. Although all facilities react to the regulation-driven market changes, only a subset of the facilities in the pulp and paper industry incur direct annual costs of compliance. The significance of these costs to directly affected facilities can be measured in terms of total revenues, total costs, and EBIDT. Comparing these ratios across small and large facilities indicates whether any disproportional direct burden of compliance exists across these populations.

3.5.4.2 Company-Level Analysis

A regulatory action to reduce pollutant discharges from facilities manufacturing pulp and paper will potentially affect the business entities that own the regulated facilities. Facilities, or mills, comprise a site of land with plant and equipment that combine inputs (raw materials, energy, and labor) to produce outputs (pulp, paper, and paperboard). Companies, or firms, that own these facilities are legal business entities that have the capacity to conduct business transactions and make business decisions that affect the facility.

Potentially affected firms include entities that own facilities that manufacture pulp, paper, and paperboard. For the base year of 1989, the market impact model identifies 214 companies potentially affected by the regulation. However, one firm lacked data necessary for inclusion in the analysis. Thus, the firm-level analysis includes 213 firms owning 565 facilities.

The baseline financial profile was based on complete financial data from EPA's *National Census* for 151 of the 213 companies included in the analysis, while the baseline financial profile of the remaining 62 firms is supplemented or constructed using data from *American Business Information* (ABI) and Dun and Bradstreet's (D&B's) *Industry Norms and Key Business Ratios* (EPA, 1991; ABI, 1993; Dun's, 1991). These sources were incorporated because of incomplete financial data, i.e., missing balance sheet data, in the *National Census* for 41 companies and missing financial data, neither income statement or balance sheet information, for 21 companies.

The measures of economic impact on which the company-level analysis is based reflect changes in the number of operating mills and employment, changes in profitability, and the change in the likelihood of financial failure (bankruptcy, as measured by the Altman Z-score).

The firm-level analysis includes the following impact measures:

- Percentage of mills owned by small and large firms predicted to close with the regulation
- Distribution of predicted employment changes with the regulation across small and large firms
- Changes from baseline in key measures of profitability (return on sales, return on assets, and return on equity) for small versus large firms, and
- Changes from baseline in the likelihood of financial failure or bankruptcy (as measured by Altman's Z'-score) for small versus large firms (Altman, 1983).

Companies In The Analysis. Companies in this analysis include those owned directly by the shareholders/owners and those owned by a "parent" company. Figure 3-13 shows the chain of ownership may be as simple as one facility owned by one company or as complex as multiple facilities owned by subsidiary companies.

Business entities that own pulp and paper manufacturing facilities will generally be one of three types of entities:

- Sole proprietorships
- Partnerships, and
- Corporations.

Each type has its own legal and financial characteristics that may have a bearing on how firms are affected by the regulatory alternatives. Table 3-27 provides information of the legal form of ownership of firms for the relevant SIC codes.

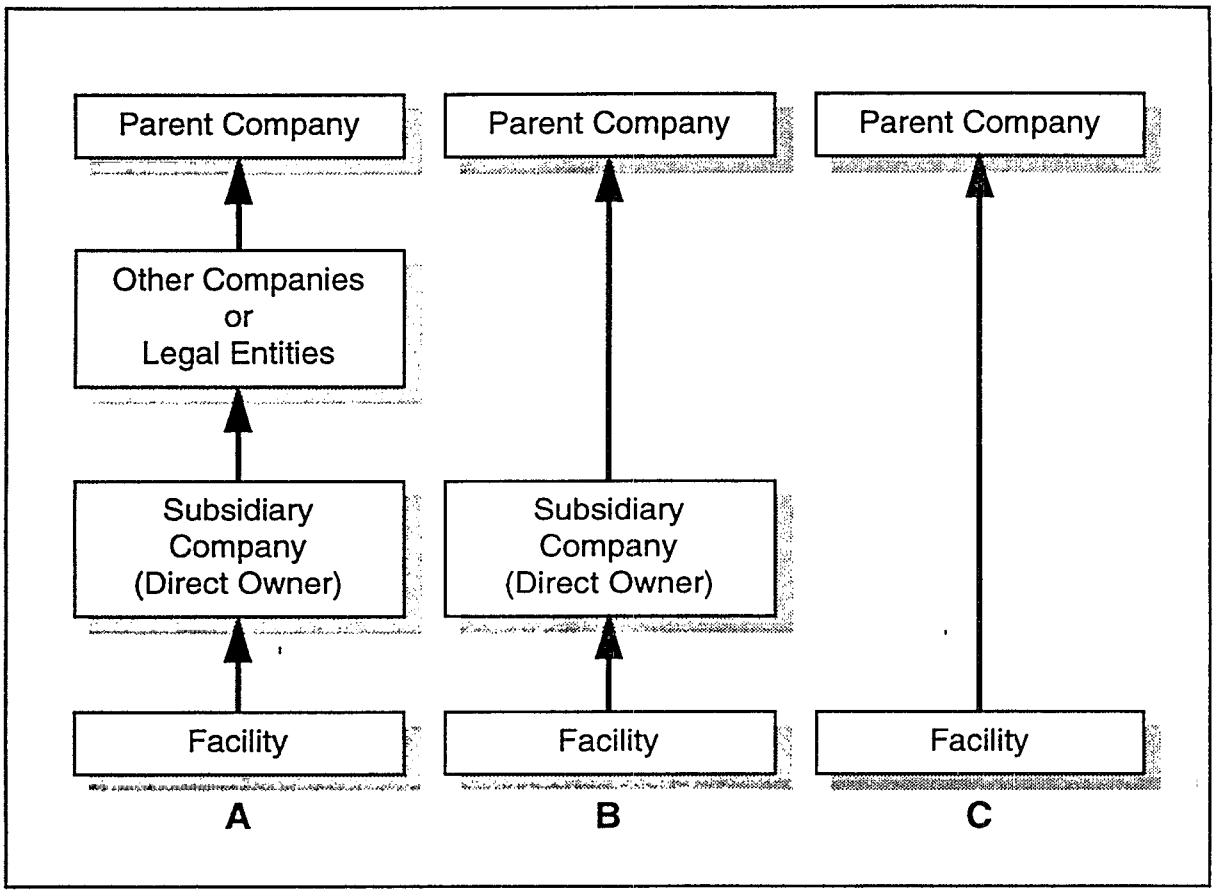

Figure 3-13. Chain of ownership.

TABLE 3-27

LEGAL FORM OF ORGANIZATION OF FIRMS IN THE PULP AND PAPER INDUSTRY: 1987

Item/SIC code	Legal form of organization				
	Corporations	Sole proprietorships	Partnerships	Other	Total
Pulp mills, 2611					
Single facility firms	2	0	0	0	2
Multifacility firms	24	0	0	0	24
All firms	26	0	0	0	26
Paper mills, 2621					
Single facility firms	25	2	6	2	35
Multifacility firms	87	0	0	0	87
All firms	112	2	6	2	122
Paperboard mills, 2631					
Single facility firms	13	0	0	0	13
Multifacility firms	78	0	0	0	78
All firms	91	0	0	0	91

Source: DOC, 1991.

The 213 companies identified in the market impact model are listed in Table 2-31. The number is firms is larger than the 135 reported in the 1987 *Census of Manufacturing for "Pulp and Paper Mills"* because it includes some firms listed under "Other Paper and Allied Products."

Company-Level Employment and Size. To arrive at employment estimates for companies in the market impact model we aggregated facility-level employment to the firm level because the 1990 *National Census* did not include company-level employment data. However, for some firms this measure of employment does not accurately reflect their employment, and thus firm size, because they may own facilities outside of the pulp and paper industry. To avoid misclassification, particularly in the case of incorrectly categorizing large firms as small, we incorporated employment data from ABI on parent companies included in the relevant SIC codes (i.e., 2611, 2621, and 2631). Based on these data 150 firms, or 70.4 percent, are categorized as small, while the remaining 63 firms, or 29.6 percent, are in the large category. Small firms employ an average of only 193 workers. Large firms have a much higher number of employees across all operations--averaging 9,896 per firm.

Firms may differ in size for one or both of the following reasons:

- First, pulp and paper facilities vary widely by size. All else being equal, firms with large facilities are larger than firms with small facilities.
- Second, firms vary in the number of facilities they own. All else being equal, firms with more facilities are larger than those with fewer facilities.

Control economies are typically facility related rather than firm related. For example, a firm with six uncontrolled facilities with an average annual receipt of $1 million per facility may face approximately six times the control capital requirements of a firm with one uncontrolled facility whose receipts total $6 million per year. Alternatively, two firms with the same number of facilities facing approximately the same control capital costs may be financially affected very differently if the facilities of one are larger than those of the other.

Table 3-28 shows the average size of facility (based on 1989 total employment level) represented in each company size category. As expected, larger firms own larger facilities on average. Table 3-29 shows the distribution of firms by the number of facilities owned. A slight

TABLE 3-28

AVERAGE SIZE OF FACILITY BY FIRM SIZE CATEGORY: 1989[a]

Firm size based on employment (1989)	Total employment at facilities owned	Total number of facilities owned	Average employment per facility
Small (< 750)	27,136	211	129
Large (>750)	190,492	354	538
Total, all firms	217,628	566	384

[a]Facility size is measured as total employment in 1989.

Source: EPA survey.

TABLE 3-29

DISTRIBUTION OF FIRMS BY NUMBER OF FACILITIES OWNED: 1989

Firm size based on employment	Number of facilities owned per firm			
	1	2 to 3	Over 3	Total
Small (< 750)	116	26	8	150
Large (> 750)	19	13	31	63
Total, all firms	135	39	39	213

Source: EPA survey.

correlation appears to exist between the number of pulp and paper manufacturing facilities owned and the size of the firm. The average number of facilities owned by small firms is 1.4 (213 facilities ÷ 150 firms) as compared to an average of 5.6 facilities (354 facilities ÷ 63 firms) owned by large firms. However, nonpulp and paper facilities are not reflected in this distribution.

Issues of Vertical and Horizontal Integration. Vertical integration is a potentially important dimension in firm-level impact analysis because the regulation could affect a vertically integrated firm on several levels. For example, the regulation may affect companies for whom the manufacture of pulp and paper is not the company's primary focus but rather is an input into the company's other production processes such as construction, print media, and food products. A regulation that increases the cost of manufacturing pulp and paper for vertically integrated firms will also affect the cost of producing the primary products. The market impacts on nonpulp and paper products are not estimated in the market impact model analysis. Table 3-30 shows the range of industries represented by firms that own pulp and paper facilities by SIC code.

Horizontal integration is also a potentially important dimension in firm-level impact analysis for either or both of two reasons:

- First, a diversified firm may own facilities in unaffected industries. This type of diversification would help mitigate the firm-level financial impacts of the regulation.
- Second, a diversified firm could be indirectly as well as directly affected by the regulation. For example, if a firm is diversified in manufacturing pollution control equipment (an unlikely scenario), the regulation could indirectly and favorably affect it.

Figure 3-14 shows the share of total receipts from business activities other than pulp and paper manufacturing for firms in each size category. Firms in the large size category receive slightly more than 50 percent of their revenues from other activities. Conversely, firms in the small size category receive the vast majority of their revenues from business activities other than pulp and paper manufacturing.

TABLE 3-30

SIC LISTINGS FOR FIRMS OWNING PULP AND PAPER MANUFACTURING FACILITIES

SIC Code	Industry and product description
2087	Flavoring extracts & syrups, n.e.c.
2099	Food preparations, n.e.c.
2411	Logging camps and logging contractors
2421	Sawmills & planing mills, general
2429	Special product sawmills, n.e.c.
2448	Wood pallets & skids
2499	Wood products, n.e.c.
2611	Pulp Mills
2621	Paper Mills, except building paper
2631	Paperboard Mills
2641	Paper coating & glazing
2643	Bags, except textile bags
2645	Die-cut paper & board
2647	Sanitary paper products
2649	Converted paper products, n.e.c.
2651	Folding paperboard boxes
2653	Corrugated & solid fiber boxes
2654	Sanitary food containers
2655	Fiber cans, tubes, drums, & similar products
2661	Building paper and board mills
2671	Paper coated & laminated, packaging
2672	Coated & laminated paper, n.e.c.
2674	Uncoated paper & multiwall bags
2679	Converted paper & paperboard products
2741	Miscellaneous publishing
2812	Alkalies & chlorine
2816	Inorganic pigments
2819	Industrial inorganic chemicals, n.e.c.
2841	Soap & other detergents, except specialty cleaners
2851	Paint & allied products
2861	Gum & wood chemicals
2869	Industrial organic chemicals, n.e.c.
2952	Asphalt felts & coatings
3081	Unsupported plastics film & sheet
3083	Laminated plastics plate, sheet, & profile shapes
3087	Custom compounding of purchased plastics resins
3275	Gypsum products
3296	Mineral wool
3471	Plating and polishing

Source: EPA survey.

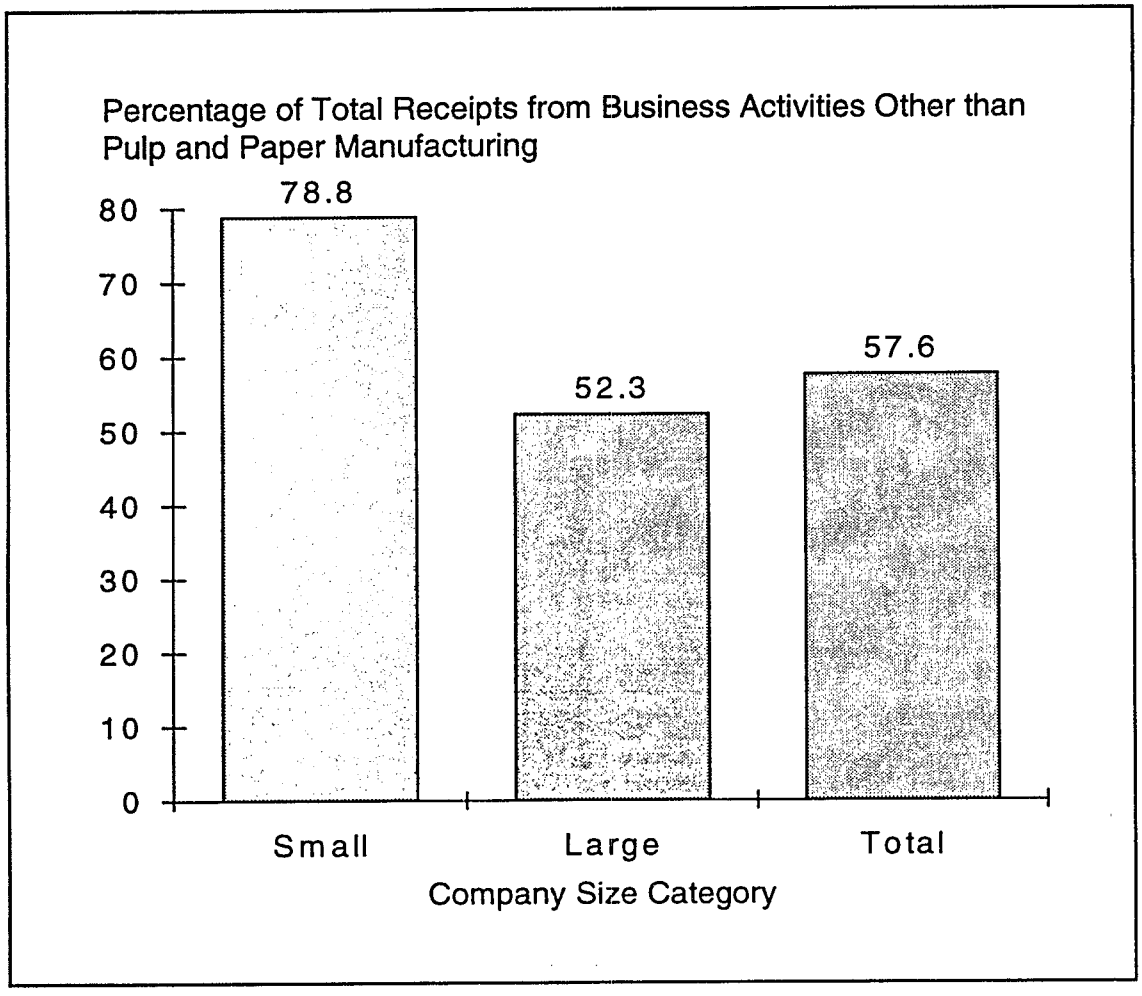

Figure 3-14. Total receipts from business activities other than pulp and paper manufacturing.

Computing Company-Level Impacts. Company-level impact results are generated by aggregating changes at the facility level and incorporating the changes into the 1989 baseline financial statements of each firm. The baseline financial profile was based on complete financial data from EPA's *National Census* for 151 of the 213 companies included in the analysis, while the baseline financial profile of the remaining 69 firms is supplemented or constructed using data from *American Business Information* (ABI, 1993) and Dun and Bradstreet's (D&B's) *Industry Norms and Key Business Ratios* (Dun's, 1991). These sources were incorporated because of incomplete financial data, i.e., missing balance sheet data, in the *National Census* for 41 companies and missing financial data, neither income statement or balance sheet information, for 21 companies.

We made several adjustments to the financial statements of each firm to account for the regulation-induced changes at all facilities owned by the firm. In the annual income statement, firm revenues and costs are both directly and indirectly affected because all facilities react to the adjustments in market prices associated with regulation. We adjusted sales revenue by the aggregate change in product revenue for facilities owned by the firm. We altered the costs of goods sold by the aggregate change in production costs across facilities owned by the firm. The change in production costs includes both the annual compliance costs (operating and maintenance costs plus annual capital expenses) and variable cost changes due to output adjustments.

In the balance sheet, changes occur only to those firms directly affected by the regulation and are determined by the manner in which firms acquire the pollution control equipment. Directly affected firms face three choices in funding the acquisition of capital equipment required to comply with the regulations. These choices include:

- Debt financing
- Equity financing, or
- A mixture of debt and equity financing.

Debt financing involves obtaining additional funds from lenders who are not owners of the firm: they include buyers of bonds, banks, or other lending institutions. Equity financing involves obtaining additional funds from the owners of the firm: proprietors, partners, or shareholders. Each source differs in its exposure to risk, in its taxation, and its costs. In general, debt financing is more risky for the firm than equity financing because of the legal obligation of repayment, while borrowing debt can allow a firm to reduce its weighted average cost of capital because of the deductibility of interest on debt for state and federal income tax purposes. The outcome is that there exists a tradeoff associated with debt financing for each firm that depends on their tax rates, their asset structures, and their inherent riskiness.

Leverage indicates the degree to which the firm's assets have been supplied by, and hence are owned by, creditors versus owners. Leverage should be in an acceptable range, indicating that the firm is using enough debt financing to take advantage of the low cost of debt, but not so much that current or potential creditors are uneasy about the ability of the firm to repay its debt. The debt ratio (d) is a common measure of leverage that divides all debt, long and short term, by total assets. Capital structure does not appear to have a significant impact on firm value over a wide range of debt ratio values. Consequently, we assume that the current capital structure, as measured by the debt ratio, reflects the optimal capital structure for each firm. Thus, we use each firm's debt ratio for 1989 to determine the amount of capital expenditures on pollution control technology that will be debt financed.

Thus, in the assets side of the balance sheet of affected firms, current assets decline by (1 - d) times the total installed capital cost (E^K), while the value of property, plant, and equipment increases by the total installed capital cost (i.e., the value of the pollution control equipment). Thus, the overall increase in a firm's total assets is equal to that fraction of the total installed capital cost that is not paid out of current assets (i.e., $d\ E^K$).

The liabilities side of the balance sheet is affected because firms enter new legal obligations to repay that fraction of the total installed capital cost that is assumed to be debt financed (i.e., $d\ E^K$). Long-term debt, and thus total liabilities, of the firm is increased by this dollar amount. Owner's equity, or net worth at these firms is unchanged because of the offsetting increases in both total assets and total liabilities. However, working capital at each

affected firm, defined as current assets minus current liabilities, unambiguously falls because of the decline in current assets.

Comparison of the baseline and post-compliance financial profiles of firms in the U.S. pulp and paper industry provides indicators of the potential disparity of economic impacts across small and large firms. These indicators include the key measures of profitability (return on sales, return on assets, and return on equity) and changes in the likelihood of financial failure or bankruptcy (as measured by Altman's Z'-score).

Company-Level Profitability Measures. Profitability is the most comprehensive measure of the firm's performance because it measures the combined effects of liquidity, asset management, and debt management. Analyzing profitability is useful because it helps evaluate both the incentive and ability of firms in the pulp and paper industry to incur the capital and operating costs required for compliance. More profitable firms have more incentive than less profitable firms to comply because the annual returns to doing business are greater. In the extreme, a single-facility firm earning zero profit has no incentive to comply with a regulation imposing any positive costs unless the entire cost of the regulation can be passed along to consumers. This same firm may also be less able to comply because its poor financial position makes it difficult to obtain funds through either debt or equity financing.

Several ratios are commonly used to measure profitability, including return on assets, return on equity, and return on sales. For all these measures, higher values are unambiguously preferred over lower values. Table 3-31 shows the ratios used in the market impact analysis to measure the financial viability of firms in terms of profitability.

Baseline and with-regulation profitability are evaluated using comparative analysis of key measures of a firm's profitability. Comparative analysis is a widely accepted way of summarizing the profitability of a firm using ratios reported on the firm's financial statements. This comparative analysis evaluates the profitability of potentially affected firms before and after regulation by comparing the firm's key measures of profitability with specific industry benchmark ratios reported in D&B's *Industry Norms and Key Business Ratios*. Tables 3-32 through 3-34

TABLE 3-31

KEY MEASURES OF FIRM PROFITABILITY

Measure of Profitability	Formula for Calculation
Return on Sales	$\frac{\text{Net Income}}{\text{Sales}}$
Return on Assets	$\frac{\text{Net Income}}{\text{Total Assets}}$
Return on Equity	$\frac{\text{Net Income}}{\text{Owner's Equity}}$

TABLE 3-32

UPPER QUARTILE BENCHMARK RATIOS

SIC code	Key measures of profitability		
	Return on sales	Return on assets	Return on equity
2611	0.108	0.117	0.183
2621	0.086	0.112	0.226
2631	0.081	0.110	0.202

Source: Duns, 1991.

TABLE 3-33

MEDIAN BENCHMARK RATIOS

SIC code	Key measures of profitability		
	Return on sales	Return on assets	Return on equity
2611	0.096	0.097	0.169
2621	0.049	0.065	0.157
2631	0.032	0.078	0.127

Source: Duns, 1991.

TABLE 3-34

LOWER QUARTILE BENCHMARK RATIOS

SIC code	Key measures of profitability		
	Return on sales	Return on assets	Return on equity
2611	0.077	0.085	0.154
2621	0.021	0.038	0.096
2631	0.016	0.020	0.084

Source: Duns, 1991.

report the benchmark upper quartile, median, and lower quartile measures used to evaluate the profitability of potentially affected firms in the pulp and paper industry (identified by SIC).

In Tables 3-35 through 3-37, we compare the profitability measures computed for potentially affected firms to the benchmark ratios reported in Tables 3-32 through 3-34. For the base year of analysis, between 60 and 74 percent of the firms in the small size category and 74.6 to 79.4 percent of firms in the large size category have a profitability measure that is below the industry upper quartile. Between 48 and 55.3 percent of the firms in the small size category and between 41.3 and 54 percent of firms in the large size category have a profitability measure below the industry median in 1989. Further, between 32 and 37.3 percent of the firms represented in the small category have a profitability measure below the industry lower quartile in 1989. Alternatively, 28.6 to 33.3 percent of firms in the large size category fall below the benchmark lower quartile value in 1989. Based on the data contained in these figures, firms in the large size category appear to be no more profitable on average than other firms in the industry.

After imposition of regulation, a reduction in overall profitability for each size category would be seen as an increase in the percentage of firms below each benchmark measure. Alternatively, an increase in overall profitability would be indicated by a decrease in the percentage of firms below each benchmark measure with regulation.

Bankruptcy Analysis. A facility, or establishment, is a site of land with a plant and equipment that combine inputs like materials, energy, and labor to produce outputs, like pulp, paper, and paperboard. Firms are legal business entities that, in this context, own one or more facilities. This distinction between facilities and firms is an important one in discussing the economic viability of facilities and firms. In the market impact analysis the viability of the facility is determined by economic criteria -- close the mill if marginal revenue (price) is below marginal cost. Alternatively, the viability of the firms as legal entities is conditional on their ability to meet their legal obligations.

Altman draws the distinction between economic failure and bankruptcy. His definition of economic failure is consistent with the mill closure decision included in the market impact model.

TABLE 3-35

PERCENTAGE OF FIRMS BELOW INDUSTRY BENCHMARK RATIOS IN BASELINE: RETURN ON SALES

	Small firms	Large firms	All firms
Percentage less than	Baseline (%)	Baseline (%)	Baseline (%)
Benchmark ratios			
Upper quartile	74.0	79.4	75.6
Median	55.3	42.9	51.6
Lower quartile	32.0	28.6	31.0

TABLE 3-36

PERCENTAGE OF FIRMS BELOW INDUSTRY BENCHMARK RATIOS IN BASELINE: RETURN ON ASSETS

	Small firms	Large firms	All firms
Percentage less than	Baseline (%)	Baseline (%)	Baseline (%)
Benchmark ratios			
Upper quartile	70.0	77.8	72.3
Median	56.7	54.0	55.9
Lower quartile	37.3	33.3	36.2

TABLE 3-37

PERCENTAGE OF FIRMS BELOW INDUSTRY BENCHMARK RATIOS IN BASELINE: RETURN ON EQUITY

	Small firms	Large firms	All firms
Percentage less than	Baseline (%)	Baseline (%)	Baseline (%)
Benchmark ratios			
Upper quartile	60.0	74.6	64.3
Median	48.0	41.3	46.0
Lower quartile	35.3	33.3	34.7

Economic failure results from the inability of invested capital (i.e., the facility) to continually cover its variable costs through revenue. Bankruptcy can be defined financially or legally, but both definitions are closely related. Financially, a business is bankrupt when the fair market value of its total assets is below its total liabilities. Legally, a business can be determined to be bankrupt when it fails to earn profits sufficient to meet enforceable debts. In such cases, firms may declare bankruptcy with a new owner taking over the operation of the physical assets (i.e., plant, equipment, and land).

The objective of the company-level bankruptcy analysis is to determine the likely effect of air and water pollution controls on the financial and legal viability of small and large firms within the pulp and paper industry. Determining whether an increased likelihood of legal bankruptcy, or business insolvency, will lead to reallocating resources away from the production of pulp and paper or to reorganizing resources within the pulp and paper industry is outside the scope of this analysis.

A composite ratio of financial condition, called the Z-score, was computed to characterize the baseline and with-regulation financial conditions of potentially affected firms. The Z-score, developed specifically for manufacturing firms, is a multidiscriminant function used to assess bankruptcy potential (Altman, 1983). The advantage of the Z-score model over traditional ratio analysis is its simultaneous consideration of liquidity, asset management, debt management, profitability, and market value. The function is given in Eq. 1:

$$Z = 1.2X_1 + 1.4X_2 + 0.33X_3 + 0.06X_4 + 0.999X_5 \quad (1)$$

where

Z	=	overall index
X_1	=	working capital/total assets
X_2	=	retained earnings/total assets
X_3	=	earnings before interest and taxes/total assets
X_4	=	market value of equity/book value of total debt
X_5	=	sales/total assets.

The market value component (X_4) uses stock price data; consequently, the Z-score is only applicable to firms with publicly traded stock. For this analysis, we used a modified

function substituting the book value of equity for the market value in X_4 referred to as the Z'-score, given in Eq. 2:

$$Z' = 0.717X_1 + 0.847X_2 + 3.107X_3 + 0.42X_4 + 0.998X_5 \quad (2)$$

where Z' is the overall index and all other variables are as defined for Z above. The modified function allows us to investigate privately-held as well as publicly-held firms on an equal basis.

Taken individually, each of the ratios given above is higher for firms in good financial condition and lower for firms in poor financial condition. Consequently, the greater a firm's bankruptcy potential, the lower its discriminant score. A Z-score below 1.81 indicates that bankruptcy is likely; a score above 2.99 indicates that bankruptcy is unlikely. Z-scores between 1.81 and 2.99 are indeterminant. Similarly, a Z'-score below 1.23 indicates that bankruptcy is likely; a score above 2.90 indicates that bankruptcy is unlikely. Z'-scores between 1.23 and 2.90 are indeterminant.

Table 3-38 shows the 1989 baseline distribution of firms by Z'-score prediction. Financial failure is likely for 7 percent of firms in the industry. Predicted failure across firm size reveals that 6 percent of the firms in the small size category, while 9.5 percent of the firms in the large size category are likely to fail in the baseline. These predicted failure rates do not compare favorably with average reported failure rates for the U.S. The 1990 failure rate averaged 0.92 percent for all manufacturing firms, 0.49 percent for all service firms, and 0.76 percent for all U.S. firms (Dun's, 1991).

A possible explanation for the high failure predictions for firms in the pulp and paper industry, as measured by the Altman Z'-score, is the capital intensive nature of the industry. Capital expenditures per year for the industry reached $16.7 billion in 1990 and neared $12 billion in 1991 (Storat, 1992). These capital expenditures are necessary to retool existing plants and construct new plants, as well as environmental compliance. Almost 60 percent of the industry's capacity exists in machinery that was either newly installed or extensively rebuilt during the past ten years—resulting in almost 21 million tons of new capacity since 1980 (Storat, 1992). The capital outlays for pollution control technology to comply with existing government

TABLE 3-38

BASELINE BANKRUPTCY PREDICTION BY FIRM SIZE

Z′-score prediction[a]	Firm size based on employment (1989)		Total
	Small (<750)	Large (>750)	
All companies	150	63	213
Bankruptcy likely	9	6	15
Indeterminant	56	32	88
Bankruptcy Unlikely	85	25	110

[a]Bankruptcy prediction is based on Altman's Z′-score for manufacturing companies. If a company's Z′-score is < 1.23, the model predicts that bankruptcy is likely. If a company's Z′-score is > 2.90, the model predicts that bankruptcy is unlikely. Z′-scores between 1.23 and 2.90 fall in the indeterminant range, and the model makes no prediction for these companies.

Source: EPA survey.

regulations and in response to public dioxin-related concerns have also increased over the past few years—exceeding $1 billion per year according to industry sources (Storat, 1992).

The investment in capital, however, also brought along a huge level of debt for many firms in the industry. The debt incurred over the past ten years is reflected in the financial statement, and the associated financial ratios, of each firm included this analysis. Consequently, it is not surprising that the predicted failure rates computed for these firms are significantly higher than 1990 rates for U.S. firms in general. However, the industry should soon, if not already, receive the returns on these large investments and reestablish financial strength as measured by Altman's Z'-score.

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SECTION FOUR

REGULATORY ALTERNATIVES AND COMPLIANCE COSTS

Effluent guidelines and Maximum Achievable Control Technology (MACT) standards are technology-based regulations. While the facility that is the source of discharge or emission need not install any specific pollution control technology, the regulatory requirements must be based on a technology that can achieve the specified limits. The Development Document and Background Information Document detail the technology basis for effluent guidelines and MACT standards. Section 4.1 presents a summary of the technologies considered as the basis for regulatory requirements. Section 4.2 summarizes the compliance costs associated with the regulatory requirements.

4.1 COMPLIANCE OPTIONS AND REGULATORY ALTERNATIVES

For the purpose of establishing effluent limitations guidelines and emission standards for hazardous air pollutants, an industry may be subcategorized based on manufacturing process and/or other distinguishing characteristics. The pulp, paper, and paperboard industry is divided into 12 subcategories that incur additional pollution control requirements under this rulemaking. Table 4-1 lists the subcategories and references the regulatory requirements for each of them. The compliance components for a given facility, therefore, depend on which regulations are applicable to that facility. While subcategorization is, in some cases, also appropriate for MACT standards, the air controls for the pulp and paper industry do not vary by subcategory.

Each set of regulatory requirements (also called compliance components) includes options, which are briefly described in Section 4.1.1. For the Best Available Technology (BAT) and Pretreatment Standards for Existing Sources (PSES) compliance component, the options vary by subcategory. The Clean Water Act requires effluent guidelines based on BAT to be

TABLE 4-1

SUBCATEGORIES AND REGULATORY COVERAGE

Effluent Subcategory	Number of Mills in this Subcategory	Clean Air Act MACT	Clean Water Act		
			BAT & PSES	BPT/ BCT	BMP
Dissolving Kraft	3	X	X	X	X
Bleached Papergrade Kraft and Soda	88	X	X	X	X
Unbleached Kraft	58	X	X	X	X
Semichemical	21	X	X	X	X
Dissolving Sulfite	5	X	X	X	X
Papergrade Sulfite	11	X	X	X	X
Mechanical Pulp	57			X	
Non-wood Chemical	12			X	X
Secondary Fiber, Deink	43			X	
Secondary Fiber, Non-deink	342			X	
Fine and Lightweight Papers from Purchased Pulp	115			X	
Tissue, Filter, Nonwoven, and Paperboard from Purchased Pulp	169			X	
Number of Mills		161	160	325	172

economically achievable. Section Five presents the economic impacts associated with the costs presented in Section Four.

Integrated regulatory alternatives are built by choosing an option for each of the following compliance components:

- Wastewater Treatment Improvements (BPT or BCT)
- Best Management Practices (BMP)
- Air Controls (MACT)
- Process Changes (BAT and PSES)

The integrated regulatory alternatives developed by the Agency for this rulemaking are discussed in Section 4.1.2.

4.1.1 Description of Compliance Components

4.1.1.1 Best Practicable Control Technology Currently Available (BPT) and Best Conventional Pollutant Control Technology (BCT)

BPT and BCT effluent standards are for the control of conventional pollutants, including biochemical oxygen demand (BOD_5), pH, total suspended solids (TSS), and oil and grease.[1] The economic considerations for effluent limitations based on BPT include a comparison of costs to effluent reduction benefits. If the effluent limitations are based on BCT, where BCT is more stringent than BPT, the standard must pass a two-part "cost-reasonableness" test—the cost per pound to meet the standard cannot exceed a specific value, and the ratio of the cost of moving from BPT to BCT to the cost of meeting BPT cannot exceed a specific value (FR, 1986). Thus,

[1]While the Clean Water Act does not specify that BPT be limited to conventional pollutants, the existing BPT limitations for this industry and the proposed revised BPT limitations cover conventional pollutants only.

the economic impact analysis must examine the BPT or BCT costs separately from the costs of the regulatory alternative.

The BCT cost test and its applicability to the proposed regulations are presented in EPA, 1993. Two technology options for conventional pollutant control are analyzed in this report; both reflect various improvements to wastewater treatment such as additional aerators or longer detention times for secondary treatment. For the purposes of this analysis, the costs and options are referred to as BPT/BCT or as BPT. The actual choice of treatment improvement for estimating costs was a site-specific judgment based on the facility's treatment in place and the regulatory option to be met.

Two BPT/BCT options are analyzed:

- Treatment to meet the effluent performance achieved by the average of the best performing 90 percent of the facilities (Option 1).
- Treatment to meet the effluent performance achieved by the average of the best performing 50 percent of the facilities (Option 2).

BPT/BCT requirements apply to all 12 subcategories.

4.1.1.2 Best Management Practices (BMP)

BMP focuses on the prevention and control of spills from pulping and chemical recovery areas. Pulping liquors contain nonchlorinated compounds that are toxic to aquatic life, are a source of hazardous air pollutants (e.g., methanol) and odors, and contain biological and chemical oxygen-demanding material and color. Pulping liquor spills increase the organic and toxic load sent to biological treatment, thereby reducing its effectiveness and efficiency.

There is only one option for BMP—they either are in place or absent. In contrast to BPT/BCT effluent standards or BAT/PSES effluent guidelines, which do not require the

installation of specific control technologies, BMP must be instituted as described in the regulation.

BMP requirements are applicable only to the seven subcategories that produce chemical pulps (see Table 4-1). For the purpose of evaluating economic achievability of best management practices, BMP costs are combined with BAT/PSES costs for the subcategories with process changes.

4.1.1.3 Maximum Achievable Control Technology (MACT)

Air emission controls consider vents, open processes, and condensate wastewaters located in either the pulping area or the bleaching area. The requirements can include adding hoods and vents in open process areas, routing vents to scrubbers and/or combustion devices, and steam stripping of condensate wastewaters to remove volatile hazardous air pollutants. Table 4-2 summarizes the baseline air emission controls, the MACT floor, and more stringent options. Shading indicates that the emission point will be controlled by the option. The control levels do not differ by subcategory.

4.1.1.4 Best Available Technology/Process Changes (BAT and PSES)

Facilities are characterized not only by subcategory, but also by discharge status: direct or indirect. BAT applies to direct dischargers; PSES applies to indirect dischargers. Both BAT and PSES control nonconventional and toxic pollutants. Process changes to pulping and bleaching operations provide the technology basis for pollution control and apply to approximately 103 mills in four subcategories (dissolving kraft, dissolving sulfite, bleached papergrade kraft and soda, and papergrade sulfite). Each subcategory includes several BAT and PSES options. The subcategories and the tables describing the options are:

- Dissolving kraft (Table 4-3)
- Bleached papergrade kraft and soda (Table 4-4)

TABLE 4-2

AIR CONTROL OPTIONS

Emission Point	Percent Controlled at Baseline	Air Control Option		
		Existing Sources		
		Floor	1	2
Pulping Area Sources Vented to a Combustion Device				
Digester Blow + Noncondensible Gases	82			
Digester Relief + Turpentine Recovery	80			
Evaporator	80			
Foam Breaker Tank	11			
Weak Black Liquor Storage	11			
Knotter	7			
Washer	7			
Decker/Screens	4			
Oxygen Delignification	3 of 12 units			
Bleaching Area Stages Vented to a Scrubber				
1st C and D Bleach Stages	79			X
plus, 1st and 2nd E-Stage and 2nd D-Stage	20			X
plus, 1st H-Stage	15			X
Wastewater Streams Steam Stripped				
Evaporator "Foul" Condensate	26			
Turpentine Decanter Condensate	22			
Digester Blow Condensate	12			
Evaporator "Clean" Condensate	0			
Bleach Plant Effluent	0			

"X" means option includes venting the scrubber to a combustion device.
"Foul" means $\geq$ 100 ppmw HAP and "Clean" means < 100 ppmw HAP.

TABLE 4-3

PROCESS CHANGE OPTIONS FOR THE DISSOLVING KRAFT SUBCATEGORY

Option	Abbreviated Description	Description
1	70% ClO_2	Substitution of chlorine dioxide for chlorine at a rate of 70%
2	OD + 70% ClO_2	Oxygen delignification, substitution of chlorine dioxide for chlorine at a rate of 70%, and COD control
3	OD + 100% ClO_2	Oxygen delignification, complete substitution of chlorine dioxide for chlorine, and COD control

All options include:

- Adequate wood chip size control
- Eliminating dioxin precursor defoamers
- Improving pulp washing
- Eliminating hypochlorite
- High shear mixing pulp
- Enhancing extraction in bleaching (with oxygen or peroxide)

TABLE 4-4

PROCESS CHANGE OPTIONS FOR THE BLEACHED PAPERGRADE KRAFT AND SODA SUBCATEGORY

Option	Abbreviated Description	Description
1	Split Cl_2	Split addition of chlorine
2	70% ClO_2	Substitution of chlorine dioxide for chlorine at a rate of 70%
3	OD **or** Ext. Cook + 70% ClO_2	Oxygen delignification or extended delignification, substitution of chlorine dioxide for chlorine at a rate of 70%, and COD control
4	OD **or** Ext. Cook + 100% ClO_2	Oxygen delignification or extended delignification, complete substitution of chlorine dioxide for chlorine, and COD control
5	OD **and** Ext. Cook + 100% ClO_2	Oxygen delignification and extended cooking, complete substitution of chlorine dioxide for chlorine, and COD control

All options include:

- Adequate wood chip size control
- Eliminating dioxin precursor defoamers
- Improving pulp washing
- Eliminating hypochlorite
- High shear mixing pulp
- Enhancing extraction in bleaching (with oxygen or peroxide)

- Dissolving sulfite (Table 4-5)
- Papergrade sulfite (Table 4-6)

Process changes also include closing the pulping area screen room for the control of Chemical Oxygen Demand (COD). Screen room closure is the only process change considered for the unbleached kraft, semichemical, and nonwood chemical subcategories.

4.1.2 Integrated Regulatory Alternatives

Seven decisions are needed to form an integrated regulatory alternative:

- Process change for dissolving kraft (BAT/PSES)
- Process change for bleached papergrade kraft and soda (BAT/PSES)
- Process change for dissolving sulfite (BAT/PSES)
- Process change for papergrade sulfite (BAT/PSES)
- Air controls for all subcategories (MACT)
- Best management practices for all subcategories (BMP)
- Wastewater treatment improvements for all subcategories (BPT)

Many combinations of these seven decisions are possible to form regulatory alternatives. Table 4-7 summarizes a subset of the regulatory alternatives to which the Agency devoted most of its analysis.

4.2 COMPLIANCE COSTS

There are several ways to describe the costs associated with the regulation. One is the *compliance cost incurred by industry*. Industry compliance cost is a measure of what the industry would actually have to pay to comply with the regulation. As such, it amortizes the capital costs

TABLE 4-5

PROCESS CHANGE OPTIONS FOR THE DISSOLVING SULFITE SUBCATEGORY

Option	Abbreviated Description	Description
1	OD and 100% ClO_2	Oxygen delignification and complete substitution of chlorine dioxide for chlorine
2	TCF	Totally chlorine-free bleaching using oxygen delignification, ozone and/or peroxide

Both options include:

- Adequate wood chip size control
- Eliminating dioxin precursor defoamers

TABLE 4-6

PROCESS CHANGE OPTIONS FOR THE PAPERGRADE SULFITE SUBCATEGORIES

Option	Abbreviated Description	Description
1	OD and 100% ClO_2	Oxygen delignification, complete substitution of chlorine dioxide for chlorine, and COD control
2	TCF	Totally chlorine-free bleaching using oxygen delignification or extraction followed by peroxide, and COD control

Both options include:

- Adequate wood chip size control
- Eliminating dioxin precursor defoamers
- Eliminating hypochlorite

TABLE 4-7

DESCRIPTION OF REGULATORY ALTERNATIVES[1]

Reg. Alt.	Process Changes				Air Controls			End of Pipe	Best Management Practices
	Bleached Papergrade Kraft and Soda	Papergrade Sulfite	Dissolving Sulfite	Dissolving Kraft	Pulp Area Vents	Bleach Area Vents	Condensate Wastewater		
1	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
2	Baseline	Baseline	Baseline	Baseline	Digester, evaporator, WBL storage, washer, knotter, and foam tank	Scrub C, D1, D2, E1, E1, H stage	100 ppmw	Baseline	Baseline
3	Baseline	Baseline	Baseline	Baseline	Reg alt 2 points plus OD	Scrub C, D1, D2, E1, E2, H stage	100 ppmw	Baseline	Baseline
4	Baseline	Baseline	Baseline	Baseline	Reg alt 3 points plus decker	Scrub C, D1, D2, E1, E2, H stage	100 ppmw	Baseline	Baseline
5	Baseline	Baseline	Baseline	Baseline	Reg alt 3 points plus decker	Duct scrubber to combustion device	100 ppmw	Baseline	Baseline
11	OD or EC + 70% ClO_2	TCF	TCF	OD + 70% ClO_2	Digester, evaporator, WBL storage, washer, knotter, and foam tank	Scrub C, D1, D2, E1, E2, H stage	100 ppmw	Treatment used by average of best 50%	Yes
16	OD or EC + 70% ClO_2	TCF	TCF	OD + 70% ClO_2	Reg alt 10 points plus OD	Scrub C, D1, D2, E1, E2, H stage	100 ppmw	Treatment used by average of best 50%	Yes

TABLE 4-7 (cont.)

Reg. Alt.	Process Changes				Air Controls			End of Pipe	Best Management Practices
	Bleached Papergrade Kraft and Soda	Papergrade Sulfite	Dissolving Sulfite	Dissolving Kraft	Pulp Area Vents	Bleach Area Vents	Condensate Wastewater		
17	OD or EC + 70% ClO_2	TCF	TCF	OD + 70% ClO_2	Reg alt 16 points plus decker	Scrub C, D1, D2, E1, E2, H stage	100 ppmw	Treatment used by average of best 50%	Yes
18	OD or EC + 70% ClO_2	TCF	TCF	OD + 70% ClO_2	Reg alt 16 points plus decker	Duct scrubber to combustion device	100 ppmw	Treatment used by average of best 50%	Yes
22	OD or EC + 100% ClO_2	TCF	TCF	OD + 70% ClO_2	Digester, evaporator, WBL storage, washer, knotter, and foam tank	Scrub C, D1, D2, E1, E2, H stage	100 ppmw	Treatment used by average of best 50%	Yes
23	OD or EC + 100% ClO_2	TCF	TCF	OD + 70% ClO_2	Reg alt 22 points plus OD	Scrub C, D1, D2, E1, E2, H stage1	100 ppmw	Treatment used by average of best 50%	Yes
24	OD or EC + 100% ClO_2	TCF	TCF	OD + 70% ClO_2	Reg alt 23 points plus decker	Scrub C, D1, D2, E1, E2, H stage	100 ppmw	Treatment used by average of best 50%	Yes
25	OD or EC + 100% ClO_2	TCF	TCF	OD + 70% ClO_2	Reg alt 23 points plus decker	Duct scrubber to combustion device	100 ppmw	Treatment used by average of best 50%	Yes

TABLE 4-7 (cont.)

Reg. Alt.	Process Changes				Air Controls			End of Pipe	Best Management Practices
	Bleached Papergrade Kraft and Soda	Papergrade Sulfite	Dissolving Sulfite	Dissolving Kraft	Pulp Area Vents	Bleach Area Vents	Condensate Wastewater		
26*	OD or EC + 100% ClO_2	TCF	OD + 100% ClO_2	OD + 70% ClO_2	Reg alt 22 points plus OD	Scrub C, D1, D2, E1, E2, H stage	500 ppmw	Treatment used by average of best 50%	Yes

[1] OD = Oxygen Delignification
EC = Extended Cook
D = Chlorine Dioxide
TCF = Totally Chlorine-free
ClO_2 = Chlorine Dioxide Substitution
WBL = Weak Black Liquor
C = Chlorination
E = Extraction
H = Hypochlorite

* Proposed Alternative

over the equipment lifetime, includes the cost of money used to purchase the equipment, includes the annual cost of operating and maintaining the equipment, and considers tax savings via depreciation and higher operating costs. The industry compliance cost is sometimes called the private cost. (See Section 3.1.1 for a more detailed description of calculating annualized costs.) If a business can reduce the taxes it owes by depreciation, however, the federal government bears the cost of the lost tax revenues. The business can raise its prices to recover the cost of additional pollution control; higher prices become a cost to consumers. A second cost, the *social cost* of the regulation, considers these and other types of costs due to the regulation. Social cost is discussed in more detail in Section 4.2.2. Throughout this section, all costs are reported in terms of 1991 dollars.

4.2.1 Industry Compliance Costs

Industry compliance costs are calculated by summing the annualized cost for a given option or regulatory alternative over all affected facilities. Since the industry compliance cost reflects what the business would actually have to pay to meet the increased pollution requirements, it is an appropriate measure with which to evaluate economic impacts. Due to the requirement to evaluate economic achievability of effluent guidelines and standards, industry compliance costs are examined separately for BPT/BCT, BAT/PSES, and the integrated regulatory alternatives. Costs associated with BMP are assigned to BAT/PSES costs for subcategories affected by process changes. Impacts associated with the regulatory costs are summarized in Section Five.

4.2.1.1 BPT Costs

Table 4-8 summarizes capital, operating and maintenance (o&m), and annualized costs for incremental BPT control. BPT requirements are applicable to approximately 325 mills. The annualized industry compliance costs are $45 million for Option 1 and $65 million for Option 2.

TABLE 4-8

SUMMARY OF BPT COSTS
THOUSANDS OF 1991 DOLLARS

	CAPITAL COST	O&M EXPENSE	ANNUALIZED COST
1	$202,409	$44,342	$44,590
2	$336,641	$59,400	$65,409

Notes: Factor for Converting $1989 to $1991: 1.0477
The annualized costs include cost savings that may be generated at some mills.
The costs above include BPT costs for all mills.
BPT is applicable to 325 mills.

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4.2.1.2 Process Change Costs (BAT/PSES)

Costs considered under BAT/PSES include the costs for process change, best management practices, COD control, and wastewater treatment for indirect dischargers, as appropriate. BAT/PSES costs are summarized by subcategory in Tables 4-9 through 4-13.

The annualized compliance costs for dissolving kraft mills range from $2 million to $15 million, depending on the option (Table 4-9). The annualized cost for Option 2 is $11.9 million. For dissolving sulfite, the annualized compliance costs range from $5 million to $15 million (Table 4-10). For bleached papergrade kraft and soda, the annualized costs range from $122 million to $641 million (Table 4-11). For Option 4, the cost is $303 million. For papergrade sulfite, the annualized costs range from $27 million to $46 million (Table 4-12).

There are 22 mills in the unbleached kraft subcategory that have production in one of the first four subcategories (dissolving kraft, dissolving sulfite, bleached papergrade kraft and soda, and papergrade sulfite). To avoid double-counting the BMP and COD control costs, the mills are not included in the costs shown in Table 4-13. The annualized compliance cost for the remaining 36 mills is $6 million.

There are two mills in the semichemical subcategory that also have production in one of the four subcategories listed above. All process change, BMP, and COD control costs for those mills already have been included in the other subcategory. They are not included in the costs for the semichemical subcategory to avoid double-counting. The annualized compliance cost for the remaining 19 mills is $7 million (Table 4-13).

Table 4-13 also summarizes the cost for BMP for the nonwood chemical pulping subcategory. The annualized compliance cost for the 12 mills is $336 thousand.

TABLE 4-9

SUMMARY OF COSTS BY SUBCATEGORY : DISSOLVING KRAFT
THOUSANDS OF 1991 DOLLARS

	CAPITAL COST	O&M EXPENSE	ANNUALIZED COST
1	$65,839	($8,457)	$1,726
2	$138,784	($2,489)	$11,900
3	$143,937	$1,653	$14,711

Notes: Factor for Converting $1989 to $1991: 1.0477
The annualized costs include cost savings that may be generated at some mills.
There are 3 mills in the dissolving kraft subcategory.

TABLE 4-10

SUMMARY OF COSTS BY SUBCATEGORY : DISSOLVING SULFITE
THOUSANDS OF 1991 DOLLARS

OPTION	CAPITAL COST	O&M EXPENSE	ANNUALIZED COST
1	$110,051	($5,141)	$4,943
2	$86,859	$14,936	$14,829

Notes: Factor for Converting $1989 to $1991: 1.0477
The annualized costs include cost savings that may be generated at some mills.
There are 5 mills in this subcategory.

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TABLE 4-11

SUMMARY OF COSTS BY SUBCATEGORY : BLEACHED PAPERGRADE KRAFT
THOUSANDS OF 1991 DOLLARS

OPTION	CAPITAL COST	O&M EXPENSE	ANNUALIZED COST
1	$815,009	$80,628	$122,172
2	$1,253,170	$40,858	$139,694
3	$2,162,296	$61,289	$237,193
4	$2,300,850	$152,665	$302,571
5	$4,899,088	$315,512	$640,576

Notes: Factor for Converting $1989 to $1991: 1.0477
The annualized costs include cost savings that may be generated at some mills.

There are 88 mills in the bleached papergrade kraft subcategory;
BAT/PSES applies to 87 mills.

TABLE 4-12

SUMMARY OF COSTS BY SUBCATEGORY : PAPERGRADE SULFITE
THOUSANDS OF 1991 DOLLARS

OPTION	CAPITAL COST	O&M EXPENSE	ANNUALIZED COST
1	$279,290	$32,844	$46,216
2	$115,408	$26,547	$26,726

Notes: Factor for Converting $1989 to $1991: 1.0477
The annualized costs include cost savings that may be generated at some mills.
There are 11 mills in this subcategory.

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TABLE 4-13

SUMMARY OF COSTS FOR THREE SUBCATEGORIES :
UNBLEACHED KRAFT, SEMICHEMICAL, AND NONWOOD CHEMICAL
THOUSANDS OF 1991 DOLLARS

SUBCATEGORY	CAPITAL COST	O&M EXPENSE	ANNUALIZED COST
Unbleached Kraft	$99,122	($6,307)	$6,004
Semichemical	$43,928	$5,389	$7,149
Nonwood Chemcal	$3,000	$120	$336

Notes: Factor for Converting $1989 to $1991: 1.0477
The annualized costs include cost savings that may be generated at some mills.
There are 58 mills in the unbleached papergrade kraft subcategory; costs for 22 mills are counted in another subcategory
There are 21 mills in the semichemical subcategory; 2 mills whose costs are counted in another subcategory.
There are 12 mills in the nonwood chemical subcategory.

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4.2.1.3 Integrated Regulatory Alternative Costs

Table 4-14 summarizes the capital, o&m, and annualized cost for the regulatory alternatives. The annualized industry compliance costs range from $173 million to $657 million, with Alternative 26 costing $592 million. In the industry profile, Table 2-27 lists the expenditures on environmental protection for 1988 to 1990 as $572 million to $1.3 billion per year. These constituted between 11 to 16 percent of the total expenditures for new plants and equipment for the 1988 to 1990 period. The annualized costs for the regulatory alternatives, then, are within the range of the expenditures seen in recent years. In 1989, the capital investment in the industry totaled about $68 billion (Table 2-26). Capital investment for the regulatory alternatives ranged from $775 million to $4.3 billion, or from about 1 to 6 percent of the existing investment at the end of 1989. Capital expenditures for Alternative 26, for example, are $3.9 billion, or about one-half the expenditures for 1990 (Table 2-27).

Table 4-15 summarizes the BAT/PSES and BPT costs as a percentage of the total cost for the regulatory alternatives. The process change costs form between 51 and 62 percent of the cost of the regulatory alternative. BPT costs form an additional 10 to 12 percent of the regulatory cost.

4.2.2 Approximations of Social Cost

One way of evaluating the merit and efficiency of social decisions, like the one to internalize the ill effects of pollution on human health and the environment through regulation, is to compare the social costs of regulation to the social benefits. The social costs of regulation are the opportunity costs borne by society for employing our scarce resources in pursuit of pollution control. The social costs of the pulp and paper regulations have been estimated two ways. The most theoretically complete way uses various results from the market impact model to estimate social costs. The less burdensome way uses the engineering estimate of control costs, but this estimate is a second-best approximation.

TABLE 4-14

SUMMARY OF POLLUTION CONTROL COSTS ASSOCIATED WITH REGULATORY ALTERNATIVES
(THOUSANDS OF 1991 DOLLARS)

Regulatory Alternative	Capital Cost	O&M Expense	Annualized Cost
2	$775,481	$174,370	$173,494
3	$779,559	$174,618	$173,960
4	$884,787	$186,972	$190,842
5	$1,161,872	$208,907	$229,365
11	$3,708,235	$322,353	$531,706
16	$3,742,111	$324,414	$536,092
17	$3,847,339	$336,767	$552,974
18	$4,126,487	$358,417	$591,619
22	$3,846,775	$413,723	$597,078
23	$3,880,651	$415,784	$601,465
24	$3,985,879	$428,137	$618,346
25	$4,265,027	$449,787	$656,991
26	$3,903,850	$395,708	$591,580

343 mills were analyzed to calculate pollution control costs of regulatory alternatives.

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TABLE 4-15

PROCESS CHANGE AND BPT COSTS
AS A PERCENT OF REGULATORY ALTERNATIVES
(MILLIONS OF 1991 DOLLARS)

Regulatory Alternative	Total Annualized Cost	BAT/PSES Annualized Costs							Percent of Regulatory Alternative	BPT Annualized Costs	Percent of Regulatory Alternative
		Dissolving Kraft	Dissolving Sulfite	Bleached Papergrade Kraft	Papergrade Sulfite	Unbleached Kraft	Semichemical	Total			
10	$532	$11.9	$14.8	$237.2	$26.7	$6.0	$7.1	$303.8	57%	$65.4	12%
16	$536	$11.9	$14.8	$237.2	$26.7	$6.0	$7.1	$303.8	57%	$65.4	12%
17	$553	$11.9	$14.8	$237.2	$26.7	$6.0	$7.1	$303.8	55%	$65.4	12%
18	$592	$11.9	$14.8	$237.2	$26.7	$6.0	$7.1	$303.8	51%	$65.4	11%
22	$597	$11.9	$14.8	$302.6	$26.7	$6.0	$7.1	$369.2	62%	$65.4	11%
23	$601	$11.9	$14.8	$302.6	$26.7	$6.0	$7.1	$369.2	61%	$65.4	11%
24	$618	$11.9	$14.8	$302.6	$26.7	$6.0	$7.1	$369.2	60%	$65.4	11%
25	$657	$11.9	$14.8	$302.6	$26.7	$6.0	$7.1	$369.2	56%	$65.4	10%
26	$592	$11.9	$4.9	$302.6	$26.7	$6.0	$7.1	$359.3	61%	$65.4	11%

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4.2.2.1 Market Model Social Cost Estimates

The social costs of regulation include both monetary and nonmonetary outlays made by society. Monetary outlays include private-sector compliance costs, government administrative costs, and various adjustment costs. Non-monetary outlays that are often assigned a monetary value include losses in consumers' or producers' surpluses in product markets, discomfort or inconvenience, loss of time, and slowing the rate of innovation.

Table 4-16 shows the estimates of social cost derived from the market impact model for the integrated Regulatory Alternatives 3, 16, 23, 24, 25, and 26. Alternatives 3, 16, 23, and 26 contain the MACT floor level of air add-on control with increasingly stringent process modification requirements. Alternatives 24 and 25 contain increasingly stringent air add-on controls on top of the process modification options selected for Alternative 23. The estimates include producer surplus loss, consumer surplus loss, annualized worker dislocation costs, and government and private administrative costs.

In a market environment, consumers and producers of pulp and paper products derive welfare from market transactions. The difference between the maximum price consumers are willing to pay for pulp and paper products and the price they actually pay is referred to as consumer surplus. Similarly, the difference between the minimum price producers are willing to accept for pulp and paper products and the price they actually receive is referred to as producer surplus. Because equilibrium prices and quantities change in each market affected by pulp and paper regulations, there are corresponding changes in consumer and producer surplus.

Worker dislocation costs are estimated based on incremental willingness-to-pay measures for job dislocations in a hedonic wage framework. This estimate conceptually approximates the onetime willingness to pay to avoid an involuntary unemployment episode. Theoretically, the estimate includes all worker-borne costs net of any off-setting pecuniary or nonpecuniary "benefits" of unemployment (e.g., unemployment compensation, leisure time enjoyment). The hedonic displacement cost estimate is a net present value valuation. For the paper and allied products sector, the implied one-time statistical cost (expressed as a net present value) of an involuntary layoff is $67,323 (1991 dollars). This value is multiplied by the total number of

TABLE 4-16

ANNUAL SOCIAL COST ESTIMATES: MARKET MODEL (MILLIONS OF 1991 DOLLARS)

Social Cost Category	Alt. 3	Alt. 16	Alt. 23	Alt. 24	Alt. 25	Alt. 26
Consumer Surplus Loss	161.4	493.2	497.7	499.0	499.2	477.2
Producer Surplus Loss	114.9	301.0	403.7	428.0	483.5	415.7
Worker Displacement Costs	4.7	24.3	24.6	24.6	24.7	24.6
Government & Private Administrative Costs (MACT only)	2.5	2.5	2.5	2.5	2.5	2.5
Total Social Cost	283.5	820.9	928.5	954.2	1,010.0	920.1

displaced workers estimated by the market impact model to calculate the net present value of the worker displacement cost. This cost is then annualized. For Regulatory Alternative 26, worker displacement costs are estimated at $24.6 million.

Government administrative costs include the cost to federal and state governments to review facility compliance reports and otherwise ensure and oversee compliance with the proposed standards. An estimate of these costs is not available at the time of this publication.

The annual social cost for Regulatory Alternative 26 is approximately $920 million.

4.2.2.2 Social Cost Estimates Using Engineering Costs

The social cost of the regulation can be approximated by the pretax annual engineering cost. The capital cost of the rule (TCI) is annualized over its expected life (15 years) at the OMB-approved social discount rate (10 percent at the time of this writing). The annual o&m is then added to the annualized capital cost to arrive at the total annual social cost approximation. Table 4-17 shows the estimates of social cost derived with this method for Regulatory Alternatives 3, 16, 23, 24, 25, and 26. The social cost, using engineering costs, for Regulatory Alternative 26 is estimated at $909 million.

4.3 REFERENCES

FR. 1986. U.S. Environmental Protection Agency. 40 CFR Parts 405 et al. Best conventional pollutant control technology; effluents limitations guidelines; final rule. Federal Register. 51(131):24974-25002. July 9.

EPA. 1993. U.S. Environmental Protection Agency. BCT cost test for the proposed effluent limitations for the pulp, paper, and paperboard industry. Washington, DC: EPA Office of Water.

TABLE 4-17

ANNUAL SOCIAL COST ESTIMATES: ENGINEERING COST
(MILLIONS OF 1991 DOLLARS)

Engineering Cost Category	Alt. 3	Alt. 16	Alt. 23	Alt. 24	Alt. 25	Alt. 26
Total Capital Investment	779.6	3,708.2	3,880.7	3,985.9	4,265.0	3,903.9
Annual O&M	174.6	324.4	415.8	428.1	449.8	395.7
Total Social Cost Approximation	277.1	811.9	926.0	952.1	1,010.5	909.0

SECTION FIVE

ECONOMIC IMPACTS

The costs associated with incremental pollution control are discussed in Section Four. The impacts of these costs were evaluated with the financial and market models presented in Section Three. The impacts estimated by the financial impact model are given in Section 5.1, the impacts projected by the market model are given in Section 5.2, and a comparison of results from both models is discussed in Section 5.3. The analysis focuses on facilities that are estimated to incur costs to comply with the regulation. Of the estimated 565 pulp, paper, and paperboard facilities in the United States, the proposed regulations are applicable to approximately 343 facilities. Of these, about 300 facilities are anticipated to incur costs; about 265 facilities—nearly half—are anticipated to incur no costs.

5.1 FINANCIAL IMPACT ANALYSIS RESULTS

5.1.1 Closure Analysis

If the present value of the future earnings for a facility after the imposition of incremental pollution control costs is less than the salvage value of the facility, the facility is projected to close. (Section 3.2.1 discusses the methods used for estimating future earnings and salvage value.) The closure analysis is conducted for each facility under several cost scenarios—under each regulatory alternative; under BAT/PSES requirements (if appropriate); and under costs for wastewater treatment upgrades (BPT costs).

5.1.1.1 Closures Due to BPT Costs

There are 325 facilities to which BPT is applicable and for which wastewater treatment upgrade costs were estimated. Some of these mills will not have to upgrade their equipment to meet the new limitations; these mills are assigned $0 costs (see Table 4-8 for total BPT costs).

Of these, 223 are in the closure analysis.[1] One facility closes under BPT Option 1, where the facility must meet the effluent treatment performance obtained by the best performing 90 percent of the subcategory. Three facilities close under BPT Option 2, where the facility must meet the effluent treatment performance obtained by the best performing 50 percent of the subcategory. These impacts are summarized with additional information in Section 5.1.2.1.

5.1.1.2 Closures Due To BAT/PSES and BMP Costs

Process change descriptions are given by subcategory in Tables 4-3 through 4-6. Costs are given by subcategory in Tables 4-9 through 4-13. Impacts associated with facility closure are shown by subcategory in Section 5.1.2.2 tables.

Dissolving Kraft: There are three facilities in this subcategory. There are no closures under any of the process change costs shown in Table 4-9.

Dissolving Sulfite: There are five facilities in this subcategory; four are included in the closure analysis. One mill is projected to close under Option 1 (oxygen delignification and 100% chlorine dioxide substitution). Two mills are projected to close under the TCF (totally chlorine free) option.

Bleached Papergrade Kraft and Soda: There are 88 facilities in this subcategory; 75 are in the closure analysis. There are two closures projected with Option 1 (split addition of chlorine) and Option 2 (70% substitution); three closures projected with Option 3 and Option 4 (oxygen delignification or extended cooking with 70% or 100% chlorine dioxide substitution, respectively); and nine closures projected with Option 5 (oxygen delignification and extended cooking with 100% chlorine dioxide substitution).

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[1]A facility can be excluded from the closure analysis for several reasons: it may be too new to be in the data base (i.e., it went into operation after 1989), there may be insufficient data held at the facility level to perform the analysis, or it may be a baseline closure.

Papergrade Sulfite: There are 11 facilities in this subcategory; 10 are in the closure analysis. There are five closures projected with Option 1 (oxygen delignification and 100% chlorine dioxide substitution) and three projected with Option 2 (TCF).

Unbleached Kraft, Semichemical, and Nonwood Chemical: There is only one option for each subcategory. There are no closures projected with the option for each of these subcategories.

5.1.1.3 Closures Due to Regulatory Alternative Costs

The regulatory alternatives are described in Table 4-7 and the costs are listed in Table 4-14. There are 343 facilities for which costs under this rulemaking were estimated; the closure analysis examined 237 facilities. There are three closures projected with Alternatives 2 through 5. Fourteen closures are projected with Alternatives 11 through 23. Fifteen closures are projected for Alternatives 24 and 25. Thirteen closures, the lowest number for an alternative involving process changes, are projected for Alternative 26.

5.1.2 Additional Economic Impacts

As explained in Section 3.2, the financial model projects losses in shipments, exports, and jobs associated with facility closure. These impacts are summarized by subcategory and by option. This section presents the impacts associated with the closures summarized in Section 5.1.1. In some cases, certain results are not reported in the summary tables because data aggregation is inadequate to protect confidential business information. These results are identified by "ND" (not disclosed) entries in the table. For comparison, the industry-wide totals for the number of mills, shipments (tonnage and value), exports, and jobs are given in the left-

hand column in each table.[2] **All dollar values shown in Tables 5-1 through 5-6 are in terms of 1989 dollars,** as in the industry profile (Section Two).

5.1.2.1 Impacts Associated with BPT Costs

The costs associated with BPT Option 1 lead to a single closure among all facilities analyzed, leading to an estimated $13 million loss in shipments (of which $1 million is exports), and about 100 jobs (Table 5-1). Option 2 results in three closures that lead to a $217 million loss in shipments, and about 1,100 jobs.

5.1.2.2 Impacts Associated with BAT/PSES Costs

Dissolving Kraft: There are no closures caused by any of the pollution control options considered for the dissolving kraft subcategory. Hence, there are no associated impacts.

Dissolving Sulfite: The costs associated with implementing Option 1 (oxygen delignification and 100 percent chlorine dioxide substitution) lead to a single projected mill closure for this subcategory (Table 5-2). The impacts with these closures are not reported in Table 5-2 to protect confidential data. The costs associated with implementing Option 2 (TCF) lead to two mill closures. For perspective, the loss in shipments is less than 0.5 percent of total industry shipments and about 3 percent of total exports.

Bleached Papergrade Kraft and Soda: Table 5-3 lists the closures and impacts associated with the pollution control options analyzed for the bleached papergrade kraft and soda subcategory. The impacts fall into three groups: Option 1/Option 2 (two closures); Option 3/Option 4 (three closures); and Option 5 (nine closures). The impacts associated with Options

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[2]The industry totals reflect all facilities that could be categorized for the regulatory flexibility analysis. The totals for shipments and exports may be slightly smaller than those given in Section Two because a small number of mills had zero employees (i.e., contract labor) or did not state the number of employees.

TABLE 5-1

IMPACTS ASSOCIATED WITH
BPT COSTS
1989 DATA

Industry Total	Option 1	Option 2
Number of Mills	Closures	
565	1	3
Number of Employees	Loss in Employees*	
220,491	100	1,100
Shipment (Tons)	Loss in Shipment Tonnage	
86,711,752	5,752	266,240
Shipments ($000)	Loss in Shipments ($000)	
$58,529,186	$13,026	$216,612
Exports ($000)	Loss in Exports ($000)	
$5,853,950	$966	$1,599

* Rounded to nearest 100 employees.

TABLE 5-2

IMPACTS ASSOCIATED WITH
BAT/PSES COSTS: DISSOLVING SULFITE
1989 DATA

Industry Total	Option 1	Option 2
Number of Mills	Closures	
565	1	2
Number of Employees	Loss in Employees	
220,491	ND	ND
Shipments (Tons)	Loss in Shipment Tonnage	
86,711,752	ND	ND
Shipments ($000)	Loss in Shipments ($000)	
$58,529,186	ND	ND
Export ($000)	Loss in Exports ($000)	
$5,853,950	ND	ND

TABLE 5-3

IMPACTS ASSOCIATED WITH
BAT/PSES COSTS: BLEACHED PAPERGRADE KRAFT AND SODA
1989 DATA

Industry Total	Option 1	Option 2	Option 3	Option 4	Option 5
Number of Mills			Closures		
565	2	3	4	4	9
Number of Employees			Loss in Employees*		
220,491	3,700	5,100	5,800	5,800	12,700
Shipments (Tons)			Loss in Shipment Tonnage		
86,711,752	757,133	1,083,421	1,393,607	1,393,607	3,685,380
Shipments ($000)			Loss in Shipment ($000)		
$58,529,186	$853,719	$1,146,540	$1,360,066	$1,360,066	$3,271,996
Export ($000)			Loss in Exports ($000)		
$5,853,950	$1,262	$2,679	$81,204	$81,204	$284,234

* Rounded to nearest 100 employees.

3 and 4 include a loss of about 5,800 jobs and $1.4 billion in shipments, representing about 2.5 percent of current production levels in the industry. Less than 6 percent of the shipments projected to be lost under Options 3 and 4 are exports. Moving from Option 4 to Option 5 nearly triples the impacts in terms of closures, employment, shipments, and exports. Projected impacts under Option 5 include losses of more than 5.5 percent of total industry production ($3.27 billion).

Papergrade Sulfite: The impacts for the papergrade sulfite category are summarized in Table 5-4. For the papergrade sulfite subcategory, there are five closures under Option 1 (oxygen delignification and 100 percent chlorine dioxide substitution). Under Option 1, there are 3,900 jobs projected to be lost along with over $766 million in shipments, $3.6 million of which constitutes export sales. Under Option 2 (TCF), losses are projected at 2,600 jobs and $475 million in shipments, including $1.4 million in exports. For this subcategory, a totally chlorine-free process (Option 2) is associated with smaller impacts (e.g., 1,200 fewer jobs lost and 40 percent lower loss in the value of shipments and exports) than an elemental-chlorine-free production process (Option 1).

Unbleached Kraft, Semichemical, and Nonwood Chemical: There are no closures associated with best management practices, COD control, and wastewater treatment for indirect dischargers (where applicable) for these subcategories. Hence, there are no associated impacts.

5.1.2.3 Impacts Associated with Regulatory Alternative Costs

Table 5-5 summarizes the impacts associated with the regulatory alternative costs. The impacts fall into three groups:

- Alternatives 2 through 5 (3 closures)
- Alternatives 11 through 23 (14 closures)[3]

[3]The alternatives analyzed in this report are not numbered sequentially. For example, there are no Alternatives 6 through 9.

TABLE 5-4

IMPACTS ASSOCIATED WITH
BAT/PSES COSTS: PAPERGRADE SULFITE
1989 DATA

Industry Total	Option 1	Option 2
Number of Mills	Closures	
565	5	3
Number of Employees	Loss in Employees*	
220,491	3,900	2,600
Shipments (Tons)	Loss in Shipment Tonnage	
86,711,752	791,600	506,535
Shipments ($000)	Loss in Shipments ($000)	
$58,529,186	$766,791	$475,372
Export ($000)	Loss in Exports ($000)	
$5,853,950	$3,612	$1,405

* Rounded to nearest 100 employees.

TABLE 5-5

IMPACTS ASSOCIATED WITH
INTEGRATED ALTERNATIVE COSTS
1989 DATA

Industry Total	Alternatives 2 Through 5	Alternatives 11 Through 23	Alternatives 24 Through 25	Alternative 26
Number of Mills		Closures		
565	3	14	15	13
Number of Employees		Loss in Employees*		
220,491	1,900	11,100	12,500	10,700
Shipments (Tons)		Loss in Shipments (tons)		
86,711,752	736,104	3,029,161	3,590,501	2,869,346
Shipments ($000)		Loss in Shipments ($000)		
$58,529,186	$459,700	$2,543,508	$2,937,776	$2,426,580
Export ($000)		Loss in Exports ($000)		
$5,853,950	$2,207	$285,658	$371,528	$191,784

* Rounded to nearest 100 employees.

- Alternatives 24 and 25 (15 closures)
- Alternative 26 (13 closures)

Alternative 26 has the smallest amount of impacts for an alternative with process changes. The impacts include approximately 10,700 jobs lost. Losses associated with the 13 closures include 2.9 million tons of pulp, paper, and paperboard (worth $2.4 billion dollars), including $192 million in exports. This is approximately 5 percent of the jobs, 3 to 4 percent of the shipments (tonnage and value), and 3 percent of the exports associated with the pulp, paper, and paperboard industry. The reader should keep in mind that the financial model includes several conservative assumptions such as no cost pass-through (i.e., the facility cannot raise prices to recoup increased costs), no growth, no additional revenue sources for the facilities included in the estimate of earnings, and the use of net income (rather than cash flow) to project future earnings (see Section 3.2 for details). The estimated impacts presented in Section 5.1 are likely to represent upper-bound estimates.

Total impacts on employment and output, both direct and indirect, are estimated with final-demand national-level input-output multipliers from the U.S. Department of Commerce's Regional Input-Output Modeling System (RIMS II; Pigler 1993; see Section 3.2.3.2, Table 3-16). Beginning with the $2.4 billion dollars in lost shipments estimated for Alternative 26, Table 5-6 subdivides these losses into pulp, paper, and paperboard. The top half of Table 5-6 uses the final-demand multiplier for employment for each category to estimate total employment losses associated with Alternative 26. The estimated 67,100 jobs lost is inclusive of direct jobs lost; that is, the 10,700 jobs lost shown in Table 5-5 should not be added to this figure. For perspective, this is approximately one-tenth of 1 percent of the estimated 90.5 million people employed in the private sector in the United States during 1989 (DOL, 1992.) Table 5-6 also includes an estimate of the total loss in output associated with Alternative 26. The final-demand multiplier for output represents the total dollar change in output for each dollar change in industry output. The $2.4 billion loss in shipments due to projected facility closures ripples through the economy to become an estimated $8 billion loss in output. For comparison, the 1989 gross domestic product was $5,251 billion (CEA, 1993). The loss is approximately two-tenths of 1 percent of the gross domestic product for 1989.

TABLE 5-6

TOTAL OUTPUT IMPACTS OF LOSS OF
SHIPMENTS IN PULP, PAPER, AND PAPERBOARD INDUSTRY
BASED ON CLOSURES FROM ALTERNATIVE 26

Production Category	Pulp	Paper	Paperboard	Total
Loss in Shipments ($000, 1989)	$343,288	$1,889,829	$193,463	$2,426,580
RIMS II Employment Multiplier	29.7	27.2	28.2	
Total Employment Loss	10,196	51,403	5,456	67,055
RIMS II Output Multiplier	$4	3.2303	3.3589	
Total Output Impacts ($000,1989)	$1,207,790	$6,104,715	$649,823	$7,962,328

* Employment multiplier represents the amount of jobs lost for every $1,000,000 reduction in output.

Source: Pigler, 1993.

The loss in federal and state revenues was also estimated for the regulatory alternatives (Table 5-7). This is the difference in the annualized cost before and after tax shields are considered (see Section 3.2.3.3 for details). The revenues that the industry saves by reducing its taxes result in revenue losses to the federal and state governments. The values presented in Table 5-7 represent the annualized value of these lost tax revenues over the 16-year period during which the equipment is purchased, installed, depreciated, and operated. The annualized losses include not only the loss of the tax revenues but also the interest that these revenues could have earned during this period. The loss to the federal and state governments is about $233 to $299 million per year for Alternatives 11 through 26. The loss associated with Alternative 26 is $268 million per year.

The national average state tax rate of 6.75 percent is used in the cost annualization model in conjunction with a 34 percent federal tax rate (see Section 3.1). The loss in state revenues, therefore, ranges from $38 to $50 million per year. This loss, in turn, is distributed among the 42 states with pulp and paper operations (see Section 2.4).

Table 5-8 presents a summary of the results from the facility-level financial ratio analysis. The left-hand side of the table lists the baseline values for 1985, 1988, and 1989. These years indicate recent low and high points in the business cycle. The percent variation from the maximum to minimum values for those three years is shown in the next column. The percent variation provides a measure of the fluctuation in financial ratios due to the business cycle. As discussed in Section 3.2.2, the regulatory costs are added to the 1989 financial data and the ratios are recalculated. The post-regulatory ratios are presented in the remainder of Table 5-8. The results shown in Table 5-8 are the average (calculated as the arithmetic mean) and median change in gross income margin, return on assets, and current ratio. The calculation and interpretation of each ratio is discussed in Section 3.2.2. For net working capital and net working capital-to-total assets, the results are reported as the change in the mean and median values. As anticipated, the mean values show greater fluctuations. This is because the mean is sensitive to a few outlying values. The median values are more stable and are more indicative of what happens to a "typical" mill. Most of the impacts are within the range seen in the business cycle. The exceptions are the ratios that involve net working capital. The changes in net working capital appear to extend beyond the envelope defined by the business cycle, but this may

TABLE 5-7

LOSS IN FEDERAL AND STATE REVENUES
FROM REGULATORY ALTERNATIVES

Regulatory Alternative	Annualized Loss in Federal and State Revenues ($000,1991)
2	$91,057
3	$91,268
4	$99,140
5	$115,693
11	$232,962
16	$234,743
17	$242,615
18	$259,120
22	$273,003
23	$274,783
24	$282,656
25	$299,160
26	$267,541

TABLE 5-8

FACILITY-LEVEL FINANCIAL RATIO ANALYSIS
ALL MILLS

Ratio	Baseline Parameter 1985	1988	1989	% Variation	Impact of Incremental Costs (Percent Decline in Parameter) Alt 2	Alt 3	Alt 4	Alt 5	Alt 11	Alt 16	Alt 17	Alt 18	Alt 22	Alt 23	Alt 24	Alt 25	Alt 26
Gross Income Margin:																	
Mean:	3.2%	16.2%	15.3%	80.4%	-1.6%	-1.6%	-1.7%	-2.0%	-5.7%	-5.8%	-5.9%	-6.2%	-6.2%	-6.2%	-6.4%	-6.6%	-6.0%
Median:	6.9%	18.3%	17.1%	62.4%	-0.3%	-0.3%	-0.4%	-0.5%	-2.1%	-2.1%	-2.1%	-2.2%	-2.2%	-2.2%	-2.3%	-2.3%	-2.1%
Return on Assets																	
Mean:	14.6%	36.1%	31.7%	59.5%	-2.9%	-2.9%	-3.2%	-3.8%	-11.5%	-11.6%	-11.8%	-12.3%	-12.0%	-12.1%	-12.4%	-12.8%	-11.9%
Median:	9.7%	22.6%	20.9%	57.1%	-0.9%	-0.9%	-1.2%	-1.8%	-6.8%	-6.8%	-6.9%	-7.2%	-7.0%	-7.0%	-7.2%	-7.6%	-7.0%
Current Ratio																	
Mean	2.54	2.38	2.19	13.8%	-2.3%	-2.3%	-2.5%	-2.9%	-7.5%	-7.5%	-7.7%	-8.1%	-8.2%	-8.3%	-8.5%	-8.9%	-8.1%
Median	1.76	1.86	1.74	6.5%	-0.9%	-0.9%	-1.0%	-1.3%	-4.3%	-4.4%	-4.4%	-4.8%	-4.5%	-4.5%	-4.8%	-4.9%	-4.5%
Net Working Capital																	
Mean ($000)	$8,396	$7,953	$6,733	19.8%	-8.4%	-8.4%	-9.3%	-11.1%	-25.4%	-25.6%	-26.4%	-28.3%	-28.7%	-28.9%	-29.7%	-31.5%	-28.4%
Median ($000)	$3,577	$4,884	$4,589	26.8%	-8.0%	-8.0%	-8.0%	-8.0%	-21.5%	-21.5%	-22.3%	-23.3%	-23.7%	-23.7%	-23.7%	-23.7%	-23.3%
Net WC/ Total Assets																	
Mean	14.4%	8.3%	6.6%	54.0%	-3.9%	-3.9%	-4.3%	-5.5%	-20.3%	-20.4%	-20.8%	-21.5%	-21.5%	-21.6%	-21.9%	-22.6%	-20.9%
Median	7.7%	7.8%	6.8%	12.1%	-5.5%	-5.5%	-6.8%	-8.7%	-21.1%	-21.1%	-21.8%	-21.8%	-21.1%	-21.1%	-21.8%	-21.8%	-21.1%

Notes: Independently-owned facilities were excluded from this analysis, but are included in the company-level analysis.
Net Working Capital is in current dollars
This level of the ratio analysis was based upon data for 285 mills.

indicate that the facility must use sources of money beyond working capital to finance the pollution control equipment.

Table 5-9 presents a summary of the results of the company-level financial ratio analysis. The complete balance sheets and income statements available at this level of the corporate hierarchy make it possible to include debt-to-asset and times-interest-earned ratios in the analysis. The debt-to-asset ratio is used to determine to what degree assets of a company are financed through debt. The times-interest-earned ratio examines the ratio of cash flow to interest payments to determine how much additional interest burden a company can absorb. For net income margin, return on assets, times-interest-earned, and net working capital ratios, the changes induced by the cost of the regulatory alternatives are within the same range seen in the business cycle. For the current ratio, debt-to-assets, and net working capital-to-total assets ratios, the means lie slightly beyond the range set by the business cycle, but the medians are within the range. This is attributable to the fact that closures may result in significant variations in the financial ratios. These outliers tend to skew the mean while only slightly affecting the median. For example, when a company with poor financial ratios suffers a worsening of financial condition, it remains in the lower half of the company population. The company(ies) in the 50th percentile stay in the 50th percentile with their previous financial ratios; there is merely a reordering of rank among the lower-ranked companies.

5.2 MARKET MODEL IMPACT RESULTS

Results for the market impact model were generated for all the integrated regulatory alternatives that were considered by the Agency as the potential basis for the proposed standards. This section presents the market impact model results for six alternatives: Alternatives 3, 16, 23, 24, 25, and 26. Alternatives 3, 16, 23, and 26 include the MACT floor options, with varying levels of process modification option stringency. Alternative 3 does not employ any process modification options. Alternatives 24 and 25 employ MACT options more stringent than the floor with the process modification options of Alternative 23. The results for the six integrated alternatives from the market impact model are anticipated to span the range of impact severity of all evaluated alternatives.

TABLE 5-9

COMPANY-LEVEL FINANCIAL RATIO ANALYSIS
ALL COMPANIES

Ratio	Baseline Parameter 1985	1988	1989	% Variation	Impact of Incremental Costs (Percent Decline in Parameter) Alt 2	Alt3	Alt4	Alt5	Alt11	Alt16	Alt17	Alt18	Alt22	Alt23	Alt24	Alt25	Alt26
Net Income Margin:																	
Mean:	2 2%	6 6%	5 4%	66.0%	-2.1%	-2.1%	-2.3%	-2.5%	-9.9%	-9.9%	-10.0%	-10.2%	-10.2%	-10.2%	-10.4%	-10.6%	-10.2%
Median:	4.1%	6 0%	5.6%	31.8%	0.0%	0.0%	0.0%	0.0%	-3.4%	-3.4%	-3.4%	-3.7%	-3.8%	-3.8%	-3.8%	-3.9%	-3.6%
Return on Assets:																	
Mean:	5 7%	8 4%	7 0%	32.6%	-2.6%	-2.6%	-2.8%	-3.2%	-13.7%	-13.7%	-13.9%	-14.2%	-14.1%	-14.1%	-14.3%	-14.5%	-14.1%
Median:	5.3%	8 9%	7.3%	39.9%	0.0%	0.0%	0.0%	0.0%	-6.1%	-6.1%	-6.2%	-6.3%	-6.7%	-6.8%	-7.0%	-7.3%	-6.8%
Current Ratio																	
Mean:	2 1	2 1	2.0	2.4%	-0.4%	-0.4%	-0.4%	-0.5%	-2.3%	-2.3%	-2.3%	-2.4%	-2.4%	-2.4%	-2.4%	-2.5%	-2.4%
Median:	1 7	1 8	1 7	7.7%	0.0%	0.0%	0.0%	0.0%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%
Debt to Asset Ratio																	
Mean:	53 2%	55 0%	56.6%	5.9%	0.7%	0.7%	0.8%	0.9%	5.5%	5.5%	5.6%	5.7%	5.6%	5.6%	5.7%	5.8%	5.6%
Median:	50 9%	53 3%	51 7%	4.5%	0.0%	0.0%	0.0%	0.0%	1.5%	1.5%	1.5%	1.6%	1.5%	1.5%	1.6%	1.7%	1.5%
Times Interest Earned:																	
Mean:	50 7	44 5	22 8	55.0%	-5.2%	-5.2%	-5.7%	-6.7%	-21.5%	-21.5%	-21.7%	-22.2%	-21.8%	-21.9%	-22.1%	-22.5%	-22.0%
Median:	6 3	9 8	8 1	36.0%	0.0%	0.0%	0.0%	0.0%	-11.2%	-11.2%	-11.3%	-11.7%	-11.2%	-11.2%	-11.3%	-11.7%	-11.2%
Net Working Capital																	
Mean ($000):	$71,425	$109,250	$97,950	34 6%	-1.4%	-1.4%	-1.6%	-1.9%	-4.4%	-4.4%	-4.6%	-4.9%	-4.9%	-5.0%	-5.1%	-5.4%	-4.9%
Median ($000):	$17,971	$17,685	$16,191	9.9%	-3.2%	-3.2%	-3.4%	-3.4%	-4.6%	-4.6%	-4.7%	-4.7%	-4.6%	-4.6%	-4.7%	-4.7%	-4.6%
Net WC/Total Assets:																	
Mean:	15 2%	15 8%	15 4%	3.6%	-1.1%	-1.1%	-1.2%	-1.4%	-11.0%	-11.0%	-11.1%	-11.3%	-11.2%	-11.2%	-11.3%	-11.5%	-11.2%
Median:	14 5%	13.5%	12.4%	14.3%	-1.7%	-1.7%	-1.9%	-2.2%	-6.4%	-6.4%	-6.7%	-6.7%	-6.4%	-6.5%	-6.7%	-7.4%	-6.5%

5.2.1 Changes in Facility Costs

The starting point for estimating post-regulatory market equilibria in the market impact model is the imposition of regulatory control costs. The market impact model requires two kinds of compliance costs for each mill directly affected by the regulation. The first is the average increase in variable production costs per ton of pulp that is used as an input to final product production. The second is the estimated total annualized capital cost of the regulation. This represents the fixed cost a facility will incur if it stays open. It is calculated on a pre-tax basis. Table 5-10 shows the production-weighted average mill-specific pulp production variable cost increases for each of the 17 pulp input types. The number of affected mills in the market model producing each of the pulp types, as either inputs to final product production or for sale as market pulp, is also shown in Table 5-10.

Mills producing pulp types 2 (bleached kraft), 3 (unbleached kraft), 14 (bleached secondary fiber), and 15 (unbleached secondary fiber) are affected most frequently by variable production cost increases. For each alternative, pulp type 4 (bleached sulfite) experiences the largest production-weighted average variable cost increase, and the variable cost increase generally rises as the stringency of the integrated regulatory alternative increases.

Table 5-11 shows the nationwide total annualized capital cost for each alternative. It is calculated on a pre-tax basis for only the capital cost; hence the numbers are different than the compliance costs shown in Table 4-14. The total annualized capital cost is calculated using the mill-specific cost-of-capital estimates given in the National Census. Table 5-11 also shows the number of facilities in the market model directly affected by capital costs, and the average, maximum, and minimum annualized capital cost for each alternative.

5.2.2 Market Price and Quantity Impacts

The increases in mill-level production costs begin the market adjustment process. The equilibrium outcome for each alternative consists of a vector of market-level product prices and

TABLE 5-10

PRODUCTION-WEIGHTED AVERAGE PULP INPUT VARIABLE COST INCREASE
(1989 $/ton)

Pulp Input Type	Alternative 3		Alternative 16		Alternative 23		Alternative 24		Alternative 25		Alternative 26	
	# Mills	Wt Avg	# Mills	Wt Avg	# Mills	Wt Avg	# Mills	Wt Avg	# Mills	Wt Avg	# Mills	Wt Avg
1	8	0.98	8	4.63	8	4.63	8	4726	8	4.79	8	-0.26
2	87	2.39	87	0.36	87	2.80	87	2.90	87	3.12	87	2.80
3	59	1.34	59	1.16	59	1.16	59	1.25	59	1.25	59	1.16
4	13	3.43	13	14.72	13	14.82	13	14.93	13	14.96	13	14.32
5	3	0.75	5	1.81	5	1.81	5	1.91	5	1.91	5	1.81
6	12	0.53	20	0.37	20	1.00	20	1.00	20	1.07	20	1.00
7	1	0.21	7	0.41	7	0.41	7	0.41	7	0.41	7	0.41
8	5	0.10	12	0.42	12	1.24	12	1.24	12	1.29	12	1.24
9	1	0.16	3	0.22	3	0.22	3	0.22	3	0.22	3	0.22
10	1	1.48	1	3.25	1	3.25	1	3.50	1	3.50	1	3.25
11	31	0.63	32	1.09	32	1.09	32	1.12	32	1.12	32	1.09
12	3	2.56	4	1.59	4	3.95	4	3.95	4	4.11	4	3.95
13	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
14	6	0.09	42	0.71	42	0.71	42	0.71	42	0.71	42	0.71
15	38	0.17	114	0.38	114	0.38	114	0.30	114	0.38	114	0.38
16	0	0.00	9	2.43	9	2.43	9	2.43	9	2.43	9	2.43
17	0	0.00	4	0.32	4	0.32	4	0.32	4	0.32	4	0.32

TABLE 5-11

NATIONWIDE TOTAL PRE-TAX ANNUALIZED CAPITAL COST INCREASE
(millions of $1989)

	Alt. 3	Alt. 16	Alt. 23	Alt. 24	Alt. 25	Alt. 26
Total Annualized Capital Cost	141.0	652.7	676.8	695.2	739.5	676.8
Number of Affected Mills	159	299	299	299	299	299
Facility Average	0.89	2.18	2.26	2.36	2.52	2.26
Facility Maximum	4.14	19.10	19.56	19.78	20.63	19.56
Facility Median	0.65	0.57	0.58	0.59	0.61	0.58
Facility Minimum	0.05	*	*	*	*	*

*Less than $10,000

facility-level production quantities at which total market supply and total consumer demand are equal.

5.2.2.1 Product Price Impacts

Tables 5-12 through 5-17 show the equilibrium market price adjustments computed for 27 of the 37 modeled product market categories, and three composite categories that index all market pulps, paper products and paperboard products. The tables include the baseline price and the absolute and percentage change in price with the regulatory alternative. For each alternative, the largest percentage change in market price is for uncoated free sheet (e.g., copy and writing paper). For Alternatives 16, 23, 24, 25, and 26 many of the market pulp products experience price declines due to the decrease in the demand for pulp by integrated mills.

5.2.2.2 Domestic Production Impacts

Tables 5-12 through 5-17 also show the equilibrium domestic production level adjustments that result for 27 of the 37 product market categories. Nearly all of the production level changes are minor, with the exception of bleached sulfite market pulp for Alternatives 16, 23, 24, 25, and 26 which is projected to decline by over 3 percent.

5.2.2.3 Import and Export Impacts

Tables 5-18 through 5-23 show the equilibrium import and export value adjustments, and Tables 5-24 through 5-29 show the equilibrium import and export quantity adjustments that result for 26 of the 37 modeled product categories.

Export Value. Of the five most important exports in terms of value, none of the export declines for Alternative 3 is significant. For the other alternatives, the most significant export decline among the most important five products is nearly 8 percent for newsprint. The most

TABLE 5-12

PRICE AND QUANTITY ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 3

Product Category	Base P	ΔP	%ΔP	Base Q	ΔQ	%ΔQ
Special alpha and dissolving pulp	735.33	0.23	*	1,470	0	*
Bleached kraft	646.49	-0.04	*	9,207	-25	*
Unbleached kraft	384.37	-0.13	*	320	-1	*
Bleached sulfite	556.77	0.22	*	359	0	*
Bleached secondary	444.13	0.25	*	120	0	*
Unbleached secondary	416.84	0.16	*	117	0	*
MARKET PULP TOTAL	635.03	0.01	*	11,593	-27	*
Newsprint	490.09	0.10	*	5,678	-1	*
Uncoated groundwood paper	693.14	0.02	*	2,090	0	*
Clay coated printing	970.31	2.18	*	9,157	-63	*
Uncoated free sheet	928.35	6.65	*	11,341	20	*
Bleached bristols	838.09	0.52	*	779	-1	*
Unbleached kraft packaging paper	548.33	0.05	*	2,943	-1	*
Tissue	1,111.30	0.40	*	5,392	-1	*
Wrapping	816.70	0.10	*	157	0	*
Shipping sack, unbl/bl sulfite	656.33	0.20	*	93	0	*
TOTAL PAPER PRODUCTS	843.14	2.62	*	40,247	-31	*
Unbl kraft packaging paperboard	395.55	0.30	*	19,375	-16	*
Semichemical paperboard	361.50	0.15	*	5,927	-2	*
Recycled paperboard	381.52	0.17	*	8,796	2	*
Wet machine board	629.15	0.55	*	80	0	*
Construction paper	392.85	0.05	*	667	0	*
Insulating board	338.32	0.00	*	92	0	*
Linerboard	543.04	0.09	*	376	-1	*
Folding carton board	721.33	0.72	*	2,395	-5	*
Milk carton board	719.37	0.21	*	1,205	-2	*
Heavyweight cup/container	700.25	0.43	*	453	-1	*
Plate, dish, and tray stock	686.05	0.39	*	219	0	*
Molded pulp products	1,196.29	0.03	*	227	0	*
TOTAL PAPERBOARD PRODUCTS	432.66	0.27	*	40,607	-27	*
TOTAL ALL PRODUCTS				92,447	-85	*

P=price ($/ton) Q=domestic production (000 ton/yr) Δ="change in" *=less than 1%
Totals and percent changes might not be exact because of rounding.

TABLE 5-13

PRICE AND QUANTITY ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 16

Product Category	Base P	ΔP	%ΔP	Base Q	ΔQ	%ΔQ
Special alpha and dissolving pulp	735.33	0.62	*	1,470	-2	*
Bleached kraft	646.49	-1.00	*	9,207	-22	*
Unbleached kraft	384.37	-0.06	*	320	-1	*
Bleached sulfite	556.77	0.88	*	359	-11	-3.2
Bleached secondary	444.13	0.21	*	120	0	-
Unbleached secondary	416.84	-7.84	-1.9	117	-2	-1.4
MARKET PULP TOTAL	635.03	-0.72	*	11,593	-39	*
Newsprint	490.09	0.90	*	5,678	-52	*
Uncoated groundwood paper	693.14	0.11	*	2,090	0	*
Clay coated printing	970.31	2.03	*	9,157	-54	*
Uncoated free sheet	928.35	25.57	*	11,341	-92	*
Bleached bristols	838.09	0.83	*	779	-2	*
Unbl kraft packaging paper	548.33	0.23	*	2,943	-1	*
Tissue	1,111.30	6.85	*	5,392	-13	*
Wrapping	816.70	13.91	1.7	157	2	1.2
Shipping sack, unbl/bl sulfite	656.33	0.33	*	93	-1	*
TOTAL PAPER PRODUCTS	843.14	7.89	*	40,247	-218	*
Unbl kraft packaging paperboard	395.55	0.25	*	19,375	-13	*
Semichemical paperboard	361.50	1.00	*	5,927	0	*
Recycled paperboard	381.52	3.61	*	8,796	-31	*
Wet machine board	629.15	9.58	1.5	80	0	*
Construction paper	392.85	0.04	*	667	0	*
Insulating board	338.32	0.22	*	92	0	*
Linerboard	543.04	0.10	*	376	-2	*
Folding carton board	721.33	0.23	*	2,395	-1	*
Milk carton board	719.37	-0.11	*	1,205	1	*
Heavyweight cup/container	700.25	-0.06	*	453	0	*
Plate, dish, and tray stock	686.05	-0.12	*	219	0	*
Molded pulp products	1,196.29	0.04	*	227	0	*
TOTAL PAPERBOARD PRODUCTS	432.66	1.07	*	40,607	-45	*
TOTAL ALL PRODUCTS				92,447	-302	*

P=price ($/ton) Q=domestic production (000 ton/yr) Δ="change in" *=less than 1%
Totals and percent changes might not be exact because of rounding.

TABLE 5-14

PRICE AND QUANTITY ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 23

Product Category	Base P	ΔP	%ΔP	Base Q	ΔQ	%ΔQ
Special alpha and dissolving pulp	735.33	0.62	*	1,470	-2	*
Bleached kraft	646.49	-1.00	*	9,207	-29	*
Unbleached kraft	384.37	-0.06	*	320	-1	*
Bleached sulfite	556.77	0.88	*	359	-11	-3.2
Bleached secondary	444.13	0.21	*	120	0	*
Unbleached secondary	416.84	-7.84	-1.9	117	-2	-1.4
MARKET PULP TOTAL	635.03	-0.72	*	11,593	-45	*
Newsprint	490.09	0.90	*	5,678	-53	*
Uncoated groundwood paper	693.14	0.11	*	2,090	0	*
Clay coated printing	970.31	2.14	*	9,157	-60	*
Uncoated free sheet	928.35	25.57	2.8	11,341	-96	*
Bleached bristols	838.09	1.51	*	779	-4	*
Unbl kraft packaging paper	548.33	0.23	*	2,943	-1	*
Tissue	1,111.30	6.85	*	5,392	-14	*
Wrapping	816.70	14.00	1.7	157	2	1.2
Shipping sack, unbl/bl sulfite	656.33	0.47	*	93	-1	*
TOTAL PAPER PRODUCTS	843.14	7.93	*	40,247	-234	*
Unbl kraft packaging paperboard	395.55	0.27	*	19,375	-14	*
Semichemical paperboard	361.50	0.99	*	5,927	0	*
Recycled paperboard	381.52	3.62	*	8,796	-31	*
Wet machine board	629.15	9.58	1.5	80	0	*
Construction paper	392.85	0.04	*	667	0	*
Insulating board	338.32	0.22	*	92	0	*
Linerboard	543.04	0.21	*	376	-3	*
Folding carton board	721.33	0.67	*	2,395	-6	*
Milk carton board	719.37	0.06	*	1,205	-1	*
Heavyweight cup/container	700.25	0.30	*	453	-1	*
Plate, dish, and tray stock	686.05	0.15	*	219	0	*
Molded pulp products	1,196.29	0.04	*	227	0	*
TOTAL PAPERBOARD PRODUCTS	432.66	1.13	*	40,607	-58	*
TOTAL ALL PRODUCTS				92,447	-337	*

P=price ($/ton) Q=domestic production (000 ton/yr) Δ="change in" *=less than 1%
Totals and percent changes might not be exact because of rounding.

TABLE 5-15

PRICE AND QUANTITY ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 24

Product Category	Base P	ΔP	%ΔP	Base Q	ΔQ	%ΔQ
Special alpha and dissolving pulp	735.33	0.62	*	1,470	-2	*
Bleached kraft	646.49	-1.01	*	9,207	-29	*
Unbleached kraft	384.37	-0.06	*	320	-1	*
Bleached sulfite	556.77	0.88	*	359	-11	-3.2
Bleached secondary	444.13	0.21	*	120	0	*
Unbleached secondary	416.84	-7.84	-1.9	117	-2	-1.4
MARKET PULP TOTAL	635.03	-0.73	*	11,593	-46	*
Newsprint	490.09	0.90	*	5,678	-53	*
Uncoated groundwood paper	693.14	0.11	*	2,090	0	*
Clay coated printing	970.31	2.14	*	9,157	-60	*
Uncoated free sheet	928.35	25.57	2.8	11,341	-96	*
Bleached bristols	838.09	1.53	*	779	-4	*
Unbl kraft packaging paper	548.33	0.20	*	2,943	-1	*
Tissue	1,111.30	6.65	*	5,392	-15	*
Wrapping	816.70	14.00	*	157	2	1.2
Shipping sack, unbl/bl sulfite	656.33	0.47	*	93	-1	*
TOTAL PAPER PRODUCTS	843.14	7.95	*	40,247	-234	*
Unbl kraft packaging paperboard	395.55	0.27	*	19,375	-15	*
Semichemical paperboard	361.50	0.90	*	5,927	-1	*
Recycled paperboard	381.52	3.63	*	8,796	-31	*
Wet machine board	629.15	9.58	1.5	80	0	*
Construction paper	392.85	0.04	*	667	0	*
Insulating board	338.32	0.22	*	92	0	*
Linerboard	543.04	0.21	*	376	-3	*
Folding carton board	721.33	0.87	*	2,395	-6	*
Milk carton board	719.37	0.18	*	1,205	-1	*
Heavyweight cup/container	700.25	0.45	*	453	-1	*
Plate, dish, and tray stock	686.05	0.30	*	219	0	*
Molded pulp products	1,196.29	0.04	*	227	0	*
TOTAL PAPERBOARD PRODUCTS	432.66	1.14	*	40,607	-59	*
TOTAL ALL PRODUCTS				92,447	-340	*

P=price ($/ton) Q=domestic production (000 ton/yr) Δ="change in" *=less than 1%
Totals and percent changes might not be exact because of rounding.

TABLE 5-16

PRICE AND QUANTITY ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 25

Product Category	Base P	ΔP	%ΔP	Base Q	ΔQ	%ΔQ
Special alpha and dissolving pulp	735.33	0.62	*	1,470	-2	*
Bleached kraft	646.49	-1.01	*	9,207	-30	*
Unbleached kraft	384.37	-0.06	*	320	-1	*
Bleached sulfite	556.77	0.88	*	359	-11	-3.2
Bleached secondary	444.13	0.21	*	120	0	*
Unbleached secondary	416.84	-7.84	-1.9	117	-2	-1.4
MARKET PULP TOTAL	635.03	-0.73	*	11,593	-46	*
Newsprint	490.09	0.89	*	5,678	-54	*
Uncoated groundwood paper	693.14	0.11	*	2,090	0	*
Clay coated printing	970.31	2.19	*	9,157	-60	*
Uncoated free sheet	928.35	25.57	2.8	11,341	-97	*
Bleached bristols	838.09	1.61	*	779	-4	*
Unbl kraft packaging paper	548.33	0.20	*	2,943	-1	*
Tissue	1,111.30	6.61	*	5,392	-15	*
Wrapping	816.70	14.00	1.7	157	2	1.1
Shipping sack, unbl/bl sulfite	656.33	0.52	*	93	-1	*
TOTAL PAPER PRODUCTS	843.14	7.95	1.0	40,247	-235	*
Unbl kraft packaging paperboard	395.55	0.27	*	19,375	-15	*
Semichemical paperboard	361.50	0.88	*	5,927	-1	*
Recycled paperboard	381.52	3.61	*	8,796	-31	*
Wet machine board	629.15	9.58	1.5	80	0	*
Construction paper	392.85	0.04	*	667	0	*
Insulating board	338.32	0.22	*	92	0	*
Linerboard	543.04	0.24	*	376	-4	*
Folding carton board	721.33	0.97	*	2,395	-6	*
Milk carton board	719.37	0.18	*	1,205	-1	*
Heavyweight cup/container	700.25	0.50	*	453	-1	*
Plate, dish, and tray stock	686.05	0.30	*	219	0	*
Molded pulp products	1,196.29	0.04	*	227	0	*
TOTAL PAPERBOARD PRODUCTS	432.66	1.14	*	40,607	-61	*
TOTAL ALL PRODUCTS				92,447	-350	*

P=price ($/ton) Q=domestic production (000 ton/yr) Δ="change in" *=less than 1%
Totals and percent changes might not be exact because of rounding.

TABLE 5-17

PRICE AND QUANTITY ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 26

Product Category	Base P	ΔP	%ΔP	Base Q	ΔQ	%ΔQ
Special alpha and dissolving pulp	735.33	0.23	*	1,470	0	*
Bleached kraft	646.49	-1.49	*	9,207	-30	*
Unbleached kraft	384.37	-0.12	*	320	-1	*
Bleached sulfite	556.77	0.84	*	359	-11	-3.1
Bleached secondary	444.13	0.18	*	120	0	*
Unbleached secondary	416.84	-7.91	-1.9	117	-2	-1.5
MARKET PULP TOTAL	635.03	-1.15	*	11,593	-44	*
Newsprint	490.09	0.76	*	5,678	-54	*
Uncoated groundwood paper	693.14	0.11	*	2,090	0	*
Clay coated printing	970.31	2.09	*	9,157	-58	*
Uncoated free sheet	928.35	25.15	2.7	11,341	-97	*
Bleached bristols	838.09	1.58	*	779	-4	*
Unbl kraft packaging paper	548.33	0.07	*	2,943	-1	*
Tissue	1,111.30	5.85	*	5,392	-18	*
Wrapping	816.70	13.75	1.7	157	2	1.2
Shipping sack, unbl/bl sulfite	656.33	0.47	*	93	-1	*
TOTAL PAPER PRODUCTS	843.14	7.67	*	40,247	-235	*
Unbl kraft packaging paperboard	395.55	0.28	*	19,375	-14	*
Semichemical paperboard	361.50	0.40	*	5,927	-3	*
Recycled paperboard	381.52	3.62	*	8,796	-31	*
Wet machine board	629.15	9.85	1.6	80	0	*
Construction paper	392.85	0.05	*	667	0	*
Insulating board	338.32	0.18	*	92	0	*
Linerboard	543.04	0.21	*	376	-3	*
Folding carton board	721.33	0.97	*	2,395	-6	*
Milk carton board	719.37	0.13	*	1,205	-1	*
Heavyweight cup/container	700.25	0.50	*	453	-1	*
Plate, dish, and tray stock	686.05	0.30	*	219	0	*
Molded pulp products	1,196.29	0.01	*	227	0	*
TOTAL PAPERBOARD PRODUCTS	432.66	1.07	*	40,607	-59	*
TOTAL ALL PRODUCTS				92,447	-220	*

P=price ($/ton) Q=domestic production (000 ton/yr) Δ="change in" *=less than 1%
Totals and percent changes might not be exact because of rounding.

TABLE 5-18

FOREIGN TRADE VALUE ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 3
(millions of $1989)

Product Category	Base $X	Δ$X	%Δ$X	Base $I	Δ$I	%Δ$I
Special alpha and dissolving pulp	614.8	-0.6	*	208.9	0.1	*
Bleached kraft	3,024.0	-0.9	*	2,426.4	-0.3	*
Unbleached kraft	69.8	-0.4	*	33.4	-0.3	-1.0
Bleached sulfite	181.1	-1.9	-1.0	199.5	0.6	*
Bleached secondary	0	0	*	274.5	1.7	*
Unbleached secondary	17.3	-0.1	*	0	0	*
MARKET PULP TOTAL	3,906.9	-1.2	*	3,142.6	1.8	*
Newsprint	306.2	-2.7	*	4,191.9	1.2	*
Uncoated groundwood paper	61.0	0	*	903.9	0.1	*
Clay coated printing	163.5	-6.4	-3.9	751.0	12.9	1.7
Uncoated free sheet	112.9	-6.7	-5.9	0	0	*
Bleached bristols	39.2	-0.6	-1.4	49.5	0.1	*
Cotton fiber writing	84.1	-0.3	*	1,215.4	1.4	*
Unbl kraft packaging paper	16.7	0	*	131.2	0	*
Tissue	23.0	0	*	134.2	0.1	*
Wrapping	7.3	0	*	1.9	0	*
Shipping sack, unbl/bl sulfite	27.2	-0.2	*	1.6	0	*
TOTAL PAPER PRODUCTS	1,148.2	-16.1	-1.4	7,639.3	22.9	*
Unbl kraft packaging paperboard	974.3	-4.1	*	65.3	0.1	*
Semichemical paperboard	11.3	0	*	42.7	0	*
Recycled paperboard	70.6	-0.3	*	63.0	0.1	*
Construction paper	13.1	0	*	74.3	0	*
Linerboard	153.7	-0.7	*	6.6	0	*
Folding carton board	139.8	-1.2	*	8.8	0.4	4.6
Milk carton board	380.7	-0.8	*	8.7	0.1	1.1
Heavyweight cup/container	7.2	0	*	8.5	0.2	2.7
Plate, dish, and tray stock	7.1	0	*	8.3	0.2	2.5
Molded pulp products	15.2	0	*	23.3	0	*
TOTAL PAPERBOARD PRODUCTS	1,809.4	-7.4	*	326.2	1.8	*
TOTAL ALL PRODUCTS	6,864.5	-24.7	*	11,108.2	26.5	*

$X=export value $I=import value Δ="change in" *=less than 1%
Totals and percent changes might not be exact because of rounding.

TABLE 5-19

FOREIGN TRADE VALUE ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 16
(millions of $1989)

Product Category	Base $X	Δ$X	%Δ$X	Base $I	Δ$I	%Δ$I
Special alpha and dissolving pulp	614.8	-1.8	*	208.9	0.3	*
Bleached kraft	3,024.0	22.3	*	2,426.4	-7.5	*
Unbleached kraft	69.8	0.2	*	33.4	-0.2	*
Bleached sulfite	181.1	-7.2	-4.0	199.5	2.2	1.1
Bleached secondary	0	0	*	274.5	1.4	*
Unbleached secondary	17.3	3.2	18.6	0	0	*
MARKET PULP TOTAL	3,906.9	16.8	*	3,142.6	-3.7	*
Newsprint	306.2	-23.5	-7.7	4,191.9	11.3	*
Uncoated groundwood paper	61.0	-0.2	*	903.9	0.4	*
Clay coated printing	163.5	-6.0	-3.7	751.0	12.0	1.6
Uncoated free sheet	112.9	-23.4	-20.8	0	0	*
Bleached bristols	39.2	-0.9	-2.3	49.5	0.2	*
Cotton fiber writing	84.1	-1.9	-2.3	1,215.4	9.4	*
Unbl kraft packaging paper	16.7	-0.1	*	131.2	0.2	*
Tissue	23.0	0.1	*	134.2	1.2	*
Wrapping	7.3	-4.2	-57.1	1.9	0.5	28.0
Shipping sack, unbl/bl sulfite	27.2	-0.3	-1.2	1.6	0	*
TOTAL PAPER PRODUCTS	1,148.2	-59.5	-5.2	7,639.3	43.2	*
Unbl kraft packaging paperboard	974.3	-3.5	*	65.3	0.1	*
Semichemical paperboard	11.3	-0.2	-1.6	42.7	0.3	*
Recycled paperboard	70.6	-5.4	-7.6	63.0	1.5	2.5
Construction paper	13.1	0	*	74.3	0	*
Linerboard	153.7	-0.8	*	6.6	0	*
Folding carton board	139.8	-0.4	*	8.8	0	1.5
Milk carton board	380.7	0.4	*	8.7	0	*
Heavyweight cup/container	7.2	0	*	8.5	0	*
Plate, dish, and tray stock	7.1	0	*	8.3	-0.1	*
Molded pulp products	15.2	0	*	23.3	0.1	*
TOTAL PAPERBOARD PRODUCTS	1,809.4	-9.7	*	326.2	1.8	*
TOTAL ALL PRODUCTS	6,864.5	-25.9	*	11,108.2	41.3	*

$X=export value $I=import value Δ="change in" *=less than 1%
Totals and percent changes might not be exact because of rounding.

TABLE 5-20

FOREIGN TRADE VALUE ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 23
(millions of $1989)

Product Category	Base $X	Δ$X	%Δ$X	Base $I	Δ$I	%Δ$I
Special alpha and dissolving pulp	614.8	-1.8	*	208.9	0.3	*
Bleached kraft	3,024.0	22.2	*	2,426.4	-7.5	*
Unbleached kraft	69.8	0.2	*	33.4	-0.2	*
Bleached sulfite	181.1	-7.2	-4.0	199.5	2.2	1.1
Bleached secondary	0	0	*	274.5	1.4	*
Unbleached secondary	17.3	3.2	18.6	0	0	*
MARKET PULP TOTAL	3,906.9	16.7	*	3,142.6	-3.7	*
Newsprint	306.2	-23.5	-7.7	4,191.9	11.3	*
Uncoated groundwood paper	61.0	-0.2	*	903.9	0.4	*
Clay coated printing	163.5	-6.3	-3.9	751.0	12.6	1.7
Uncoated free sheet	112.9	-23.4	-20.8	0	0	*
Bleached bristols	39.2	-1.6	-4.2	49.5	0.4	*
Cotton fiber writing	84.1	-1.9	-2.3	1,215.4	9.4	*
Unbl kraft packaging paper	16.7	-0.1	*	131.2	0.2	*
Tissue	23.0	0.1	*	134.2	1.2	*
Wrapping	7.3	-4.2	-57.3	1.9	0.5	28.2
Shipping sack, unbl/bl sulfite	27.2	-0.4	-1.6	1.6	0	1.1
TOTAL PAPER PRODUCTS	1,148.2	-60.8	-5.3	7,639.3	44.0	*
Unbl kraft packaging paperboard	974.3	-3.7	*	65.3	0.1	*
Semichemical paperboard	11.3	-0.2	-1.6	42.7	0.3	*
Recycled paperboard	70.6	-5.4	-7.6	63.0	1.5	2.5
Construction paper	13.1	0	*	74.3	0	*
Linerboard	153.7	-1.7	-1.1	6.6	0.1	1.3
Folding carton board	139.8	-1.1	*	8.8	0.4	4.3
Milk carton board	380.7	-0.2	*	8.7	0	*
Heavyweight cup/container	7.2	0	*	8.5	0.2	1.9
Plate, dish, and tray stock	7.1	0	*	8.3	0.1	1.0
Molded pulp products	15.2	0	*	23.3	0.1	*
TOTAL PAPERBOARD PRODUCTS	1,809.4	-12.5	*	326.2	2.9	*
TOTAL ALL PRODUCTS	6,864.5	-56.6	*	11,108.2	43.2	*

$X=export value $I=import value Δ="change in" *=less than 1%
Totals and percent changes might not be exact because of rounding.

TABLE 5-21

FOREIGN TRADE VALUE ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES

Regulatory Alternative 24
(millions of $1989)

Product Category	Base $X	Δ$X	%Δ$X	Base $I	Δ$I	%Δ$I
Special alpha and dissolving pulp	614.8	-1.8	*	208.9	0.3	*
Bleached kraft	3,024.0	22.6	*	2,426.4	-7.6	*
Unbleached kraft	69.8	0.2	*	33.4	-0.2	*
Bleached sulfite	181.1	-7.2	-4.0	199.5	2.2	1.1
Bleached secondary	0	0	*	274.5	1.4	*
Unbleached secondary	17.3	3.2	18.6	0	0	*
MARKET PULP TOTAL	3,906.9	17.0	*	3,142.6	-3.8	*
Newsprint	306.2	-23.5	-7.7	4,191.9	11.3	*
Uncoated groundwood paper	61.0	-0.2	*	903.9	0.4	1.7
Clay coated printing	163.5	-6.3	-3.9	751.0	12.6	1.7
Uncoated free sheet	112.9	-23.4	-20.8	0	0	*
Bleached bristols	39.2	-1.7	-4.2	49.5	0.4	*
Cotton fiber writing	84.1	-1.9	-2.3	1,215.4	9.4	*
Unbl kraft packaging paper	16.7	-0.1	*	131.2	0.2	*
Tissue	23.0	0.1	*	134.2	1.2	*
Wrapping	7.3	-4.2	-57.3	1.9	0.5	28.2
Shipping sack, unbl/bl sulfite	27.2	-0.4	-1.6	1.6	0	1.1
TOTAL PAPER PRODUCTS	1,148.2	-60.8	-5.3	7,639.3	44.4	*
Unbl kraft packaging paperboard	974.3	-3.7	*	65.3	0.1	*
Semichemical paperboard	11.3	-0.2	-1.4	42.7	0.2	*
Recycled paperboard	70.6	-5.4	-7.6	63.0	1.6	2.5
Construction paper	13.1	0	*	74.3	0	*
Linerboard	153.7	-1.7	-1.1	6.6	0.1	1.3
Folding carton board	139.8	-1.5	-1.1	8.8	0.5	5.6
Milk carton board	380.7	-0.7	*	8.7	0.1	*
Heavyweight cup/container	7.2	0	*	8.5	0.2	2.8
Plate, dish, and tray stock	7.1	0	*	8.3	0.2	1.9
Molded pulp products	15.2	0	*	23.3	0.1	*
TOTAL PAPERBOARD PRODUCTS	1,809.4	-13.3	*	326.2	3.3	1.0
TOTAL ALL PRODUCTS	6,864.5	-57.1	*	11,108.2	43.9	*

$X=export value $I=import value Δ="change in" *=less than 1%
Totals and percent changes might not be exact because of rounding.

TABLE 5-22

FOREIGN TRADE VALUE ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 25
(millions of $1989)

Product Category	Base $X	Δ$X	%Δ$X	Base $I	Δ$I	%Δ$I
Special alpha and dissolving pulp	614.8	-1.8	*	208.9	0.3	*
Bleached kraft	3,024.0	22.6	*	2,426.4	-7.6	*
Unbleached kraft	69.8	0.2	*	33.4	-0.2	*
Bleached sulfite	181.1	-7.2	-4.0	199.5	2.2	1.1
Bleached secondary	0	0	*	274.5	1.4	*
Unbleached secondary	17.3	3.2	18.6	0	0	*
MARKET PULP TOTAL	3,906.9	17.0	*	3,142.6	-3.8	*
Newsprint	306.2	-23.3	-7.6	4,191.9	11.2	*
Uncoated groundwood paper	61.0	-0.2	*	903.9	0.4	*
Clay coated printing	163.5	-6.5	-3.9	751.0	12.9	1.7
Uncoated free sheet	112.9	-23.4	-20.8	0	0	*
Bleached bristols	39.2	-1.7	-4.4	49.5	0.4	*
Cotton fiber writing	84.1	-1.9	-2.3	1,215.4	9.4	*
Unbl kraft packaging paper	16.7	-0.1	*	131.2	0.2	*
Tissue	23.0	0.1	*	134.2	1.2	*
Wrapping	7.3	-4.2	-57.3	1.9	0.5	28.2
Shipping sack, unbl/bl sulfite	27.2	-0.5	-1.8	1.6	0	1.2
TOTAL PAPER PRODUCTS	1,148.2	-60.8	-5.3	7,639.3	44.6	*
Unbl kraft packaging paperboard	974.3	-3.7	*	65.3	0.1	*
Semichemical paperboard	11.3	-0.2	-1.4	42.7	0.2	*
Recycled paperboard	70.6	-5.4	-7.6	63.0	1.5	2.5
Construction paper	13.1	0	*	74.3	0	*
Linerboard	153.7	-1.9	-1.3	6.6	0.1	1.4
Folding carton board	139.8	-1.6	-1.2	8.8	0.5	6.3
Milk carton board	380.7	-0.7	*	8.7	0.1	*
Heavyweight cup/container	7.2	0	*	8.5	0.3	3.1
Plate, dish, and tray stock	7.1	0	*	8.3	0.2	1.9
Molded pulp products	15.2	0	*	23.3	0.1	*
TOTAL PAPERBOARD PRODUCTS	1,809.4	-13.7	*	326.2	3.5	1.1
TOTAL ALL PRODUCTS	6,864.5	-57.5	*	11,108.2	44.3	*

$X=export value $I=import value Δ="change in" *=less than 1%
Totals and percent changes might not be exact because of rounding.

TABLE 5-23

FOREIGN TRADE VALUE ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 26
(millions of $1989)

Product Category	Base $X	Δ$X	%Δ$X	Base $I	Δ$I	%Δ$I
Special alpha and dissolving pulp	614.8	-0.6	*	208.9	0.1	*
Bleached kraft	3,024.0	33.3	1.1	2,426.4	-11.2	*
Unbleached kraft	69.8	0.4	*	33.4	-0.3	*
Bleached sulfite	181.1	-6.9	-3.8	199.5	2.1	1.1
Bleached secondary	0	0	*	274.5	1.2	*
Unbleached secondary	17.3	3.3	18.8	0	0	*
MARKET PULP TOTAL	3,906.9	29.5	*	3,142.6	-8.1	*
Newsprint	306.2	-20.0	-6.5	4,191.9	9.5	*
Uncoated groundwood paper	61.0	-0.2	*	903.9	0.4	*
Clay coated printing	163.5	-6.2	-3.8	751.0	12.3	1.6
Uncoated free sheet	112.9	-23.1	-20.5	0	0	*
Bleached bristols	39.2	-1.7	-4.4	49.5	0.4	*
Cotton fiber writing	84.1	-1.8	-2.1	1,215.4	8.9	*
Unbl kraft packaging paper	16.7	0	*	131.2	0.1	*
Tissue	23.0	0.1	*	134.2	1.0	*
Wrapping	7.3	-4.1	-56.7	1.9	0.5	27.6
Shipping sack, unbl/bl sulfite	27.2	-0.4	-1.6	1.6	0	1.1
TOTAL PAPER PRODUCTS	1,148.2	-56.6	-4.9	7,639.3	41.1	*
Unbl kraft packaging paperboard	974.3	-3.9	*	65.3	0.1	*
Semichemical paperboard	11.3	-0.1	*	42.7	0.1	*
Recycled paperboard	70.6	-5.4	-7.6	63.0	1.5	2.5
Construction paper	13.1	0	*	74.3	0	*
Linerboard	153.7	-1.7	-1.1	6.6	0.1	1.3
Folding carton board	139.8	-1.6	-1.2	8.8	0.5	6.3
Milk carton board	380.7	-0.5	*	8.7	0.1	*
Heavyweight cup/container	7.2	0	*	8.5	0.3	3.1
Plate, dish, and tray stock	7.1	0	*	8.3	0.2	1.9
Molded pulp products	15.2	0	*	23.3	0	*
TOTAL PAPERBOARD PRODUCTS	1,809.4	-13.4	*	326.2	3.3	1.0
TOTAL ALL PRODUCTS	6,864.5	-40.5	*	11,108.2	36.3	*

$X=export value $I=import value Δ="change in" *=less than 1%
Totals and percent changes might not be exact because of rounding.

TABLE 5-24

FOREIGN TRADE QUANTITY ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 3
(000 tons/yr)

Product Category	Base X	ΔX	%ΔX	Base I	ΔI	%ΔI
Special alpha and dissolving pulp	836	-1	*	284	0	*
Bleached kraft	4,678	2	*	3,753	0	*
Unbleached kraft	181	1	*	87	-1	-1.0
Bleached sulfite	325	-3	-1.1	358	1	*
Bleached secondary	0	0	*	618	4	*
Unbleached secondary	41	0	*	0	0	*
MARKET PULP TOTAL	6,062	-2	*	5,100	3	*
Newsprint	625	-6	*	8,553	1	*
Uncoated groundwood paper	88	0	*	1,304	0	*
Clay coated printing	169	-7	-4.1	774	11	1.5
Uncoated free sheet	122	-8	-6.6	0	0	*
Bleached bristols	47	-1	-1.5	59	0	*
Cotton fiber writing paper	41	0	*	596	0	*
Unbl kraft packaging paper	30	0	*	239	0	*
Tissue	21	0	*	121	0	*
Wrapping	9	0	*	2	0	*
Shipping sack, unbl/bl sulfite	42	0	*	2	0	*
TOTAL PAPER PRODUCTS	1,391	-24	-1.7	11,811	15	*
Unbl kraft packaging paperboard	2,463	-12	*	165	0	*
Semichemical paperboard	31	0	*	118	0	*
Recycled paperboard	185	-1	*	165	0	*
Construction paper	33	0	*	189	0	*
Linerboard	283	-1	*	12	0	*
Folding carton board	194	-2	-1.0	12	1	4.5
Milk carton board	529	-1	*	12	0	1.1
Heavyweight cup/container	10	0	*	12	0	*
Plate, dish, and tray stock	10	0	*	12	0	2.4
Molded pulp products	13	0	*	19	0	*
TOTAL PAPERBOARD PRODUCTS	3,807	-18	*	743	3	*
TOTAL ALL PRODUCTS	11,260	--44	*	17,654	21	*

X = export quantity I = import quantity Δ = "change in" * = less than 1%
Totals and percent changes might not be exact because of rounding.

TABLE 5-25

FOREIGN TRADE QUANTITY ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 16
(000 tons/yr)

Product Category	Base X	ΔX	%ΔX	Base I	ΔI	%ΔI
Special alpha and dissolving pulp	836	-3	*	284	0	*
Bleached kraft	4,678	42	*	3,753	-6	*
Unbleached kraft	181	1	*	87	0	*
Bleached sulfite	325	-13	-4.1	358	3	1.0
Bleached secondary	0	0	*	618	3	*
Unbleached secondary	41	9	20.9	0	0	*
MARKET PULP TOTAL	6,062	35	*	5,100	0	*
Newsprint	625	-49	-7.8	8,553	7	*
Uncoated groundwood paper	88	0	*	1,304	0	*
Clay coated printing	169	-7	-3.9	774	11	1.4
Uncoated free sheet	122	-28	-22.9	0	0	*
Bleached bristols	47	-1	-2.4	59	0	*
Cotton fiber writing paper	41	-1	-2.6	596	2	*
Unbl kraft packaging paper	30	0	*	239	0	*
Tissue	21	0	*	121	0	*
Wrapping	9	-5	-57.8	2	1	25.8
Shipping sack, unbl/bl sulfite	42	-1	-1.2	2	0	*
TOTAL PAPER PRODUCTS	1,391	-94	-6.7	11,811	25	*
Unbl kraft packaging paperboard	2,463	-10	*	165	0	*
Semichemical paperboard	31	-1	-1.9	118	0	*
Recycled paperboard	185	-16	-8.5	165	2	1.5
Construction paper	33	0	*	189	0	*
Linerboard	283	-2	*	12	0	*
Folding carton board	194	-1	*	12	0	1.4
Milk carton board	529	1	*	12	0	*
Heavyweight cup/container	10	0	*	12	0	*
Plate, dish, and tray stock	10	0	*	12	0	*
Molded pulp products	13	0	*	19	0	*
TOTAL PAPERBOARD PRODUCTS	3,807	-28	*	743	3	*
TOTAL ALL PRODUCTS	11,260	-87	*	17,654	28	*

X = export quantity I = import quantity Δ = "change in" * = less than 1%
Totals and percent changes might not be exact because of rounding.

TABLE 5-26

FOREIGN TRADE QUANTITY ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 23
(000 tons/yr)

Product Category	Base X	ΔX	%ΔX	Base I	ΔI	%ΔI
Special alpha and dissolving pulp	836	-3	*	284	0	*
Bleached kraft	4,678	42	*	3,753	-6	*
Unbleached kraft	181	1	*	87	0	*
Bleached sulfite	325	-13	-4.1	358	3	1.0
Bleached secondary	0	0	*	618	3	*
Unbleached secondary	41	9	20.9	0	0	*
MARKET PULP TOTAL	6,062	34	*	5,100	0	*
Newsprint	625	-49	-7.8	8,553	7	*
Uncoated groundwood paper	88	0	*	1,304	0	*
Clay coated printing	169	-7	-4.1	774	11	1.5
Uncoated free sheet	122	-28	-22.9	0	0	*
Bleached bristols	47	-2	*	59	0	*
Cotton fiber writing paper	41	-1	*	596	2	*
Unbl kraft packaging paper	30	0	*	239	0	*
Tissue	21	0	*	121	0	*
Wrapping	9	-5	-58.1	2	1	26.0
Shipping sack, unbl/bl sulfite	42	-1	-1.7	2	0	1.0
TOTAL PAPER PRODUCTS	1,391	-95	-6.8	11,811	26	*
Unbl kraft packaging paperboard	2,463	-11	*	165	0	*
Semichemical paperboard	31	-1	-1.8	118	0	*
Recycled paperboard	185	-16	-8.5	165	2	1.5
Construction paper	33	0	*	189	0	*
Linerboard	283	-3	-1.1	12	0	1.2
Folding carton board	194	-2	*	12	1	4.2
Milk carton board	529	0	*	12	0	*
Heavyweight cup/container	10	0	*	12	0	1.8
Plate, dish, and tray stock	10	0	*	12	0	*
Molded pulp products	13	0	*	19	0	*
TOTAL PAPERBOARD PRODUCTS	3,807	-33	*	743	4	*
TOTAL ALL PRODUCTS	11,260	-94	*	17,654	30	*

X = export quantity I = import quantity Δ = "change in" * = less than 1%
Totals and percent changes may not be exact due to rounding.

TABLE 5-27

FOREIGN TRADE QUANTITY ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 24
(000 tons/yr)

Product Category	Base X	ΔX	%ΔX	Base I	ΔI	%ΔI
Special alpha and dissolving pulp	836	-3	*	284	0	*
Bleached kraft	4,678	42	*	3,753	-6	*
Unbleached kraft	181	1	*	87	0	*
Bleached sulfite	325	-13	-4.1	358	3	1.0
Bleached secondary	0	0	*	618	3	*
Unbleached secondary	41	9	20.9	0	0	*
MARKET PULP TOTAL	6,062	35	*	5,100	0	*
Newsprint	625	-49	-7.8	8,553	7	*
Uncoated groundwood paper	88	0	*	1,304	0	*
Clay coated printing	169	-7	-4.1	774	11	1.5
Uncoated free sheet	122	-28	-22.9	0	0	*
Bleached bristols	47	-2	-4.4	59	0	*
Cotton fiber writing paper	41	-1	-2.6	596	2	*
Unbl kraft packaging paper	30	0	*	239	0	*
Tissue	21	0	*	121	0	*
Wrapping	9	-5	-58.1	2	1	26.0
Shipping sack, unbl/bl sulfite	42	-1	-1.7	2	0	1.0
TOTAL PAPER PRODUCTS	1,391	-95	-6.9	11,811	26	*
Unbl kraft packaging paperboard	2,463	-11	*	165	0	*
Semichemical paperboard	31	-1	-1.7	118	0	*
Recycled paperboard	185	-16	-8.5	165	2	1.5
Construction paper	33	0	*	189	0	*
Linerboard	283	-3	-1.1	12	0	1.2
Folding carton board	194	-2	-1.2	12	1	5.5
Milk carton board	529	-1	*	12	0	*
Heavyweight cup/container	10	0	*	12	0	*
Plate, dish, and tray stock	10	0	*	12	0	*
Molded pulp products	13	0	*	19	0	*
TOTAL PAPERBOARD PRODUCTS	3,807	-34	*	743	5	*
TOTAL ALL PRODUCTS	11,260	-94	*	17,654	31	*

X = export quantity I = import quantity Δ = "change in" * = less than 1%
Totals and percent changes may not be exact due to rounding.

TABLE 5-28

FOREIGN TRADE QUANTITY ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 25
(000 tons/yr)

Product Category	Base X	ΔX	%ΔX	Base I	ΔI	%ΔI
Special alpha and dissolving pulp	836	-3	*	284	0	*
Bleached kraft	4,678	42	*	3,753	-6	*
Unbleached kraft	181	1	*	87	0	*
Bleached sulfite	325	-13	-4.1	358	3	1.0
Bleached secondary	0	0	*	618	3	*
Unbleached secondary	41	9	20.9	0	0	*
MARKET PULP TOTAL	6,062	35	*	5,100	0	*
Newsprint	625	-49	-7.8	8,553	7	*
Uncoated groundwood paper	88	0	*	1,304	0	*
Clay coated printing	169	-7	-4.2	774	12	1.5
Uncoated free sheet	122	-28	-22.9	0	0	*
Bleached bristols	47	-2	-4.6	59	0	*
Cotton fiber writing paper	41	-1	-2.6	596	2	*
Unbl kraft packaging paper	30	0	*	239	0	*
Tissue	21	0	*	121	0	*
Wrapping	9	-5	-58.1	2	1	26.0
Shipping sack, unbl/bl sulfite	42	-1	-1.9	2	0	1.1
TOTAL PAPER PRODUCTS	1,391	-95	-6.8	11,811	26	*
Unbl kraft packaging paperboard	2,463	-11	*	165	0	*
Semichemical paperboard	31	-1	-1.6	118	0	*
Recycled paperboard	185	-16	-8.5	165	2	1.5
Construction paper	33	0	*	189	0	*
Linerboard	283	-4	-1.3	12	0	1.4
Folding carton board	194	-3	-1.3	12	1	6.1
Milk carton board	529	-1	*	12	0	*
Heavyweight cup/container	10	0	*	12	0	3.1
Plate, dish, and tray stock	10	0	*	12	0	1.9
Molded pulp products	13	0	*	19	0	*
TOTAL PAPERBOARD PRODUCTS	3,807	-35	*	743	5	*
TOTAL ALL PRODUCTS	11,260	-95	*	17,654	31	*

X = export quantity I = import quantity Δ = "change in" * = less than 1%
Totals and percent changes might not be exact because of rounding.

TABLE 5-29

FOREIGN TRADE QUANTITY ADJUSTMENTS (1989): SELECTED PRODUCT CATEGORIES
Regulatory Alternative 26
(000 tons/yr)

Product Category	Base X	ΔX	%ΔX	Base I	ΔI	%ΔI
Special alpha and dissolving pulp	836	-1	*	284	0	*
Bleached kraft	4,678	62	1.3	3,753	-9	*
Unbleached kraft	181	1	*	87	-1	*
Bleached sulfite	325	-13	-3.9	358	3	*
Bleached secondary	0	0	*	618	3	*
Unbleached secondary	41	9	21.1	0	0	*
MARKET PULP TOTAL	6,062	58	1.0	5,100	-4	*
Newsprint	625	-42	-6.7	8,553	6	*
Uncoated groundwood paper	88	0	*	1,304	0	*
Clay coated printing	169	-7	-4.0	774	11	1.4
Uncoated free sheet	122	-27	-22.6	0	0	*
Bleached bristols	47	-2	-4.5	59	0	*
Cotton fiber writing paper	41	-1	-2.5	596	2	*
Unbl kraft packaging paper	30	0	*	239	0	*
Tissue	21	0	*	121	0	*
Wrapping	9	-5	-57.4	2	1	25.5
Shipping sack, unbl/bl sulfite	42	-1	-1.7	2	0	1.0
TOTAL PAPER PRODUCTS	1,391	-87	-6.3	11,811	24	*
Unbl kraft packaging paperboard	2,463	-12	*	165	0	*
Semichemical paperboard	31	0	*	118	0	*
Recycled paperboard	185	-16	-8.5	165	2	1.5
Construction paper	33	0	*	189	0	*
Linerboard	283	-3	-1.1	12	0	1.2
Folding carton board	194	-3	-1.3	12	1	6.1
Milk carton board	529	-1	*	12	0	*
Heavyweight cup/container	10	0	*	12	0	3.1
Plate, dish, and tray stock	10	0	*	12	0	1.9
Molded pulp products	13	0	*	19	0	*
TOTAL PAPERBOARD PRODUCTS	3,807	-34	*	743	5	*
TOTAL ALL PRODUCTS	11,260	-63	*	17,654	25	*

X = export quantity I = import quantity Δ = "change in" * = less than 1%
Totals and percent changes might not be exact because of rounding.

significant decline overall is for wrapping paper; the more stringent alternatives experience a large 57 percent decline. However, wrapping paper contributes very little to the U.S. total export value of pulp, paper, and paperboard products. Uncoated free sheet also experiences a notable decline of 21 percent for the more stringent alternatives.

Import Value. Three product categories (bleached kraft, newsprint, and cotton fiber writing paper) comprised more than 70 percent of total export value in 1989. None of these categories is shown to be significantly affected by any of the regulatory alternatives. Of the lesser valued products, the most notable changes in import value are the 6 percent increase for folding carton board and the 28 percent increase in wrapping paper.

Import and Export Quantity. The results for import and export quantity generally mimic the results for import and export value. The largest percent declines in export quantity occur for wrapping paper and uncoated free sheet. The largest percent increases in import quantity occur for wrapping paper and folding carton board.

5.2.3 Facility and Product Line Closures

The estimated number of pulp and paper facility closures and product line closures are shown by facility type in Table 5-30. The more stringent alternatives are estimated to result in 11 possible mill closures and 14 total product-line closures. The majority of the closures occur at paper or paperboard mills that buy market pulp to produce paper products.

5.2.4 Employment Impacts

The estimated employment impacts are shown in Tables 5-31 and 5-32. The market impact model is capable of estimating employment changes in two ways. The first results from facility closure, where all production and non-production employees at closure facilities are dislocated. The second results from production level changes at facilities that continue

TABLE 5-30

ESTIMATED FACILITY AND PRODUCT LINE CLOSURES (1989)

	Alternative	Facility Type			Total
		Pulp Mill	Paper/Paper-board Mill	Integrated Mill	
Closures	Baseline	(28)	(303)	(235)	(566)
	3	0	0	1	1
	16	0	8	3	11
	23	0	8	3	11
	24	0	8	3	11
	25	0	8	3	11
	26	0	8	3	11
Line Shutdowns	Baseline	(35)	(377)	(468)	(880)
	3	0	0	2	2
	16	0	9	5	14
	23	0	9	5	14
	24	0	9	5	14
	25	0	9	5	14
	26	0	9	5	14

TABLE 5-31

EMPLOYMENT IMPACTS: POTENTIAL JOB LOSSES (1989)

Facility Type	Baseline			Impacts					
	Production	Non-Production	Total	Alt. 3	Alt. 16	Alt. 23	Alt. 24	Alt. 25	Alt. 26
Pulp Mills	7,386	1,340	8,727	-1	-11	-12	-12	-12	-7
Paper/Paperboard Mills	44,352	13,449	57,851	0	-816	-816	-816	-816	-816
Integrated Mills	119,221	31,827	151,047	-517	-1,920	-1,951	-1,951	-1,957	-1,952
Total	170,959	46,666	217,625	-518	-2,747	-2,779	-2,779	-2,785	-2,775

TABLE 5-32

EMPLOYMENT IMPACTS: POTENTIAL JOB CREATION

Facility Type	Regulatory Alternative					
	3	16	23	24	25	26
Pulp Mills	1	3	3	3	3	3
Paper/Paperboard Mills	441	565	565	571	570	570
Integrated Mills	202	350	308	307	303	300
Total	644	918	876	881	876	873

operations after regulation. Higher mill production levels require more production workers and lower mill production levels require fewer workers.

Table 5-31 shows the estimated number of employees dislocated due to closure and reduced production levels.[4] The majority of job losses occur at integrated mills even though paper or paperboard mills incur the majority of facility closures. This is because integrated mills generally employ a greater number of employees than non-integrated mills.

Table 5-32 shows the estimated number of potential jobs created by increases in production levels at some mills. This estimate assumes that the mills that increase output are currently operating at their maximum worker-to-output ratio. To the extent they are not, the number of potential jobs created may be less. The majority of the potential new jobs are created at non-integrated paper or paperboard mills.

5.2.5 Consumer and Producer Surplus Changes

The estimated social welfare impacts as measured by changes in consumer and producer surplus are shown in Tables 5-33 through 5-38. Because of higher prices and lower equilibrium quantities consumed, both U.S. and foreign consumers experience losses in consumer surplus. Because foreign producers increase output to U.S. markets in response to higher U.S. market prices, foreign producers experience increases in producer surplus. U.S. producers generally experience losses in producer surplus due to the reduced earnings that result from increased pollution abatement costs.

For the more stringent regulatory alternatives, the majority of total welfare loss is attributable to losses in U.S. consumer surplus. However, as the alternatives become more stringent, U.S. producers share a greater portion of the total welfare loss burden because product prices, and hence producer revenues, do not keep pace with the increases in regulatory compliance costs.

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[4]The estimates of baseline employment are discussed in Section 2.3 and Section 3.3.2.1.

TABLE 5-33

WELFARE IMPACTS: CONSUMER AND PRODUCER SURPLUS CHANGES
Regulatory Alternative 3
(millions of $1989)

Product Type	Δ Consumer Surplus		Δ Producer Surplus		Net Change		Total
	U.S.	Foreign	U.S.	Foreign	U.S.	Foreign	
Market Pulp	I	-0.1	*	0.1	*	*	
Paper Products	-131.0	-4.6	*	6.3	*	*	
Paperboard Products	-10.1	-1.1	*	0.1	*	*	
Total	-141.1	-5.8	-111.2	6.6	-252.3	0.8	-251.5

* = Not computed for each product category
I = Included in surplus measure for U.S. producers

TABLE 5-34

WELFARE IMPACTS: CONSUMER AND PRODUCER SURPLUS CHANGES
Regulatory Alternative 16
(millions of $1989)

Product Type	Δ Consumer Surplus		Δ Producer Surplus		Net Change		Total
	U.S.	Foreign	U.S.	Foreign	U.S.	Foreign	
Market Pulp	I	4.3	*	-3.1	*	*	
Paper Products	-401.1	-8.0	*	18.3	*	*	
Paperboard Products	-43.0	-1.3	*	0.8	*	*	
Total	-444.0	-5.0	-290.0	16.0	-734.0	10.9	-723.1

* = Not computed for each product category
I = Included in surplus measure for U.S. producers

TABLE 5-35

WELFARE IMPACTS: CONSUMER AND PRODUCER SURPLUS CHANGES
Regulatory Alternative 23
(millions of $1989)

Product Type	Δ Consumer Surplus		Δ Producer Surplus		Net Change		
	U.S.	Foreign	U.S.	Foreign	U.S.	Foreign	
Market Pulp	I	4.3	*	-3.1	*	*	
Paper Products	-402.8	-8.0	*	18.4	*	*	
Paperboard Products	-44.9	-1.6	*	0.8	*	*	Total
Total	-447.7	-5.4	-383.6	16.1	-831.4	10.8	-820.6

* = Not computed for each product category
I = Included in surplus measure for U.S. producers

TABLE 5-36

WELFARE IMPACTS: CONSUMER AND PRODUCER SURPLUS CHANGES
Regulatory Alternative 24
(millions of $1989)

	Δ Consumer Surplus -		Δ Producer Surplus		Net Change		
Product Type	U.S.	Foreign	U.S.	Foreign	U.S.	Foreign	
Market Pulp	I	4.3	*	-3.2	*	*	
Paper Products	-403.5	-8.2	*	18.6	*	*	
Paperboard Products	-45.2	-1.7	*	0.8	*	*	Total
Total	-448.7	-5.6	-405.9	16.2	-854.6	10.6	-844.0

* = Not computed for each product category
I = Included in surplus measure for U.S. producers

TABLE 5-37

WELFARE IMPACTS: CONSUMER AND PRODUCER SURPLUS CHANGES
Regulatory Alternative 25
(millions of $1989)

Product Type	Δ Consumer Surplus		Δ Producer Surplus		Net Change		
	U.S.	Foreign	U.S.	Foreign	U.S.	Foreign	
Market Pulp	I	4.3	*	-3.2	*	*	
Paper Products	-403.7	-8.2	*	18.6	*	*	
Paperboard Products	-45.2	-1.7	*	0.8	*	*	Total
Total	-448.9	-5.7	-458.9	16.2	-905.3	10.5	-894.8

* = Not computed for each product category
I = Included in surplus measure for U.S. producers

TABLE 5-38

WELFARE IMPACTS: CONSUMER AND PRODUCER SURPLUS CHANGES
Regulatory Alternative 26
(millions of $1989)

Product Type	Δ Consumer Surplus		Δ Producer Surplus		Net Change		Total
	U.S.	Foreign	U.S.	Foreign	U.S.	Foreign	
Market Pulp	I	6.9	*	-5.1	*	*	
Paper Products	-389.3	-7.9	*	16.8	*	*	
Paperboard Products	-42.6	-1.7	*	0.7	*	*	
Total	-431.9	-2.6	-390.9	12.4	-822.8	9.8	-813.0

* = Not computed for each product category
I = Included in surplus measure for U.S. producers

5.3 RELATIONSHIP BETWEEN FINANCIAL MODEL AND MARKET MODEL RESULTS

The overall results of the financial and market models are consistent and complementary. There are differences in the details, as expected from the differences in modeling assumptions and approaches (described in more detail in Section 3.4). Both models indicate minor declines to domestic production levels in the range of 4 percent or less. Exports show a similar decline, although the market model indicates that the declines may be concentrated in a small set of product categories.

For Alternative 26, the models estimate that about 11 to 13 facilities will close. The financial model contains the conservative assumption that no facility can pass the increased costs of pollution control to purchasers through higher prices. The facilities that close with the financial model, then, are the larger mills that incur the cost of process changes and air pollution control requirements. The financial model estimates that 10,700 jobs are lost with the 13 closures. The market model assumes that incremental pollution control costs will be passed through in accordance with what the market will bear. The closures projected by the market model include smaller facilities that produce products with prices that do not increase enough to offset the addition of pollution control costs, the changes in input prices, or reduced consumption demand. The market model estimates nearly 2,800 job losses associated with the 11 facility closures and product line closures for these alternatives.

5.4 REFERENCES

CEA. 1993. Council of Economic Advisers. Economic report of the president. Washington, DC. Table B-1.

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Pigler, Carmen C. 1993. RIMS multipliers for the United States. Letter from Carmen C. Pigler, U.S. Department of Commerce, Bureau of Economic Analysis, Washington, D.C. to Maureen F. Kaplan, Eastern Research Group, Inc. Lexington, MA. 1 September.

SECTION SIX

SMALL BUSINESS IMPACTS

An analysis of impacts on small business entities was performed, in part, to comply with the analysis requirements of the Regulatory Flexibility Act (RFA) and to provide information on how regulatory options affect small entities. The small business analysis focuses on whether regulatory alternatives have undue or disproportionate impacts on small entities. Section 3.5 discusses various definitions for small entities.

Several definitions are used in this analysis. The financial model analysis uses a three-tiered subdivision for both companies and facilities:

- Very small: 0 to 125 employees
- Small: 126 to 750 employees
- Large: More than 750 employees

The market model uses the same subdivisions plus a combination group of facilities and companies with fewer than 750 employees.

6.1 FINANCIAL IMPACT ANALYSIS RESULTS

The impacts shown in Section 5.1 are split into size categories based on facility and company employment. The results are examined several ways—under costs for wastewater treatment upgrades (BPT costs), under each BAT/PSES option (as applicable), and under each regulatory alternative. The definitions for the options and regulatory alternatives are shown in Section 4.1. In some cases, certain results are not reported in the summary tables because data aggregation is inadequate to protect confidential business information. These results are identified by "ND" (not disclosed) entries in the table.

6.1.1 Impacts from BPT Costs

Tables 6-1 and 6-2 present the impacts from BPT costs on very small, small, and large entities. Table 6-1 uses a facility basis for the categorization, and Table 6-2 uses a company basis for the categorization. This pairing of tables is used throughout Section 6.1. The percentages shown in each table refer to the percent of impact in the size category for that option and parameter.[1]

Approximately 300 facilities are anticipated to incur costs of wastewater treatment upgrades. The impacts do not change regardless of whether a facility basis or company basis is used for the definition. One very small facility, which belongs to a very small company, is projected to close under either option for wastewater treatment upgrades. Two small facilities that belong to small companies also are projected to close under BPT Option 2. Three facilities out of 300 represent only 1 percent of the entire population estimated to incur costs and only 0.5 percent of the entire population of pulp, paper, and paperboard facilities in the United States. This is a very small overall percentage of closure, and the result that no large facilities close with these costs is not indicative of undue impacts on small facilities or companies.

6.1.2 Impacts from BAT/PSES Costs

6.1.2.1 Dissolving Kraft

Since BAT/PSES costs are not projected to close facilities in the dissolving kraft subcategory, there are no impacts projected for small facilities.

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[1]For example, three facilities—two small and one very small—are projected to close under BPT Option 2 (Tables 6-1 and 6-2). Of the closures, 33 percent are in the very small category and 67 percent are in the small category.

TABLE 6-1

REGULATORY FLEXIBILITY ANALYSIS
BPT COSTS
FACILITY-LEVEL 1989 DATA

Category			Option 1		Option 2	
	Number of Mills		Closures			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	182	34.7%	1	100.0%	1	33.3%
Small	256	48.9%	0	0.0%	2	66.7%
Large	86	16.4%	0	0.0%	0	0.0%
Total	524	100.0%	1	100.0%	3	33.3%
	Number of Employees		Loss in Employees**			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	13,630	6.2%	100	100.0%	100	9.1%
Small	91,966	41.7%	0	0.0%	1000	90.9%
Large	114,895	52.1%	0	0.0%	0	0.0%
Total	220,491	100.0%	100	100.0%	1,100	100.0%
	Shipments (Tons)		Loss in Shipment Tonnage			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	4,919,637	5.7%	5,752	100 0%	5,752	2.2%
Small	45,372,710	52.3%	0	0 0%	260,488	97.8%
Large	36,419,405	42.0%	0	0.0%	0	0.0%
Total	86,711,752	100.0%	5,752	100.0%	266,240	2.2%
	Shipments ($000)		Loss in Shipments ($000)			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$2,521,977	4.3%	$13,026	100 0%	$13,026	6.0%
Small	$26,412,033	45.1%	$0	0 0%	$203,586	94 0%
Large	$29,595,176	50.6%	$0	0 0%	$0	0 0%
Total	$58,529,186	100.0%	$13,026	100 0%	$216,612	6 0%
	Export ($000)		Loss in Exports ($000)			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$99,493	1 7%	$966	100 0%	$966	60 4%
Small	$2,891,979	49 4%	$0	0 0%	$633	39 6%
Large	$2,862,478	48 9%	$0	0 0%	$0	0 0%
Total	$5,853,950	100.0%	$966	100 0%	$1,599	100 0%

Note: (*) Percent of impact in size category
(**) Rounded to nearest 100 employees

TABLE 6-2

REGULATORY FLEXIBILITY ANALYSIS
BPT COSTS
COMPANY-LEVEL 1989 DATA

Category			Option 1		Option 2	
	Number of Mills		Closures			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	63	32.1%	1	100.0%	1	33.3%
Small	83	42.3%	0	0.0%	2	66.7%
Large	50	25.5%	0	0.0%	0	0.0%
Total	196	100.0%	1	100.0%	3	100.0%
	Number of Employees		Loss in Employees**			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	4,197	1.9%	100	100.0%	100	9.1%
Small	27,010	12.2%	0	0.0%	1000	90.9%
Large	189,284	85.8%	0	0.0%	0	0.0%
Total	220,491	100.0%	100	100.0%	1,100	100.0%
	Shipments (Tons)		Loss in Shipment Tonnage			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	1,361,956	1.6%	5,752	100.0%	5,752	2.2%
Small	9,369,963	10.8%	0	0.0%	260,488	97.8%
Large	75,979,833	87.6%	0	0.0%	0	0.0%
Total	86,711,752	100.0%	5,752	100.0%	266,240	100.0%
	Shipments ($000)		Loss in Shipments ($000)			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$695,040	1.2%	$13,026	100.0%	$13,026	6.0%
Small	$5,748,242	9.8%	$0	0.0%	$203,586	94.0%
Large	$52,085,904	89.0%	$0	0.0%	$0	0.0%
Total	$58,529,186	100.0%	$13,026	100.0%	$216,612	100.0%
	Export ($000)		Loss in Exports ($000)			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$39,508	0.7%	$966	100.0%	$966	60.4%
Small	$756,824	12.9%	$0	0.0%	$633	39.6%
Large	$5,057,618	86.4%	$0	0.0%	$0	0.0%
Total	$5,853,950	100.0%	$966	100.0%	$1,599	100.0%

Note (*) Percent of impact in size category
(**) Rounded to nearest 100 employees

6.1.2.2 Dissolving Sulfite

Tables 6-3 and 6-4 are an outline of the impacts of process change costs for dissolving sulfite facilities and companies. The impacts associated with closures of dissolving sulfite facilities are not reported to protect confidential data. The overall loss in shipments for this subcategory is less than 0.5 percent of total industry shipments and about 3 percent of total exports.

6.1.2.3 Bleached Papergrade Kraft and Soda

Tables 6-5 and 6-6 list the impacts for facilities and companies in the bleached papergrade kraft and soda subcategory. For Option 1, the mill closures are evenly split between small and large facilities and companies. Large entities (both facilities and companies), however, experience 80 percent or more of the loss in employees, shipments (tonnage and value), and exports. For Option 2, two-thirds of the closures and 80 percent or more of the losses belong to the large facilities and companies. For Options 3 and 4, there is an additional closure, which is a small facility that belongs to a large company. Large entities, by either definition, experience a disproportionate share of the impacts. For Option 5, on a facility basis, the large entities have:

- 16 percent of the facilities, 78 percent of the closures
- 50 percent of the employees, 90 percent of the job losses
- 40 to 50 percent of shipments and exports, 70 to 90 percent of the losses

On a company basis, large entities bear the larger impacts (90 to 96 percent of the losses).

TABLE 6-3

REGULATORY FLEXIBILITY ANALYSIS
BAT/PSES PROCESS CHANGE COSTS: DISSOLVING SULFITE
FACILITY-LEVEL 1989 DATA

Category			Option 1		Option 2	
	Number of Mills		Closures			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	182	34.7%	ND	ND	ND	ND
Small	256	48.9%	ND	ND	ND	ND
Large	86	16.4%	ND	ND	ND	ND
Total	524	100.0%	1	100.0%	2	100.0%
	Number of Employees		Loss in Employees**			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	13,630	6.2%	ND	ND	ND	ND
Small	91,966	41.7%	ND	ND	ND	ND
Large	114,895	52.1%	ND	ND	ND	ND
Total	220,491	100.0%	ND	100.0%	ND	100.0%
	Shipments (Tons)		Loss in Shipment Tonnage			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	4,919,637	5.7%	ND	ND	ND	ND
Small	45,372,710	52.3%	ND	ND	ND	ND
Large	36,419,405	42.0%	ND	ND	ND	ND
Total	86,711,752	100.0%	ND	100 0%	ND	100.0%
	Shipments ($000)		Loss in Shipments ($000)			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$2,521,977	4.3%	ND	ND	ND	ND
Small	$26,412,033	45.1%	ND	ND	ND	ND
Large	$29,595,176	50 6%	ND	ND	ND	ND
Total	$58,529,186	100 0%	ND	100.0%	ND	100 0%
	Export ($000)		Loss in Exports ($000)			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$99,493	1.7%	ND	ND	ND	ND
Small	$2,891,979	49 4%	ND	ND	ND	ND
Large	$2,862,478	48.9%	ND	ND	ND	ND
Total	$5,853,950	100 0%	ND	100 0%	ND	100 0%

Note (*) Percent of impact in size category
(**) Rounded to nearest 100 employees

TABLE 6-4

REGULATORY FLEXIBILITY ANALYSIS
BAT/PSES PROCESS CHANGE COSTS: DISSOLVING SULFITE
COMPANY-LEVEL 1989 DATA

Category	Number of Mills		Option 1		Option 2	
			Closures			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	63	32.1%	ND	ND	ND	ND
Small	83	42.3%	ND	ND	ND	ND
Large	50	25.5%	ND	ND	ND	ND
Total	196	100.0%	1	100.0%	2	100.0%
	Number of Employees		Loss in Employees**			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	4,197	1.9%	ND	ND	ND	ND
Small	27,010	12.2%	ND	ND	ND	ND
Large	189,284	85.8%	ND	ND	ND	ND
Total	220,491	100.0%	ND	100.0%	ND	100.0%
	Shipments (Tons)		Loss in Shipment Tonnage			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	1,361,956	1.6%	ND	ND	ND	ND
Small	9,369,963	10.8%	ND	ND	ND	ND
Large	75,979,833	87.6%	ND	ND	ND	ND
Total	86,711,752	100.0%	ND	100.0%	ND	100.0%
	Shipments ($000)		Loss in Shipments ($000)			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$695,040	1.2%	ND	ND	ND	ND
Small	$5,748,242	9.8%	ND	ND	ND	ND
Large	$52,085,904	89.0%	ND	ND	ND	ND
Total	$58,529,186	100.0%	ND	100.0%	ND	100.0%
	Export ($000)		Loss in Exports ($000)			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$39,508	0.7%	ND	ND	ND	ND
Small	$756,824	12.9%	ND	ND	ND	ND
Large	$5,057,618	86.4%	ND	ND	ND	ND
Total	$5,853,950	100.0%	ND	100.0%	ND	100.0%

Note (*) Percent of impact in size category
(**) Rounded to nearest 100 employees

TABLE 6-5

REGULATORY FLEXIBILITY ANALYSIS
BAT/PSES PROCESS CHANGE COSTS: PAPERGRADE KRAFT AND SODA
FACILITY-LEVEL 1989 DATA

Category			Option 1		Option 2		Option 3		Option 4		Option 5	
	Number of Mills		Closures									
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	182	34 7%	0	0 0%	0	0 0%	0	0 0%	0	0.0%	0	0.0%
Small	256	48 9%	1	50 0%	1	33 3%	2	50 0%	2	50.0%	2	22.2%
Large	86	16 4%	1	50 0%	2	66 7%	2	50.0%	2	50.0%	7	77.8%
Total	524	100 0%	2	100 0%	3	100 0%	4	100.0%	4	100.0%	9	100.0%
	Number of Employees		Loss in Employees**									
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	13 630	6 2%	0	0 0%	0	0 0%	0	0 0%	0	0.0%	0	0.0%
Small	91 966	41 7%	600	16 2%	600	12 6%	1,300	23 0%	1,300	23.0%	1,300	10.4%
Large	114 895	52 1%	3 100	83 8%	4,400	87 4%	4,400	77 0%	4,400	77.0%	11,400	89.8%
Total	220 491	100 0%	3 700	100 0%	5,100	100 0%	5,800	100 0%	5,800	100.0%	12,700	100.0%
	Shipments (Tons)		Loss in Shipment Tonnage									
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	4 919 637	5 7%	0	0 0%	0	0 0%	0	0 0%	0	0.0%	0	0.0%
Small	45 372 710	52 3%	141,445	18 7%	141,445	13 1%	451,631	32.4%	451,631	32.4%	451,631	12.3%
Large	36,419 405	42 0%	615,688	81 3%	941,976	86 9%	941,976	67.6%	941,976	67.6%	3,233,749	87.7%
Total	86,711,752	100 0%	757,133	100 0%	1,083,421	100 0%	1,393,607	100.0%	1,393,607	100.0%	3,685,380	100.0%
	Shipments ($000)		Loss in Shipments ($000)									
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$2,521,977	4 3%	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Small	$26,412,033	45 1%	$133,820	15.7%	$133,820	11.7%	$347,346	25.5%	$347,346	25.5%	$347,346	10.6%
Large	$29,595,176	50 6%	$719,899	84.3%	$1,012,720	88.3%	$1,012,720	74.5%	$1,012,720	74.5%	$2,924,650	89.4%
Total	$58,529,186	100 0%	$853,719	100.0%	$1,146,540	100.0%	$1,360,066	100.0%	$1,360,066	100.0%	$3,271,996	100.0%
	Export ($000)		Loss in Exports ($000)									
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$99,493	1.7%	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Small	$2,891,979	49.4%	$0	0.0%	$0	0.0%	$78,525	96.7%	$78,525	96.7%	$78,525	27.6%
Large	$2,862,478	48 9%	$1,262	100 0%	$2,679	100.0%	$2,679	3.3%	$2,679	3.3%	$205,709	72.4%
Total	$5,853,950	100.0%	$1,262	100.0%	$2,679	100.0%	$81,204	100.0%	$81,204	100.0%	$284,234	100.0%

Note: (*) Percent of impact in size category.
(**) Rounded to nearest 100 employees.

TABLE 6-6

REGULATORY FLEXIBILITY ANALYSIS
BAT/PSES PROCESS CHANGE COSTS: PAPERGRADE KRAFT AND SODA
COMPANY-LEVEL 1989 DATA

Category			Option 1		Option 2		Option 3		Option 4		Option 5	
	Number of Mills		Closures									
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	63	32.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Small	83	42.3%	1	50.0%	1	33.3%	1	25.0%	1	25.0%	1	11.1%
Large	50	25.5%	1	50.0%	2	66.7%	3	75.0%	3	75.0%	8	88.9%
Total	196	100.0%	2	100.0%	3	100.0%	4	100.0%	4	100.0%	9	100.0%
	Number of Employees		Loss in Employees**									
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	4,197	1.9%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Small	27,010	12.2%	600	16.2%	600	12.6%	600	11.1%	600	11.1%	600	5.0%
Large	189,284	85.8%	3,100	83.8%	4,400	87.4%	5,100	88.9%	5,100	88.9%	12,100	95.0%
Total	220,491	100.0%	3,700	100.0%	5,100	100.0%	5,800	100.0%	5,800	100.0%	12,700	100.0%
	Shipments (Tons)		Loss in Shipment Tonnage									
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	1,361,956	1.6%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Small	9,369,963	10.8%	141,445	18.7%	141,445	13.1%	141,445	10.1%	141,445	10.1%	141,445	3.8%
Large	75,979,833	87.6%	615,688	81.3%	941,976	86.9%	1,252,162	89.9%	1,252,162	89.9%	3,543,935	96.2%
Total	86,711,752	100.0%	757,133	100.0%	1,083,421	100.0%	1,393,607	100.0%	1,393,607	100.0%	3,685,380	100.0%
	Shipments ($000)		Loss in Shipments ($000)									
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$695,040	1.2%	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Small	$5,748,242	9.8%	$133,820	15.7%	$133,820	11.7%	$133,820	9.8%	$133,820	9.8%	$133,820	4.1%
Large	$52,085,904	89.0%	$719,899	84.3%	$1,012,720	88.3%	$1,226,246	90.2%	$1,226,246	90.2%	$3,138,176	95.9%
Total	$58,529,186	100.0%	$853,719	100.0%	$1,146,540	100.0%	$1,360,066	100.0%	$1,360,066	100.0%	$3,271,996	100.0%
	Export ($000)		Loss in Exports ($000)									
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$39,508	0.7%	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Small	$756,824	12.9%	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Large	$5,057,618	86.4%	$1,262	100.0%	$2,679	100.0%	$81,204	100.0%	$81,204	100.0%	$284,234	100.0%
Total	$5,853,950	100.0%	$1,262	100.0%	$2,679	100.0%	$81,204	100.0%	$81,204	100.0%	$284,234	100.0%

Note: (*) Percent of impact in size category.
(**) Rounded to nearest 100 employees.

6.1.2.4 Papergrade Sulfite

Tables 6-7 and 6-8 list the impacts for facilities and companies in the papergrade sulfite subcategory. On a facility basis, under Option 1, small entities have more closures and larger losses of export revenues, but smaller impacts in the loss of jobs, total shipment tonnage, and total shipment value. Option 2 has larger impacts on large facilities (although the details are not reported). On a company level, large entities bear a greater proportion of impacts, although the details are not reported in Table 6-8.

6.1.2.5 Unbleached Papergrade Kraft, Semichemical, and Nonwood Chemical

No closures are projected for the costs associated with the options for these subcategories. There are therefore no impacts on small facilities or companies.

6.1.3 Impacts from Regulatory Alternative Costs

Tables 6-9 and 6-10 list the impacts for the regulatory alternatives. The impacts for the regulatory alternatives cluster into four groups based on the number of projected mill closures.

For Alternatives 2 through 5, the impacts generally fall on small facilities that are owned by large companies. With the exception of the loss in exports (where losses occur only for the large companies), the impacts look roughly proportional to the distribution of closures. Given the small number of closures (three of approximately 300 facilities), the distribution shows no clustering by size category.

The three remaining groups of alternatives have 13 to 15 projected mill closures. The distribution of these projected closures among the size categories is comparable for Alternatives 11 through 26. There appear to be no disproportionate impacts on smaller facilities or companies. Very small facilities and companies show proportionately fewer impacts than other size entities.

TABLE 6-7

REGULATORY FLEXIBILITY ANALYSIS
BAT/PSES PROCESS CHANGE COSTS: PAPERGRADE SULFITE
FACILITY-LEVEL 1989 DATA

Category			Option 1		Option 2	
	Number of Mills		Closures			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	182	34.7%	0	0.0%	0	0.0%
Small	256	48.9%	3	60.0%	1	33.0%
Large	86	16.4%	2	40.0%	2	66.7%
Total	524	100.0%	5	100.0%	3	100.0%
	Number of Employees		Loss in Employees**			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	13,630	6.2%	0	0.0%	0	0.0%
Small	91,966	41.7%	1,700	43.6%	ND	ND
Large	114,895	52.1%	2,100	53.8%	ND	ND
Total	220,491	100.0%	3,900	100.0%	2,600	100.0%
	Shipments (Tons)		Loss in Shipment Tonnage			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	4,919,637	5.7%	0	0.0%	0	0.0%
Small	45,372,710	52.3%	357,026	45.1%	ND	ND
Large	36,419,405	42.0%	434,574	54.9%	ND	ND
Total	86,711,752	100.0%	791,600	100.0%	506,535	100.0%
	Shipments ($000)		Loss in Shipments ($000)			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$2,521,977	4.3%	$0	0.0%	$0	0.0%
Small	$26,412,033	45.1%	$366,062	47.7%	ND	ND
Large	$29,595,176	50.6%	$400,729	52.3%	ND	ND
Total	$58,529,186	100.0%	$766,791	100.0%	$475,372	100.0%
	Export ($000)		Loss in Exports ($000)			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$99,493	1.7%	$0	0.0%	$0	0.0%
Small	$2,891,979	49.4%	$2,207	61.1%	ND	ND
Large	$2,862,478	48.9%	$1,405	38.9%	ND	ND
Total	$5,853,950	100.0%	$3,612	100.0%	$1,405	100.0%

Note (*) Percent of impact in size category.
(**) Rounded to nearest 100 employees

TABLE 6-8

REGULATORY FLEXIBILITY ANALYSIS
BAT/PSES PROCESS CHANGE COSTS: PAPERGRADE SULFITE
COMPANY-LEVEL 1989 DATA

Category	Number of Mills		Option 1		Option 2	
			Closures			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	182	34.7%	0	0.0%	0	0.0%
Small	256	48.9%	ND	ND	ND	ND
Large	86	16.4%	ND	ND	ND	ND
Total	524	100.0%	5	100.0%	3	100.0%
	Number of Employees		Loss in Employees**			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	13,630	6.2%	0	0.0%	0	0.0%
Small	91,966	41.7%	ND	ND	ND	ND
Large	114,895	52.1%	ND	ND	ND	ND
Total	220,491	100.0%	3,900	100.0%	2,600	100.0%
	Shipments (Tons)		Loss in Shipment Tonnage			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	4,919,637	5.7%	0	0.0%	0	0.0%
Small	45,372,710	52.3%	ND	ND	ND	ND
Large	36,419,405	42.0%	ND	ND	ND	ND
Total	86,711,752	100.0%	791,600	100.0%	506,535	100.0%
	Shipments ($000)		Loss in Shipments ($000)			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$2,521,977	4.3%	$0	0.0%	$0	0.0%
Small	$26,412,033	45.1%	ND	ND	ND	ND
Large	$29,595,176	50.6%	ND	ND	ND	ND
Total	$58,529,186	100.0%	$766,791	100.0%	$475,372	100.0%
	Export ($000)		Loss in Exports ($000)			
	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$99,493	1.7%	$0	0.0%	$0	0.0%
Small	$2,891,979	49.4%	ND	ND	ND	ND
Large	$2,862,478	48.9%	ND	ND	ND	ND
Total	$5,853,950	100.0%	$3,612	100.0%	$1,405	100.0%

Note (*) Percent of impact in size category
(**) Rounded to nearest 100 employees.

TABLE 6-9

REGULATORY FLEXIBILITY ANALYSIS
INTEGRATED ALTERNATIVES
FACILITY-LEVEL 1989 DATA

Category			Alternatives 2 through 5		Alternatives 11 through 23		Alternatives 24 through 25		Alternative 26	
	Number of Mills		Closures							
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	182	34.7%	0	0.0%	1	7.1%	1	6.7%	1	7.7%
Small	256	48.9%	3	100.0%	9	64.3%	9	60.0%	8	61.5%
Large	86	16.4%	0	0.0%	4	28.6%	5	33.3%	4	30.8%
Total	524	100.0%	3	100.0%	14	100.0%	15	100.0%	13	100.0%
	Number of Employees		Loss in Employees**							
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	13,630	6.2%	0	0.0%	100	0.9%	100	0.8%	100	0.9%
Small	91,966	41.7%	1,900	100.0%	4,400	39.6%	4,400	35.2%	4,000	37.4%
Large	114,895	52.1%	0	0.0%	6,600	59.5%	7,900	63.2%	6,600	61.7%
Total	220,491	100.0%	1,900	100.0%	11,100	100.0%	12,500	100.0%	10,700	100.0%
	Shipments (Tons)		Loss in Shipment Tonnage							
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	4,919,637	5.7%	0	0.0%	5,752	0.2%	5,752	0.2%	5,752	0.2%
Small	45,372,710	52.3%	736,104	100.0%	1,646,859	54.4%	1,646,859	45.9%	1,487,044	51.8%
Large	36,419,405	42.0%	0	0.0%	1,376,550	45.4%	1,937,890	54.0%	1,376,550	48.0%
Total	86,711,752	100.0%	736,104	100.0%	3,029,161	100.0%	3,590,501	100.0%	2,869,346	100.0%
	Shipments ($000)		Loss in Shipments ($000)							
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$2,521,977	4.3%	$0	0.0%	$13,026	0.5%	$13,026	0.4%	$13,026	0.5%
Small	$26,412,033	45.1%	$459,700	100.0%	$1,117,033	43.9%	$1,117,033	38.0%	$1,000,105	41.2%
Large	$29,595,176	50.6%	$0	0.0%	$1,413,449	55.6%	$1,807,717	61.5%	$1,413,449	58.2%
Total	$58,529,186	100.0%	$459,700	100.0%	$2,543,508	100.0%	$2,937,776	100.0%	$2,426,580	100.0%
	Export ($000)		Loss in Exports ($000)							
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$99,493	1.7%	$0	0.0%	$966	0.3%	$966	0.3%	$966	0.5%
Small	$2,891,979	49.4%	$2,207	100.0%	$280,608	98.2%	$280,608	75.5%	$193,734	97.5%
Large	$2,862,478	48.9%	$0	0.0%	$4,084	1.4%	$89,954	24.2%	$4,084	2.1%
Total	$5,853,950	100.0%	$2,207	100.0%	$285,658	100.0%	$371,528	100.0%	$198,784	100.0%

Note: (*) Percent of impact in size category.
(**) Rounded to nearest 100 employees.

TABLE 6-10

REGULATORY FLEXIBILITY ANALYSIS
INTEGRATED ALTERNATIVES
COMPANY-LEVEL 1989 DATA

Category			Alternatives 2 through 5		Alternatives 11 through 23		Alternatives 24 through 25		Alternative 26	
	Number of Mills		Closures							
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	63	32.1%	0	0.0%	1	7.1%	1	6.7%	1	7.7%
Small	83	42.3%	1	33.3%	5	35.7%	5	33.3%	5	38.5%
Large	50	25.5%	2	66.7%	8	57.1%	9	60.0%	7	53.8%
Total	196	100.0%	3	100.0%	14	100.0%	15	100.0%	13	100.0%
	Number of Employees		Loss in Employees**							
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	4,197	1.9%	0	0.0%	100	0.9%	100	0.8%	100	0.9%
Small	27,010	12.2%	600	31.6%	2,100	18.9%	2,100	16.8%	2,100	19.6%
Large	189,284	85.8%	1,200	63.2%	8,900	80.2%	10,300	82.4%	8,500	79.4%
Total	220,491	100.0%	1,900	100.0%	11,100	100.0%	12,500	100.0%	10,700	100.0%
	Shipments (Tons)		Loss in Shipment Tonnage							
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	1,361,956	1.6%	0	0.0%	5,752	0.2%	5,752	0.2%	5,752	0.2%
Small	9,369,963	10.8%	141,445	19.2%	582,199	19.2%	582,199	16.2%	582,199	20.3%
Large	75,979,833	87.6%	594,659	80.8%	2,441,210	80.6%	3,002,550	83.6%	2,281,395	79.5%
Total	86,711,752	100.0%	736,104	100.0%	3,029,161	100.0%	3,590,501	100.0%	2,869,346	100.0%
	Shipments ($000)		Loss in Shipments ($000)							
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$695,040	1.2%	$0	0.0%	$13,026	0.5%	$13,026	0.4%	$13,026	0.5%
Small	$5,748,242	9.8%	$133,820	29.1%	$460,699	18.1%	$460,699	15.7%	$460,699	19.0%
Large	$52,085,904	89.0%	$325,880	70.9%	$2,069,783	81.4%	$2,464,051	83.9%	$1,952,855	80.5%
Total	$58,529,186	100.0%	$459,700	100.0%	$2,543,508	100.0%	$2,937,776	100.0%	$2,426,580	100.0%
	Export ($000)		Loss in Exports ($000)							
	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*	Count	Percent*
Very Small	$39,508	0.7%	$0	0.0%	$966	0.3%	$966	0.3%	$966	0.5%
Small	$756,824	12.9%	$0	0.0%	$113,002	39.6%	$113,002	30.4%	$113,002	56.8%
Large	$5,057,618	86.4%	$2,207	100.0%	$171,690	60.1%	$257,560	69.3%	$84,816	42.7%
Total	$5,853,950	100.0%	$2,207	100.0%	$285,658	100.0%	$371,528	100.0%	$198,784	100.0%

Note: (*) Percent of impact in size category.
(**) Rounded to nearest 100 employees.

On a facility basis, large facilities account for 16 percent of the population, but about one-third of the closures. Large facilities account for nearly half of the jobs, shipments, and exports, and bear about half the impacts in job loss and loss in shipment tonnage and value. Small facilities show higher proportional impacts in the loss of export revenues.

On a company basis, large companies form about 25 percent of the population. They bear 50 to 60 percent of the impacts in terms of the number of closures. Large companies account for approximately 80 to 90 percent of the number of employees and shipments in the industry population; impacts to large companies account for about 80 percent of the losses for these parameters. Large companies incur 40 to 70 percent of the loss in exports, depending on the alternative.

Tables 6-11 through 6-14 summarize the results of the financial ratio analysis at the facility level. Table 6-11 has all mills in the analysis; results for very small, small, and large facilities are shown in Tables 6-12 through 6-14. Large facilities show greater impacts in their financial ratios than either the small or very small facilities.

Tables 6-15 through 6-18 list the financial ratio analysis on a company basis. Based on the average change in financial ratios, very small companies show the greatest impact for Alternatives 5 though 26. Mean values, however, are sensitive to outliers and there is one closure in the very small category. Hence, the larger impacts seen for the average change in financial ratios can be a reflection of the single closure. Median values are more representative of the impacts to "typical" facilities. The median change in financial ratios for very small companies is generally well within the range seen for the business cycle. The exception is net working capital-to-total assets. Regulatory costs can affect this ratio by reducing the numerator (net working capital) and increasing the denominator (total assets). The fluctuation in this ratio could indicate that very small firms are likely to need sources of money other than or in addition to working capital to finance the pollution control expenditures.

Based on the median change in financial ratios, large companies are projected to incur more significant financial impact than small companies. This result is consistent with the data

TABLE 6-11

FACILITY-LEVEL FINANCIAL RATIO ANALYSIS
ALL MILLS

Ratio	Baseline 1985	Baseline 1988	Baseline 1989	% Variation	Impact of Incremental Costs (Percent Decline In Parameter) Alt 2	Alt 3	Alt 4	Alt 5	Alt 11	Alt 16	Alt 17	Alt 18	Alt 22	Alt 23	Alt 24	Alt 25	Alt 26
Gross Income Margin																	
Mean	3 2%	16 2%	15 3%	80 4%	-1 6%	-1 6%	-1.7%	-2.0%	-5.7%	-5 8%	-5 9%	-6.2%	-6.2%	-6.2%	-6.4%	-6.6%	-6.0%
Median	6 9%	18 3%	17 1%	62 4%	-0.3%	-0 3%	-0.4%	-0 5%	-2.1%	-2.1%	-2.1%	-2.2%	-2.2%	-2.2%	-2.3%	-2.3%	-2.1%
Return on Assets																	
Mean	14 6%	36 1%	31 7%	59 5%	-2 9%	-2 9%	-3 2%	-3.8%	-11 5%	-11.6%	-11.8%	-12.3%	-12.0%	-12.1%	-12.4%	-12.8%	-11.9%
Median	9 7%	22 6%	20 9%	57 1%	-0 9%	-0 9%	-1.2%	-1.8%	-6.8%	-6.8%	-6.9%	-7.2%	-7.0%	-7.0%	-7.2%	-7.6%	-7.0%
Current Ratio																	
Mean:	2 54	2 38	2 19	13 8%	-2 3%	-2.3%	-2.5%	-2 9%	-7.5%	-7.5%	-7.7%	-8.1%	-8.2%	-8.3%	-8.5%	-8.9%	-8.1%
Median	1 76	1 86	1 74	6 5%	-0 9%	-0 9%	-1.0%	-1.3%	-4.3%	-4.4%	-4.4%	-4.8%	-4.5%	-4.5%	-4.8%	-4.9%	-4.5%
Net Working Capital																	
Mean ($000)	$8,396	$7,953	$6,733	19 8%	-8 4%	-8 4%	-9 3%	-11 1%	-25.4%	-25.6%	-26.4%	-28.3%	-28.7%	-28.9%	-29.7%	-31.5%	-28.4%
Median ($000)	$3,577	$4,884	$4,589	26 8%	-8 0%	-8 0%	-8.0%	-8.0%	-21.5%	-21.5%	-22.3%	-23.3%	-23.7%	-23.7%	-23.7%	-23.7%	-23.3%
Net WC/ Total Assets																	
Mean	14 4%	8 3%	6 6%	54 0%	-3 9%	-3 9%	-4 3%	-5.5%	-20.3%	-20.4%	-20.8%	-21.5%	-21.5%	-21.6%	-21.9%	-22.6%	-20.9%
Median	7 7%	7 8%	6 8%	12 1%	-5 5%	-5.5%	-6.8%	-8.7%	-21.1%	-21.1%	-21.8%	-21.8%	-21.1%	-21.1%	-21.8%	-21.8%	-21.1%

Notes: Independently-owned facilities were excluded from this analysis, but are included in the company-level analysis.
Net Working Capital is in current dollars
This ratio analysis was based upon data for 285 mills

TABLE 6-12

FACILITY-LEVEL FINANCIAL RATIO ANALYSIS
VERY SMALL MILLS

Ratio	Baseline Parameter 1985	1988	1989	% Variation	Impact of Incremental Costs (Percent Decline In Parameter) Alt 2	Alt 3	Alt 4	Alt 5	Alt 11	Alt 16	Alt 17	Alt 18	Alt 22	Alt 23	Alt 24	Alt 25	Alt 26
Gross Income Margin:																	
Mean:	7.6%	6.5%	2.3%	69.9%	0.0%	0.0%	0.0%	0.0%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%
Median.	11.1%	6.0%	7.7%	45.6%	0.0%	0.0%	0.0%	0.0%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
Return on Assets:																	
Mean:	31.6%	31.3%	35.6%	12.0%	0.0%	0.0%	0.0%	0.0%	-5.7%	-5.7%	-5.7%	-5.7%	-5.7%	-5.7%	-5.7%	-5.7%	-5.7%
Median	21.1%	11.4%	11.6%	46.2%	0.0%	0.0%	0.0%	0.0%	-1.5%	-1.5%	-1.5%	-1.5%	-1.5%	-1.5%	-1.5%	-1.5%	-1.5%
Current Ratio																	
Mean	3.07	3.81	3.01	21.0%	0.0%	0.0%	0.0%	0.0%	-4.4%	-4.4%	-4.4%	-4.4%	-4.4%	-4.4%	-4.4%	-4.4%	-4.4%
Median	1.83	2.43	2.10	24.8%	0.0%	0.0%	0.0%	0.0%	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%
Net Working Capital																	
Mean ($000)	$978	$1,759	$974	44.6%	0.0%	0.0%	0.0%	0.0%	-6.5%	-6.5%	-6.5%	-6.5%	-6.5%	-6.5%	-6.5%	-6.5%	-6.5%
Median ($000)	$719	$1,028	$1,041	30.9%	0.0%	0.0%	0.0%	0.0%	-6.4%	-6.4%	-6.4%	-6.4%	-6.4%	-6.4%	-6.4%	-6.4%	-6.4%
Net WC/ Total Assets																	
Mean	16.4%	20.1%	17.8%	18.4%	0.0%	0.0%	0.0%	0.0%	-9.5%	-9.5%	-9.5%	-9.5%	-9.5%	-9.5%	-9.5%	-9.5%	-9.5%
Median	15.9%	17.3%	14.6%	15.6%	0.0%	0.0%	0.0%	0.0%	-18.5%	-18.5%	-18.5%	-18.5%	-18.5%	-18.5%	-18.5%	-18.5%	-18.5%

Notes. Independently-owned facilities were excluded from this analysis, but are included in the company-level analysis.
Net Working Capital is in current dollars
This level of the ratio analysis was based upon data for 45 mills.

TABLE 6-13

FACILITY-LEVEL FINANCIAL RATIO ANALYSIS
SMALL MILLS

Ratio	Baseline Parameter 1985	1988	1989	% Variation	Impact of Incremental Costs (Percent Decline in Parameter) Alt 2	Alt 3	Alt 4	Alt 5	Alt 11	Alt 16	Alt 17	Alt 18	Alt 22	Alt 23	Alt 24	Alt 25	Alt 26
Gross Income Margin:																	
Mean:	-0.3%	16.8%	16.4%	101.9%	-1.5%	-1.5%	-1.6%	-1.8%	-5.0%	-5.0%	-5.2%	-5.3%	-5.2%	-5.2%	-5.3%	-5.5%	-4.8%
Median:	5.9%	21.5%	19.2%	72.6%	-0.3%	-0.3%	-0.4%	-0.5%	-1.7%	-1.7%	-1.7%	-1.8%	-1.8%	-1.8%	-1.8%	-1.8%	-1.7%
Return on Assets:																	
Mean:	10.5%	42.9%	33.7%	75.6%	-3.0%	-3.0%	-3.3%	-3.8%	-10.3%	-10.4%	-10.6%	-10.9%	-10.6%	-10.6%	-10.9%	-11.2%	-10.3%
Median:	8.2%	28.0%	25.2%	70.7%	-1.0%	-1.1%	-1.4%	-1.8%	-5.1%	-5.2%	-5.7%	-6.2%	-6.0%	-6.0%	-6.2%	-6.2%	-6.0%
Current Ratio:																	
Mean:	2.62	2.27	2.09	20.5%	-2.6%	-2.6%	-2.8%	-3.1%	-7.2%	-7.3%	-7.5%	-7.8%	-7.9%	-7.9%	-8.2%	-8.5%	-7.7%
Median:	1.75	1.82	1.65	9.1%	-0.9%	-0.9%	-1.1%	-1.3%	-3.6%	-3.6%	-4.0%	-4.3%	-4.2%	-4.2%	-4.3%	-4.4%	-3.9%
Net Working Capital																	
Mean ($000)	$4,326	$4,512	$1,930	57.2%	-19.6%	-19.6%	-21.9%	-25.0%	-52.7%	-53.0%	-55.2%	-58.1%	-57.7%	-58.1%	-60.3%	-63.2%	-54.9%
Median ($000)	$3,038	$4,746	$4,337	36.0%	-6.3%	-6.3%	-6.3%	-6.3%	-12.4%	-12.4%	-14.2%	-14.2%	-12.4%	-12.4%	-14.2%	-14.2%	-10.5%
Net WC/ Total Assets																	
Mean:	16.8%	5.9%	3.2%	81.2%	-6.1%	-6.2%	-7.0%	-9.1%	-30.7%	-30.9%	-31.6%	-32.7%	-32.5%	-32.7%	-33.3%	-34.4%	-30.2%
Median	7.7%	8.2%	6.7%	18.4%	-3.8%	-3.8%	-5.0%	-7.8%	-22.9%	-23.4%	-24.3%	-26.3%	-23.2%	-23.4%	-24.4%	-26.3%	-23.4%

Notes: Independently-owned facilities were excluded from this analysis, but are included in the company-level analysis.
Net Working Capital is in current dollars
This level of the ratio analysis was based upon data for 160 mills

TABLE 6-14

FACILITY-LEVEL FINANCIAL RATIO ANALYSIS
LARGE MILLS

Ratio	Baseline Parameter 1985	1988	1989	% Variation	Impact of Incremental Costs (Percent Decline In Parameter) Alt 2	Alt 3	Alt 4	Alt 5	Alt 11	Alt 16	Alt 17	Alt 18	Alt 22	Alt 23	Alt 24	Alt 25	Alt 26
Gross Income Margin																	
Mean:	7 7%	20.2%	20 8%	62 8%	-2.7%	-2.7%	-2.9%	-3.6%	-9.9%	-10.0%	-10.3%	-11.0%	-11.1%	-11.2%	-11.5%	-12.2%	-11.2%
Median:	8.0%	19.8%	21.3%	62.4%	-1.5%	-1.5%	-1.6%	-2.2%	-4.7%	-4.8%	-4.9%	-5.5%	-5.4%	-5.5%	-5.8%	-6.3%	-5.5%
Return on Assets																	
Mean	13 6%	24.6%	25.4%	46.6%	-4.3%	-4.3%	-4.7%	-6.0%	-17.2%	-17.3%	-17.7%	-18.8%	-18.5%	-18.7%	-19.0%	-20.1%	-18.7%
Median	10 5%	18.7%	19.8%	47.0%	-3.4%	-3.4%	-3.7%	-4.8%	-13.8%	-13.9%	-14.2%	-16.1%	-15.1%	-15.3%	-15.6%	-17.3%	-15.3%
Current Ratio																	
Mean	2 19	2 03	2 04	7.2%	-2.7%	-2.7%	-2.9%	-3.6%	-9.2%	-9.3%	-9.5%	-10.2%	-10.5%	-10.6%	-10.8%	-11.5%	-10.6%
Median	1 73	1 77	1.72	2 9%	-2.2%	-2.2%	-2.5%	-3.1%	-7.4%	-7.5%	-7.9%	-8.5%	-9.0%	-9.0%	-9.2%	-9.7%	-9.0%
Net Working Capital																	
Mean ($000)	$19,849	$18,001	$19,513	9 3%	-6 4%	-6.5%	-7.0%	-8.7%	-20.5%	-20.7%	-21.3%	-23.0%	-23.5%	-23.7%	-24.3%	-26.0%	-23.7%
Median ($000)	$13,959	$18,113	$19,084	26 9%	-5.5%	-5.5%	-6.0%	-7.0%	-18.1%	-18.4%	-19.2%	-22.6%	-21.7%	-21.9%	-22.4%	-24.6%	-21.9%
Net WC/ Total Assets																	
Mean	8 9%	6 6%	7 4%	25 6%	-7.2%	-7 2%	-7 8%	-9.7%	-25.8%	-26.0%	-26.5%	-28.0%	-27.9%	-28.1%	-28.6%	-30.1%	-28.1%
Median	6 1%	6 2%	6 0%	3 6%	-12 3%	-12.3%	-13.5%	-15.9%	-32.2%	-32.5%	-33.3%	-36.7%	-35.0%	-35.3%	-36.0%	-39.8%	-35.3%

Notes. Independently-owned facilities were excluded from this analysis, but are included in the company-level analysis.
Net Working Capital is in current dollars
This level of the ratio analysis was based upon data for 80 mills.

TABLE 6-15

COMPANY-LEVEL FINANCIAL RATIO ANALYSIS
ALL COMPANIES

Ratio	Baseline Parameter 1985	1988	1989	% Variation	Impact of Incremental Costs (Percent Decline in Parameter) Alt 2	Alt3	Alt4	Alt5	Alt11	Alt16	Alt17	Alt18	Alt22	Alt23	Alt24	Alt25	Alt26
Net Income Margin																	
Mean	2 2%	6 6%	5 4%	66 0%	-2 1%	-2 1%	-2 3%	-2 5%	-9 9%	-9 9%	-10 0%	-10.2%	-10.2%	-10.2%	-10.4%	-10.6%	-10.2%
Median	4 1%	6 0%	5 6%	31 8%	0 0%	0 0%	0 0%	0.0%	-3.4%	-3.4%	-3.4%	-3.7%	-3.8%	-3.8%	-3.8%	-3.9%	-3.6%
Return on Assets																	
Mean	5 7%	8 4%	7 0%	32 6%	-2 6%	-2 6%	-2.8%	-3.2%	-13.7%	-13.7%	-13.9%	-14.2%	-14.1%	-14.1%	-14.3%	-14.5%	-14.1%
Median	5 3%	8 9%	7 3%	39 9%	0 0%	0 0%	0.0%	0.0%	-6.1%	-6.1%	-6.2%	-6.3%	-6.7%	-6.8%	-7.0%	-7.3%	-6.8%
Current Ratio																	
Mean	2 1	2 1	2 0	2 4%	-0 4%	-0 4%	-0.4%	-0.5%	-2.3%	-2.3%	-2.3%	-2.4%	-2.4%	-2.4%	-2.4%	-2.5%	-2.4%
Median	1 7	1 8	1 7	7 7%	0 0%	0 0%	0 0%	0.0%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%
Debt to Asset Ratio																	
Mean	53 2%	55 0%	56 6%	5 9%	0 7%	0 7%	0 8%	0 9%	5.5%	5.5%	5.6%	5.7%	5.6%	5.6%	5.7%	5.8%	5.6%
Median	50 9%	53 3%	51 7%	4 5%	0 0%	0 0%	0 0%	0 0%	1.5%	1.5%	1.5%	1.6%	1.5%	1.5%	1.6%	1.7%	1.5%
Times Interest Earned																	
Mean	50 7	44 5	22 8	55 0%	-5 2%	-5 2%	-5 7%	-6 7%	-21 5%	-21.5%	-21.7%	-22.2%	-21.8%	-21.9%	-22.1%	-22.5%	-22.0%
Median	6 3	9 8	8 1	36 0%	0 0%	0 0%	0 0%	0 0%	-11.2%	-11.2%	-11.3%	-11.7%	-11.2%	-11.2%	-11.3%	-11.7%	-11.2%
Net Working Capital																	
Mean ($000)	$71 425	$109 250	$97 950	34 6%	-1 4%	-1 4%	-1 6%	-1.9%	-4.4%	-4.4%	-4.6%	-4.9%	-4.9%	-5.0%	-5.1%	-5.4%	-4.9%
Median ($000)	$17 971	$17 685	$16 191	9 9%	-3 2%	-3 2%	-3 4%	-3 4%	-4.6%	-4.6%	-4.7%	-4.7%	-4.6%	-4.6%	-4.7%	-4.7%	-4.6%
Net WC/Total Assets																	
Mean	15 2%	15 8%	15 4%	3 6%	-1 1%	-1 1%	-1 2%	-1.4%	-11.0%	-11.0%	-11.1%	-11.3%	-11.2%	-11.2%	-11.3%	-11.5%	-11.2%
Median	14 5%	13 5%	12 4%	14 3%	-1 7%	-1.7%	-1 9%	-2.2%	-6.4%	-6.4%	-6.7%	-6.7%	-6.4%	-6.5%	-6.7%	-7.4%	-6.5%

TABLE 6-16

COMPANY-LEVEL FINANCIAL RATIO ANALYSIS
VERY SMALL COMPANIES

Ratio	Baseline Parameter				Impact of Incremental Costs (Percent Decline in Parameter)												
	1985	1988	1989	% Variation	Alt 2	Alt3	Alt4	Alt5	Alt11	Alt16	Alt17	Alt18	Alt22	Alt23	Alt24	Alt25	Alt26
Net Income Margin:																	
Mean:	-6 8%	5.2%	5 9%	215.8%	0.0%	0.0%	0.0%	0.0%	-31.9%	-31.9%	-31.9%	-31.9%	-31.9%	-31.9%	-31.9%	-31.9%	-31.9%
Median:	2.6%	4.1%	5.6%	53.6%	0 0%	0.0%	0.0%	0.0%	-4.0%	-4.0%	-4.0%	-4.0%	-4.0%	-4.0%	-4.0%	-4.0%	-4.0%
Return on Assets																	
Mean	6 8%	9 3%	10 2%	33 2%	0.0%	0.0%	0.0%	0.0%	-35.9%	-35.9%	-35.9%	-35.9%	-35.9%	-35.9%	-35.9%	-35.9%	-35.9%
Median	6 0%	9 8%	11 1%	45.9%	0 0%	0.0%	0.0%	0.0%	-7.3%	-7.3%	-7.3%	-7.3%	-7.3%	-7.3%	-7.3%	-7.3%	-7.3%
Current Ratio																	
Mean	3 1	2 5	2 4	23 2%	0 0%	0 0%	0.0%	0.0%	-3.4%	-3.4%	-3.4%	-3.4%	-3.4%	-3.4%	-3.4%	-3.4%	-3.4%
Median	2 2	1 9	2 0	14 8%	0 0%	0.0%	0.0%	0.0%	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%
Debt to Asset Ratio																	
Mean	51 8%	51 5%	54 4%	5 4%	0 0%	0.0%	0 0%	0 0%	8.7%	8.7%	8.7%	8.7%	8.7%	8.7%	8.7%	8.7%	8.7%
Median	54 9%	56 9%	52 0%	8 6%	0 0%	0 0%	0 0%	0 0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Times Interest Earned																	
Mean	29 3	21 7	38 9	44 1%	0 0%	0 0%	0 0%	0 0%	-23 1%	-23 1%	-23.1%	-23.1%	-23.1%	-23.1%	-23.1%	-23.1%	-23.1%
Median	3 8	8 2	7 3	53 0%	0 0%	0 0%	0 0%	0.0%	-9.1%	-9.1%	-9.1%	-9.1%	-9.1%	-9.1%	-9.1%	-9.1%	-9.1%
Net Working Capital																	
Mean ($000)	$2,110	$2 379	$2 604	18 9%	0 0%	0 0%	0 0%	0 0%	-2.4%	-2.4%	-2.4%	-2.4%	-2.4%	-2.4%	-2.4%	-2.4%	-2.4%
Median ($000)	$1,021	$776	$1,041	25 5%	0 0%	0 0%	0 0%	0 0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Net WC/Total Assets																	
Mean	29 3%	24 4%	25 0%	16 8%	0 0%	0 0%	0 0%	0 0%	-17.6%	-17.6%	-17.6%	-17.6%	-17.6%	-17.6%	-17.6%	-17.6%	-17.6%
Median	30 1%	27 4%	28 1%	9 1%	0 0%	0 0%	0.0%	0.0%	-18.4%	-18.4%	-18.4%	-18.4%	-18.4%	-18.4%	-18.4%	-18.4%	-18.4%

TABLE 6-17

COMPANY-LEVEL FINANCIAL RATIO ANALYSIS
SMALL COMPANIES

Ratio	Baseline Parameter			%	Impact of Incremental Costs (Percent Decline in Parameter)											
	1985	1988	1989	Variation	Alt 2	Alt3	Alt4	Alt5	Alt11	Alt16	Alt17	Alt18	Alt22	Alt23	Alt24	Alt25	Alt26
Net Income Margin																	
Mean	2 3%	6 4%	4 4%	63 6%	-3 3%	-3 3%	-3 4%	-3.6%	-3.8%	-3.8%	-3.9%	-4.1%	-4.0%	-4.0%	-4.1%	-4.3%	-4.0%
Median	4 4%	5 5%	4 2%	22.4%	0 0%	0 0%	0.0%	0.0%	-2.6%	-2.6%	-2.6%	-2.8%	-2.6%	-2.6%	-2.6%	-2.8%	-2.6%
Return on Assets																	
Mean	4 7%	7 9%	5 3%	40 6%	-3 8%	-3 8%	-3.9%	-4.3%	-8.4%	-8.4%	-8.5%	-8.7%	-8 6%	-8.6%	-8.8%	-9.0%	-8.7%
Median	5 1%	8 3%	5 7%	38.1%	0 0%	0 0%	0.0%	0.0%	-3.8%	-3.8%	-4.2%	-4.2%	-3.8%	-3.8%	-4.2%	-4.2%	-3.8%
Current Ratio																	
Mean	1 9	2 2	2 2	16 7%	-0 4%	-0.4%	-0.4%	-0 5%	-2.1%	-2.1%	-2.1%	-2.2%	-2.2%	-2.2%	-2.2%	-2.3%	-2.2%
Median	1 7	2 1	2 0	16 8%	0.0%	0 0%	0.0%	0.0%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
Debt to Asset Ratio																	
Mean	57 0%	56 9%	57 0%	0 3%	1 0%	1 0%	1.1%	1.2%	5.9%	5.9%	6.0%	6.1%	5.9%	6.0%	6.0%	6.1%	6.0%
Median	49 0%	53 0%	54 2%	9 6%	0.0%	0 0%	0.0%	0 0%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.4%
Times Interest Earned																	
Mean	52 2	46 6	16 3	68 7%	-5 3%	-5 3%	-5.7%	-6 3%	-20.8%	-20.8%	-20.9%	-21.1%	-20.9%	-20.9%	-21.1%	-21.2%	-21.1%
Median	6 8	8 4	5 4	34 8%	0 0%	0.0%	0.0%	0.0%	-8.7%	-8.7%	-8.7%	-8.7%	-8.7%	-8.7%	-8.7%	-8.7%	-8.7%
Net Working Capital																	
Mean ($000)	$62,827	$91,831	$76,269	31 6%	-0 2%	-0.2%	-0.3%	-0.3%	-1.0%	-1.0%	-1.0%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
Median ($000)	$6,501	$14,678	$15,027	56 7%	-3 5%	-3 5%	-4.1%	-6.3%	-13.3%	-13.5%	-13.8%	-15.2%	-16.3%	-16.4%	-16.8%	-18.1%	-16.4%
Net WC/Total Assets																	
Mean	12 6%	17 5%	16 6%	28.0%	-1 2%	-1.2%	-1.3%	-1.6%	-8.0%	-8.0%	-8.1%	-8.2%	-8.1%	-8.1%	-8.2%	-8.4%	-8.2%
Median	14 5%	18 7%	17 1%	22.8%	-1.1%	-1.1%	-1.1%	-1.1%	-2.9%	-2.9%	-2.9%	-2.9%	-2.9%	-2.9%	-2.9%	-2.9%	-2.9%

TABLE 6-18

COMPANY-LEVEL FINANCIAL RATIO ANALYSIS
LARGE COMPANIES

Ratio	Baseline Parameter				Impact of Incremental Costs (Percent Decline in Parameter)												
	1985	1988	1989	% Variation	Alt 2	Alt3	Alt4	Alt5	Alt11	Alt16	Alt17	Alt18	Alt22	Alt23	Alt24	Alt25	Alt26
Net Income Margin:																	
Mean	5 6%	7.3%	6 3%	24 2%	-2.0%	-2 0%	-2.2%	-2.5%	-6.2%	-6.2%	-6.4%	-6.7%	-6.8%	-6.8%	-7.0%	-7.3%	-6.7%
Median	4 1%	7.2%	6.6%	42 8%	-1 5%	-1.5%	-1.7%	-2.1%	-4.6%	-4.7%	-4.9%	-5.5%	-5.2%	-5.3%	-5.5%	-6.1%	-5.2%
Return on Assets:																	
Mean	6 1%	8 6%	7.4%	28 5%	-2 6%	-2.6%	-2.9%	-3.4%	-9.1%	-9.2%	-9.4%	-9.9%	-9.8%	-9.8%	-10.1%	-10.6%	-9.7%
Median	5 3%	8 9%	7.3%	39.7%	-2 2%	-2.2%	-2.5%	-2.9%	-7.5%	-7.6%	-7.8%	-8.4%	-8.1%	-8.1%	-8.4%	-9.1%	-8.0%
Current Ratio:																	
Mean	1 9	1 8	1 7	8 5%	-0 6%	-0.6%	-0.6%	-0 8%	-2.0%	-2.0%	-2.1%	-2.2%	-2.2%	-2.2%	-2.3%	-2.4%	-2.2%
Median	1 7	1 7	1 6	8 5%	-0.4%	-0.5%	-0.5%	-0.6%	-1.3%	-1.3%	-1.3%	-1.4%	-1.4%	-1.4%	-1.5%	-1.6%	-1.4%
Debt to Asset Ratio																	
Mean	50 2%	54 8%	57 0%	11 9%	0 7%	0 7%	0.8%	1.1%	3.8%	3.8%	3.9%	4.1%	3.9%	3.9%	4.0%	4.2%	3.9%
Median	51 6%	51 9%	48 6%	6 4%	0 5%	0 5%	0.6%	0.7%	1.9%	1.9%	2.0%	2.4%	2.0%	2.0%	2.1%	2.4%	2.0%
Times Interest Earned																	
Mean	55 8	50 2	23 2	58 4%	-7 0%	-7 0%	-7.8%	-9.5%	-21.5%	-21.6%	-22.1%	-22.9%	-22.3%	-22.4%	-22.8%	-23.5%	-22.3%
Median	6 2	10 9	11 1	43 7%	-3 4%	-3.5%	-4.1%	-5.7%	-16.3%	-16.3%	-16.7%	-16.7%	-16.3%	-16.3%	-16.7%	-16.7%	-16.3%
Net Working Capital																	
Mean ($000)	$105 443	$173,136	$162,234	39 1%	-2 0%	-2 0%	-2.2%	-2.7%	-6.0%	-6.1%	-6.3%	-6.7%	-6.8%	-6.8%	-7.0%	-7.5%	-6.7%
Median ($000)	$61,419	$75,766	$101,006	39 2%	-1 5%	-1.5%	-1.6%	-2.2%	-3.9%	-3.9%	-4.0%	-4.2%	-4.1%	-4.1%	-4.3%	-4.5%	-4.1%
Net WC/Total Assets																	
Mean	12 3%	10 4%	9 9%	20 0%	-2 1%	-2.1%	-2.4%	-2.9%	-8.7%	-8.7%	-8.9%	-9.4%	-9.3%	-9.3%	-9.5%	-9.9%	-9.2%
Median	10 4%	9 1%	8 7%	16.7%	0 0%	0.0%	0.0%	0.0%	-7.0%	-7.0%	-7.0%	-7.0%	-7.0%	-7.0%	-7.0%	-7.0%	-7.0%

that large facilities with chemical pulping operations bear a substantial portion of the cost of pollution control.

6.2 MARKET IMPACT ANALYSIS RESULTS

Given the similarity of results seen with the financial model analysis and market model analysis of impacts in Section Five, the market model analysis for this section focuses on Regulatory Alternative 26.

6.2.1 Facility-Level Results

6.2.1.1 Closure Distribution

Facility closures associated with regulating the industry are estimated by the market impact model for each size category. Table 6-19 shows that just over 2 percent of the facilities in the small combination group are predicted to close due to regulation, while just over 1 percent of the facilities in the large combination group discontinue operations. Within the small combination group, facility closures are almost evenly divided across the small and very small subgroups. Of those facilities projected to close by the market impact model, almost two-thirds are independently owned and operated with the remaining one-third part of a multifacility group.

6.2.1.2 Employment Changes

Production and non-production worker employment changes associated with regulating the industry are also estimated by the market impact model. The changes in employment result from both mill closures and production changes at mills continuing to operate with the regulations. Table 6-20 shows that small combination group facilities, as a whole, incur a 0.9 percent loss in employment due to regulation, while large facilities are also predicted to lose less than 1 percent of their employment. Within the small combination category, small facilities are

TABLE 6-19

CLOSURES OF INDEPENDENT AND MULTIFACILITY MILLS BY SIZE: VALUES WITH REGULATORY ALTERNATIVE 26

	Independently Owned		Multifacility Group		Total	
Size based on employment	Number	Percent Change	Number	Percent Change	Number	Percent Change
Small Combination Group (<750)	4	-4.2	6	-1.5	10	-2.1
Small (<750 & >125)	1	-2.3	3	-1.4	4	-1.5
Very Small (≤125)	3	-6.0	3	-1.8	6	-2.7
Large (>750)	0	0.0	1	-1.2	1	-1.2
Total	4	-4.1	7	-1.5	11	-1.9

TABLE 6-20

CHANGES IN EMPLOYMENT OF INDEPENDENT AND MULTIFACILITY MILLS BY SIZE: VALUES WITH REGULATORY ALTERNATIVE 26

	Independently Owned		Multifacility Group		Total	
Size based on employment	Number	Percent Change	Number	Percent Change	Number	Percent Change
Small Combination Group (<750)	-273	-1.5	-647	-0.7	-921	-0.9
Small (<750 & >125)	-237	-1.6	-652	-0.9	-889	-1.0
Very Small (≤125)	-37	-1.1	5	-0.0	-32	-0.2
Large (>750)	2	0.1	-984	-0.9	-982	-0.9
Total	-271	-1.3	-1,631	-0.8	-1,902	-0.9

predicted to lose 1 percent of their baseline employment, but very small facilities only incur a loss of 0.2 percent. The largest employment loss, over 50 percent of the predicted decline, is realized by large facilities that are part of a multifacility group, while large independently owned and operated facilities, as a group, realize a slight net increase in employment.

6.2.1.3 Product Revenues, Total Costs of Production, and EBIDT

Additional indicators of the severity of the economic impact on small facilities include the changes in product revenues, total costs of production, and EBIDT as estimated by the market impact model. Table 6-21 provides the changes in facility-level revenues, costs, and EBIDT by size, for mills that continue to operate with the regulation.

6.2.1.4 Annual Compliance Costs

The relative severity of the regulations can also be measured by comparing the ratios of annual compliance costs to total revenues, total costs, and EBIDT across small and large facilities. Table 6-22 shows the ratio of facility-level annual compliance costs to total revenues, total costs, and EBIDT by size, for facilities that continue to operate after regulation.

6.2.2 Company-Level Results

6.2.2.1 Closure Distribution

The distribution of facility closures across small and large firms is presented in Table 6-23. The absolute number of facility closures estimated by the market impact model is almost evenly split across small and large firms with 6 facilities closing that are owned by small firms and 5 facility closures for large firms. In terms of percentage change from baseline, small firms incur two times the facility closures of large firms—a 2.8 percent loss at small firms versus a 1.4 percent loss at large firms.

TABLE 6-21

CHANGES IN FACILITY-LEVEL REVENUES, COSTS, AND EBIDT[a] BY SIZE: VALUES WITH REGULATORY ALTERNATIVE 26

Facility size based on employment	Percentage change		
	Total revenues	Total costs	EBIDT[a]
Small Combination Group (<750)			
Mean	2.4	11.5	6.5
Minimum	-11.4	-7.8	-99.8
Maximum	118.2	3,940.9	296.2
Small (<750 & >125)			
Mean	2.4	11.8	6.7
Minimum	-11.4	-7.8	-99.8
Maximum	118.2	3,940.9	296.2
Very Small (≤125)			
Mean	0.8	1.5	-0.6
Minimum	-3.8	-2.2	-37.0
Maximum	8.0	7.9	44.8
Large (>750)			
Mean	1.2	2.6	-2.3
Minimum	-1.0	-0.1	-28.0
Maximum	17.4	20.6	35.8
Total			
Mean	2.1	9.6	4.7
Minimum	-11.4	-7.8	-99.8
Maximum	118.2	3,940.9	296.2

[a]Earnings before interest, depreciation, and taxes.

TABLE 6-22

RATIO OF FACILITY-LEVEL ANNUAL COMPLIANCE COSTS TO TOTAL REVENUES, TOTAL COSTS, AND EBIDT[a] BY SIZE: VALUES WITH REGULATORY ALTERNATIVE 26

Facility size based on employment	Ratio of annual compliance costs to		
	Total revenues	Total costs	EBIDT[a]
Small Combination Group (<750)			
Mean	0.5	0.7	4.1
Minimum	-0.2	-0.3	-1.7
Maximum	15.5	25.5	324.3
Small (<750 & >125)			
Mean	0.5	0.7	4.0
Minimum	-0.2	-0.3	-1.7
Maximum	15.5	25.5	324.3
Very Small (≤125)			
Mean	0.7	0.9	6.9
Minimum	0.0	0.0	0.0
Maximum	5.0	7.3	74.3
Large (>750)			
Mean	1.4	2.0	6.8
Minimum	0.0	0.0	0.0
Maximum	5.4	7.4	53.5
Total			
Mean	0.7	1.0	4.5
Minimum	-0.2	-0.3	-1.7
Maximum	15.5	25.5	324.3

[a]Earnings before interest, depreciation, and taxes.

TABLE 6-23

FACILITY CLOSURES BY FIRM SIZE CATEGORY:[a] REGULATORY ALTERNATIVE 26

Firm size based on employment (1989)	Operating facilities		
	Baseline	With regulation	Facility closures
Small (<750)	211	205	6
Large (>750)	354	349	5
Total, all firms[b]	565	554	11

[a]Facility closures result from the market impact model.
[b]Excludes one mill in the facility-level analysis since owned by company excluded from firm-level analysis due to lack of necessary data.

6.2.2.2 Employment Loss

The distribution of employment changes across small and large firms is presented in Table 6-24. Firm-level employment changes are calculated as the sum of net employment changes at facilities owned by the firm. The facility-level employment changes associated with the regulations are estimates from the market impact model.

6.2.2.3 Profitability Impacts

Several ratios are commonly used to measure company profitability, including return on assets, return on equity, and return on sales. For all these measures, higher values are unambiguously preferred over lower values. In Tables 6-25 through 6-27, we compare the profitability measures computed for potentially affected firms to the benchmark ratios reported in Section 3.5.4.2, Tables 3-32 through 3-34. The tables indicate that the changes due to regulation vary across both firm size and profitability measure. In the case of the return to sales, the percentage of firms below the upper quartile increases for both size categories, the percentage below the median increases for large firms and declines for small firms, and the percentage below the lower quartile benchmark declines for both small and large firms. This result reflects a general decline in profitability (as measured by the return on sales) across all large firms above the median benchmark and small firms above the upper quartile benchmark, while also indicating a general increase across all firms below the median benchmark.

Alternatively, in the cases of the return on assets and the return on equity, the percentage of firms below the benchmark levels increases and decreases across small and large firms. For the return on assets, the percentage of small firms below each benchmark level declines, while it increases in each case for large firms. This indicates an overall increase in profitability, as measured by the return on assets, for small firms and an overall decline in the profitability for large firms due to imposition of the regulations. For the return on equity, the percentage of small firms below each benchmark level also declines, but the percentage of large firms below the upper quartile and median benchmarks increases and below the lower quartile level it decreases. This indicates an overall increase in profitability, as measured by the return on equity, for small

TABLE 6-24

CHANGE IN EMPLOYMENT BY FIRM SIZE CATEGORY:[a]
REGULATORY ALTERNATIVE 26

Firm size based on employment (1989)	Total employment		Change in employment
	Baseline	With regulation	
Small (<750)	28,989	28,624	-365
Large (>750)	623,455	622,706	-1,537
Total, all firms	652,444	651,330	-1,902

[a]Firm-level employment changes are the sum of employment changes at facilities owned by the firm. The facility-level employment changes result from the market impact model.

TABLE 6-25

PERCENTAGE OF FIRMS BELOW INDUSTRY BENCHMARK RATIOS IN BASELINE AND WITH REGULATION: RETURN ON SALES REGULATORY ALTERNATIVE 26

	Small firms		Large firms		All firms	
Percentage less than	Baseline (%)	With regulation (%)	Baseline (%)	With regulation (%)	Baseline (%)	With regulation (%)
Benchmark ratios						
Upper quartile	74.0	74.7	79.4	85.7	75.6	77.9
Median	55.3	52.7	42.9	47.6	51.6	51.2
Lower quartile	32.0	28.7	28.6	28.6	31.0	28.6

TABLE 6-26

PERCENTAGE OF FIRMS BELOW INDUSTRY BENCHMARK RATIOS IN BASELINE AND WITH REGULATION: RETURN ON ASSETS REGULATORY ALTERNATIVE 26

Percentage less than	Small firms		Large firms		All firms	
	Baseline (%)	With regulation (%)	Baseline (%)	With regulation (%)	Baseline (%)	With regulation (%)
Benchmark ratios						
Upper quartile	70.0	67.3	77.8	85.7	72.3	72.8
Median	56.7	49.3	54.0	55.6	55.9	51.2
Lower quartile	37.3	32.0	33.3	34.9	36.2	32.9

TABLE 6-27

PERCENTAGE OF FIRMS BELOW INDUSTRY BENCHMARK RATIOS IN BASELINE AND WITH REGULATION: RETURN ON EQUITY REGULATORY ALTERNATIVE 26

Percentage less than	Small firms		Large firms		All firms	
	Baseline (%)	With regulation (%)	Baseline (%)	With regulation (%)	Baseline (%)	With regulation (%)
Benchmark ratios						
Upper quartile	60.0	52.0	74.6	77.8	64.3	59.6
Median	48.0	42.7	41.3	50.8	46.0	45.1
Lower quartile	35.3	30.0	33.3	30.2	34.7	30.0

firms and a general decline in profitability for large firms at the higher tail of the distribution along with a general increase for large firms at the lower tail of the distribution.

The previous observations are supported by the summary statistics for the measures of profitability shown in Table 6-28. The summary statistics include the mean, minimum, and maximum values for each measure in baseline and with regulation across small, large, and all firms in the industry. A comparison of the values in baseline and after imposition of the regulations provides more detail on the distributional changes in these profitability measures across firms.

As Table 6-28 illustrates, the mean return on sales slightly declines for all firms after imposition of the regulation. This finding is also true for small firms, while the mean return on sales for large firms increases by an inconsiderable amount. Further, the mean return on assets increase for all firms with regulation, fueled by the increase in the mean return for small firms from 8.8 to 9.4 percent. Alternatively, the mean return on assets for large firms slightly declines from 5.57 to 5.40 percent. As measured across all firms, the post-regulation mean return on equity increases from the baseline level of 20.4 to 22.3 percent. As a group, small firms realize an increase in the mean return on equity, while the mean return on equity for large firms very slightly decreases. Overall, a disproportionate impact on small firms is not evident from the profitability analysis.

6.2.2.4 Bankruptcy Analysis

Table 6-29 provides the with-regulation bankruptcy prediction by firm size. This can be compared to the baseline prediction shown in Table 3-38. Under regulation, the likelihood of financial failure for small firms is not affected. However, the likelihood of financial failure for large firms declines because one large firm moved into the indeterminate range after regulation. The number of firms in the indeterminate range increases by nine firms. Two-thirds of these firms are small, six out of nine. As seen in Table 6-29, regulation reduces the number of firms for which bankruptcy was unlikely in baseline by 7.3 percent, or eight firms. Nearly two-thirds of these firms are small, five out of eight. Small firms, as a group, incur a 20 percent reduction in

TABLE 6-28

SUMMARY STATISTICS FOR KEY MEASURES OF PROFITABILITY IN BASELINE AND WITH REGULATION BY FIRM SIZE CATEGORY: REGULATORY ALTERNATIVE 26

Measure of Profitability/ Summary Statistics	Baseline			With regulation		
	Small firms	Large firms	All firms	Small firms	Large firms	All firms
Return on sales						
Mean	5.39	5.23	5.34	5.34	5.21	5.30
Minimum	-21.55	-77.92		-46.53	-68.32	
Maximum	28.51	17.36		28.98	17.36	
Return on assets						
Mean	8.80	5.57	7.84	9.37	5.40	8.20
Minimum	-47.07	-149.27		-45.56	-140.37	
Maximum	62.35	24.55		60.60	26.15	
Return on equity						
Mean	25.58	8.40	20.40	28.31	8.27	22.30
Minimum	-179.83	-262.42		-185.71	-246.77	
Maximum	664.00	88.91		662.91	94.77	

TABLE 6-29

WITH-REGULATION BANKRUPTCY PREDICTION BY FIRM SIZE: REGULATORY ALTERNATIVE 26

Z'-Score Prediction[a]	Firm Size Based on Employment (1989) Small (<750)	Percent Change	Large (>750)	Percent Change	Total	Percent Change
All Companies						
Bankruptcy Likely	9	0.0	5	-16.7	14	-6.7
Indeterminant	59	5.4	38	18.8	97	10.2
Bankruptcy Unlikely	82	-3.5	20	-20.0	102	-7.3

[a]Bankruptcy prediction is based on Altman's Z'-score for manufacturing companies. If a company's Z'-score is < 1.23, the model predicts that bankruptcy is likely. If a company's Z'-score is > 2.90, the model predicts that bankruptcy is unlikely. Z'-scores between 1.23 and 2.90 fall in the indeterminant range, and the model makes no prediction for these companies.

the number unlikely to become bankrupt, while the large category shows only a 3.5 percent decline after imposition of the regulation.

6.3 SUMMARY AND CONCLUSIONS

The financial and market model analyses use different methods to examine the impacts on small entities. The financial model compares the number of closures and the losses in jobs, shipments (tonnage and value), and exports and changes in financial ratios. The market model also examines the number of closures and job losses, and includes an analysis of profitability and bankruptcy impacts.

Both approaches provide consistent results. Using the number of employees at a company to define size (as used by the Small Business Administration), small entities are not more severely affected than large entities. Very small companies show the least amount of impacts and, as indicated by the market model analysis, large companies generally are more severely affected than small ones. Using the number of employees at a facility to define size provides a more conservative analysis. In the financial model, only one very small facility that is also a very small company is adversely affected by the regulatory alternatives. There is one parameter (exports) where small facilities show greater proportional impacts but there are several parameters where large facilities show greater proportional impacts (closures, shipments, and employment).

In general, there is no consistent pattern of disproportionate impacts on small entities. The results indicate the regulatory alternatives do not cause a significant impact on a substantial number of small entities. This conclusion is reached for all definitions of small entity used in both analytical models.

APPENDIX A:

MARKET IMPACT METHODOLOGY AND MODEL

A.1 INTRODUCTION AND OVERVIEW OF APPROACH

The U.S. Environmental Protection Agency's (EPA's) Office of Air and Radiation (OAR) and Office of Water (OW) are developing regulations to control the release of air and water pollutants that result from manufacturing pulp and paper. The OAR contributes to the regulatory development effort by providing analyses and supporting documents that describe the likely economic and financial effects of the proposed guidelines on the regulated community and other entities of interest.

Generally, when evaluating the economic impact of regulations, the EPA may consider estimates of the impact on the following types of variables for the economic impact analysis:

- Facility-level impacts:
  - costs (capital and annual operating)
  - closures
  - employment
  - production
- Market-level impacts for selected products:
  - product price changes
  - production changes
  - consumption changes
  - changes in imports
  - changes in exports

Further, the Agency must also consider the requirements of E.O. 12291. That Order requires a Regulatory Impact Analysis (RIA), which is essentially a benefit-cost analysis, of all "major" regulations. The Order defines "major" as any regulation having annual costs of over $100 million, causing significant changes in costs or prices, or resulting in significant market

disruptions. Also, under the Regulatory Flexibility Act the Agency must provide a Regulatory Flexibility Analysis (RFA) of the effects on small entities if a "substantial" number of these entities are significantly affected. If an RFA is prepared, the Agency must also make a special effort to design the regulation to address the effects of the regulation on small entities.

The total number of mills directly and indirectly affected by these regulations depends on the policy options considered, but the number will be some subset of the U.S. mills included in the EPA's *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities.*[1]

The key challenge facing the designer of the analytical approach for addressing the economic impact of regulations on the pulp and paper industry is how to integrate facility-level impacts with the market(s) for their outputs in a realistic and conceptually correct manner. This task is complicated by the complex production relationships and the degree of product differentiation that characterize the pulp and paper manufacturing industry. Despite these complexities, we developed an economic model that assesses product market responses for 37 markets and facility-level impacts on 338 directly and 228 indirectly affected mills within the U.S. pulp and paper industry.

The model is a multidimensional Lotus spreadsheet incorporating various data sources to provide an empirical characterization of the U.S. pulp and paper industry and product markets for a base year of 1989. This base year of analysis was chosen because it is the last year for which facility-specific production and technical data were available from the *1990 National Census* and for which supporting economic data were readily available. The model analyzes market adjustments for 31 paper and paperboard product markets and 6 market pulps. Integrated facilities and paper-making facilities constitute those facilities supplying final paper and paperboard products, while the pulp mills and those integrated mills involved in the market for pulp, either as a supplier or demander, constitute those facilities included in the model for market pulps. The model also includes a foreign trade sector with imports and exports for each paper and paperboard product and market pulp.

The exogenous shock to the economic model is the imposition of the regulations and the corresponding control costs (i.e., the installed capital and per-unit output operating and

maintenance [O&M] costs of the regulatory alternative). We annualized the installed capital costs of the controls for each facility using firm-specific costs of capital from the *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities*. The annualized installed capital costs enter the model at the facility-level, while the per-unit output O&M costs enter at the product-level for all facilities affected by the regulatory alternative.

We obtained model parameters and supporting data from the EPA's *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities*, industry data sources, and econometric estimation. Specification and parameterization of facility-specific, upward-sloping supply curves for each product allow the model to take facility-specific reactions to the regulatory costs (shifts in facility-level supply curves aggregated to the market level) and determine new equilibria in all product markets. Facilities may cease to produce a particular product by closing a product line, which is determined by the shutdown point on the supply curve, or they may stop production altogether by closing the entire facility, which is determined by comparing total revenues and total costs (including regulatory control costs) at the facility level.

We incorporated a competitive market structure to compute the equilibrium prices and quantities of all commodities in the system. Demand for the "final" commodities in the system--that is, commodities whose demand is exogenous--is expressed in equation form. Domestic demand elasticities are econometrically estimated for all paper and paperboard products. Domestic demand for market pulp is derived from paper and paperboard production decisions via fixed input coefficients or purchased input ratios, which determine the amount of market pulp needed to produce paper or paperboard at each facility. Similarly, import supply and export demand are expressed in equation form with derived estimates of import supply and export demand elasticities. The model analyzes market adjustments for 31 paper and paperboard product markets and for 6 market pulps by employing a process of **tatonnement** whereby prices approach equilibrium through successive correction via a Walrasian auctioneer. To our knowledge this empirical model is the only one that integrates the facility and market in a conceptually correct manner that addresses multiple products and derived demand relationships.

The major outputs of this model are market-level adjustments in price and quantity for all affected products as well as facility-level adjustments in production, including product-line or

facility closures. We estimated impacts on foreign trade through comparing baseline and with-regulation levels of exports and imports of affected products. We used the market adjustments in price and quantity to calculate the changes in the aggregate economic welfare using applied welfare economics principles. The net change in economic welfare associated with the regulation is measured by consumer and producer surplus changes.

In addition, we also computed the changes in employment attributable to the change in output from mills. The change in output results from both changes in production at the affected facilities and facility and product-line closures. We computed worker dislocation costs given the industry employment losses based on the method outlined in Anderson and Chandran.[2]

A.2 FEATURES OF THE PULP AND PAPER INDUSTRY

For this analysis, a paper or paperboard product is formed by two processes: pulping-bleaching and papermaking. As seen in Figure A-1, pulpwood is the raw material input into the pulping process, which results in pulp that may or may not be bleached depending on its final end use. Chemical pulping and bleaching processes and secondary wastewater treatment are the three major processes the regulations will affect. Air and water pollutants resulting specifically from wood preparation or papermaking processes are not addressed by the regulations or this analysis; however, this analysis is capable of including these activities.

A.2.1 Pulp Production Processes

Pulp can be manufactured by a variety of processes that separate the wood into its cell components. Important pulping processes are

- Chemical
- Semichemical
- Mechanical

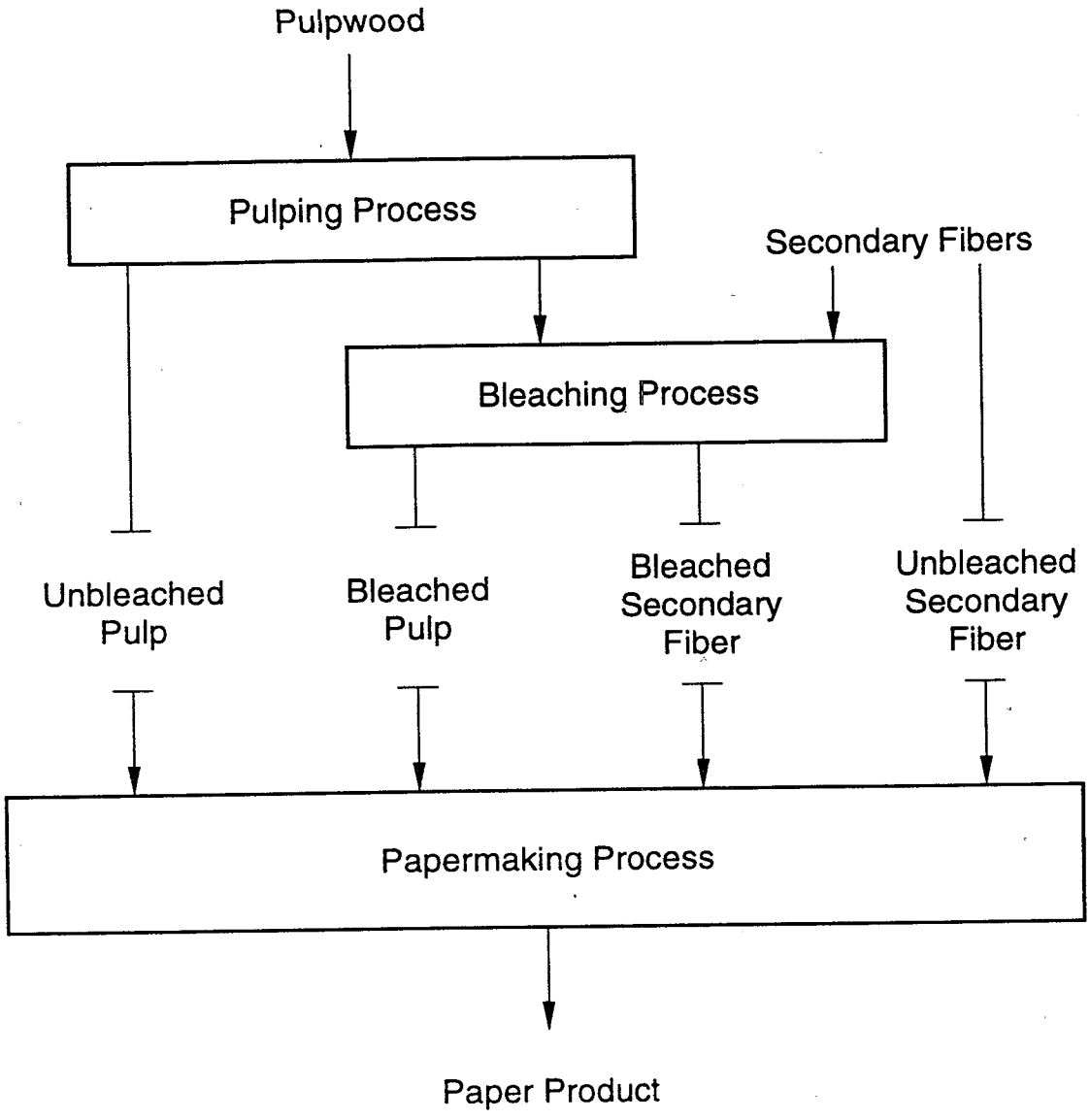


Figure A-1 Paper production process

- Thermomechanical, chemimechanical, and chemithermomechanical
- Bleaching and brightening

Each process imbues the final product with special characteristics according to the relative balance of the components remaining in the pulp. The characteristics affect the quality of the pulp, thus dictating its end use and, in turn, influence the quality of the paper or board produced. In addition, pulps may or may not undergo a further bleaching or brightening process after manufacturing.

A.2.1.1 Chemical Pulping Method

Chemical pulping methods involve a chemical reaction between the lignin and the active chemicals in the pulping liquor. Kraft (or sulfate) and sulfite are two chemical processes that use different chemicals and produce pulps with slightly different characteristics. Kraft pulping first cooks the chips in a mixture of sodium hydroxide and sodium sulfide (white liquor); the procedure is halted before the pulp is completely delignified. The mixture is then separated into vapor, liquid, and pulp. Next the pulp is washed and may be bleached. Finally, chemical and by-product recovery is employed to convert used chemicals, tall oil, and turpentine into reusable inputs or products. Both hardwoods and softwoods can be used in the kraft process, and it produces a very strong pulp that can be combined with weaker pulps.

The sulfite pulping process is similar to the kraft process in that both processes use sulfur-based chemicals to remove lignin from the wood. The difference between sulfite and kraft pulping is that the alkaline white liquor is replaced with an acidic liquor made of sulfurous acid and the bisulfate ion. Fiber furnishes used in this process include softwoods such as spruce, fir, and hemlock. The primary advantage of the sulfite method is that it produces a pulp with a lower residual lignin content. As a result, sulfite pulp is easier to bleach and requires fewer bleaching steps, making it better suited for papermaking applications. However, the lower residual lignin content causes sulfite pulp to be weaker than kraft pulp because the chemical recovery stage of the sulfite process is less thorough than that of the kraft process.

The economic feasibility of chemical recovery is ultimately determined by the cost of the initial compounds. Calcium (limestone)-based reactions do not generally involve recovery phases because the cost of recovery exceeds the cost of purchasing new calcium. On the other hand, magnesium-based reactions are followed by recovery because magnesium recovery is less costly than acquiring fresh magnesium.

A.2.1.2 Semichemical Method

Semichemical pulping combines aspects of chemical and mechanical treatment to pulp hardwoods. Chips are first softened and partially delignified by using chemicals and steam and then pulped by mechanical action. The primary method of semichemical pulping is the neutral sulfite method. In this method, wood chips are cooked in a neutral solution of sodium sulfite and either sodium carbonate or sodium hydroxide. The extent of chemical delignification is determined by the length of cooking and chemical concentration. After partial chemical delignification, the furnish is then subjected to further nonpressurized mechanical delignification.

A.2.1.3 Mechanical Methods

Mechanical pulping involves either shredding unchipped pulpwood with a grindstone or fiberizing wood chips with a specially designed refiner. Mechanical pulping is used primarily for softwoods, although variations of the mechanical process have been devised to allow mechanical pulping of hardwoods. The mechanical pulping process simply rips loose the bond that lignin creates, but the lignin remains attached to the cellulosic fibers. As a result, mechanical pulp is highly opaque, making it suitable for uses such as newsprint. However, mechanical pulp produces low strength paper that yellows easily, and the process is highly energy intensive. Two variations of mechanical pulping are commonly used: stone groundwood and refiner groundwood.

The stone groundwood process mechanically grinds bolts of lumber (uniformly sized, debarked logs) against a grinding stone to separate fiber from lignin. The stone is then cleaned

with water to recover the pulp, the resulting slurry is screened to remove oversized pieces, and finally water is removed. The stone groundwood method produces short strands of pulp, which accounts for the pulp's weakness. Refiner processing replaces the grinding stone with a pair of discs and is designed to generate longer, stronger strands of pulp fiber. Grooved discs spinning against each other in opposite directions effectively shred the pulp instead of grinding it. The main disadvantage of refiner pulping is that it produces a darker pulp that is more difficult to bleach than stone groundwood pulp.

A.2.1.4 Thermomechanical, Chemimechanical, and Chemi-thermomechanical Pulping Processes

Thermomechanical pulping is a fourth pulping process. In this method, steam is used to soften the fibers before shredding. The chips are presteamed or refined in one or more stages of pressurized refining or followed by atmospheric refining. Following the brief cooking process, the pulp is mechanically defibrated in refiners. Thermomechanical pulping, which produces pulp of low strength but higher than the groundwood and refiner mechanical processes, is used for products such as newsprint, publication papers, and fiberboard.

Another pulping process is chemimechanical pulping, which produces a pulp of slightly higher strength than thermomechanical pulping. The method allows hardwoods to be pulped mechanically by first subjecting the wood to a chemical softening stage. Two major processes are used: the chemigroundwood process and the cold soda process. Chemigroundwood processing cooks bolts of timber in an alkaline sulfite solution prior to mechanical grinding. The sulfite solution softens the fiber to make it more responsive to the grinding stone. Cold soda chemimechanical processing uses a caustic soda to soften wood chips at room temperature. The chips are then pulped by the mechanical refiner method. Chemimechanical pulping is similar to semichemical pulping, but the semichemical pulping process employs a chemical stage to partially delignify the furnish, whereas the chemimechanical method relies exclusively on mechanical delignification. Chemical treatment in the chemimechanical process is only a means of preparing the furnish for mechanical delignification; the semichemical process supplements mechanical delignification with chemical delignification.

Chemi-thermomechanical pulping employs chemicals and heat to break down the chips, followed by mechanical defibration. The wood is cooked in a chemical liquor of sodium sulfite and sodium carbonates at elevated temperatures to prepare it for defibration. Some paper products produced from this type of pulp are newsprint, tissue, and board.

A.2.1.5 Bleaching and Brightening

Bleaching may be an additional process added to any of the pulping methods described above. Bleaching is a means of whitening pulp and involves further delignification as well as alteration of chromophoric compounds present in the pulp fiber. Bleaching permanently alters the pulp by removing lignin. Thus, in addition to whitening the pulp, bleaching increases the longevity of whiteness and retards discoloring in the final product. The main disadvantage associated with bleaching is that lignin removal weakens the pulp. The bleaching process can be either single stage or multi-stage, depending on the desired color of the final product. The following five procedures are generally used in bleaching: chlorine, chlorine dioxide, hypochlorite, peroxide, and ozone. The order in which the steps occur varies and is determined by the degree of delignification required, the wood type, and the pulping process used.

As Figure A-1 shows, secondary fibers may also be used as inputs to the bleaching process and papermaking process. Secondary fibers are any type of fiber obtained from wastepapers and other used, reclaimable fiber sources.

Brightening, the alternative and the complement to bleaching, involves altering only the chromophoric compounds present in the pulp. No delignification occurs. As a result, the brightening process is less damaging to the strength of the pulp, but the whiteness of the pulp lasts only temporarily, and exposure to the sun yellows brightened pulps easily.

A.2.2 Paper Production Processes

The papermaking process uses pulp as an input to produce paper and paperboard products. The process begins with refining, which mechanically cuts and macerates pulp to convert raw fiber into a form suitable for papermaking. Pulps also may be mixed with other pulp types to enhance strength or other characteristics. Additives to impart certain characteristics may be added, and then the stock, or furnish, is pumped to the paper machine.

Three basic steps occur in paper and paperboard production:

1. A web of fiber is formed from a fiber and water suspension on a paper machine wire.
2. Water is pressed out of the web.
3. The remaining water is driven off by heat.

A variety of machines make paper, but the two most common are the fourdrinier and cylinder machines. The fourdrinier machine typically is used for manufacturing a variety of paper grades and lightweight bonds and the cylinder machine for multi-ply paperboard or building board grades.

Each paper or paperboard product may be made using some combination of bleached or unbleached pulps and secondary fiber depending on the desired characteristics of the final product. These combinations are very closely related--the pulpwood input (hardwood or softwood) requires a particular pulping process that results in a certain type of pulp, which may or may not require bleaching to obtain the brightness required for the final product. For example, the "recipe" for uncoated free sheet might call for 80 percent kraft pulp (from the kraft pulping process) and 20 percent groundwood pulp (from the mechanical pulping process) with each type of pulp bleached with a particular bleaching sequence.

A.2.3 Producers

The pulp and paper industry is characterized by both nonintegrated and vertically integrated mills. Vertically integrated mills rely mostly on their own production of pulp to produce paper and paperboard products, while nonintegrated mills include pulp mills that produce market pulp as well as paper mills that purchase market pulp to produce paper and paperboard products. Mills producing low-value products are usually integrated, and mills making specialized, high-value products are usually nonintegrated. Those vertically integrated mills without enough internally produced pulp are also demanders of market pulp; those mills that produce an excess supply of pulp are suppliers of market pulp.

A mill is defined as a single physical entity with a unique geographic location that includes one or several production lines. A mill may have several parallel decision-making units in place at once, reflecting the decision-maker's choice to produce multiple outputs. For this study, three types of mills exist for producing pulp and paper: pulp mills, paper mills, and integrated facilities. Their total number and distinguishing characteristics are as follows:

- Pulp mills (28)—mills engaging solely in the production of pulp to be sold on the pulp market for use as an input in the production process of a paper or paperboard product. Pulp mills include mills producing pulp from both virgin fiber as well as secondary fibers such as recycled paper, rags, linters (cottonseed fiber fuzz), and straw.

- Paper mills (303)—mills producing paper and paperboard products from market-purchased pulp produced from pulp mills and integrated mills. Paper mills include makers of all paper and paperboard products in the *National Census* that do not produce their own pulp on-site but may repulp secondary fiber as an input to production.

- Integrated mills (235)—mills producing not only final products but also the pulp required to manufacture these products. Also included are mills that have some production lines devoted to paper production and others devoted to market pulp production (a mill that is both a pulp mill and a paper mill but that does not use the pulp produced on-site as an input to the on-site paper production).[3]

This categorization of mills divides them only according to whether they engage in market activities to meet their input needs; it does not discriminate according to facility size. Hence, this

definition does not imply that an integrated facility is necessarily larger than a pulp facility; however, in reality the integrated mill may dwarf the pulp mill. This characterization refers to each mill's evaluation of the relative costs of purchasing or manufacturing their input; integrated mills produce their input rather than purchase it, whereas nonintegrated facilities rely on the market to meet their input demand.

A.2.4 Products and Markets

The analysis described in the following sections accounts for all marketable commodities involved in producing pulp and paper. The first marketable product is pulp, either bleached or unbleached, and the second marketable product is the final paper or paperboard product. An additional marketable commodity is secondary fiber. All of these products are consumed and produced domestically, as well as traded internationally. Therefore, domestic producers export some pulp and paper products to other countries, and foreign producers supply their pulp and paper products to U.S. markets. This section includes tables and figures on value, quantity, and price trends over the past decade for aggregate products (i.e., market pulp, paper, and paperboard).

Domestic quantity and value shipped for pulp products from 1981 to 1989 are shown in Table A-1 (see Figures A-2 and A-3). In 1989, the domestic shipments of pulp products were valued at $7.4 billion, which was an increase of 115 percent over the pulp shipment value in 1981. As shown in Table A-1 and Figure A-2, the quantity of pulp shipped grew fairly steadily over the 9-year period, reaching 11.4 million tons in 1989. The average price for pulp per ton was approximately $645 (see Table A-1). Aggregate prices per ton for pulp, paper, and paperboard products are shown in Figure A-4. Special Alpha and dissolving woodpulp products had the highest estimated price per ton at $735.33. Bleached sulfate pulps were close to average for all pulps with a price of $646 per ton. Lower end pulps included unbleached sulfate, $384 per ton, and unbleached secondary fiber, $417 per ton.

Table A-2 shows domestic quantity and value shipped for paper products from 1981 to 1989 (see also Figures A-2 and A-3). Total paper products in 1989 were valued at $33.3 billion;

TABLE A-1

U.S. PRODUCTION OF PULP: 1981-1989[4, 5, 6, 7, 8]

Year	Quantity Shipped Short Tons	Value Shipped (10^3)	Price/Ton
1981	8,259,272	3,424,840	414.67
1982	8,581,831	3,238,794	377.40
1983	9,359,292	3,252,707	347.54
1984	9,927,473	4,001,373	403.06
1985	9,952,129	3,686,080	370.38
1986	11,132,855	4,017,736	360.89
1987	11,575,838	5,135,618	443.65
1988	11,553,220	6,494,338	562.12
1989	11,423,483	7,369,559	645.12

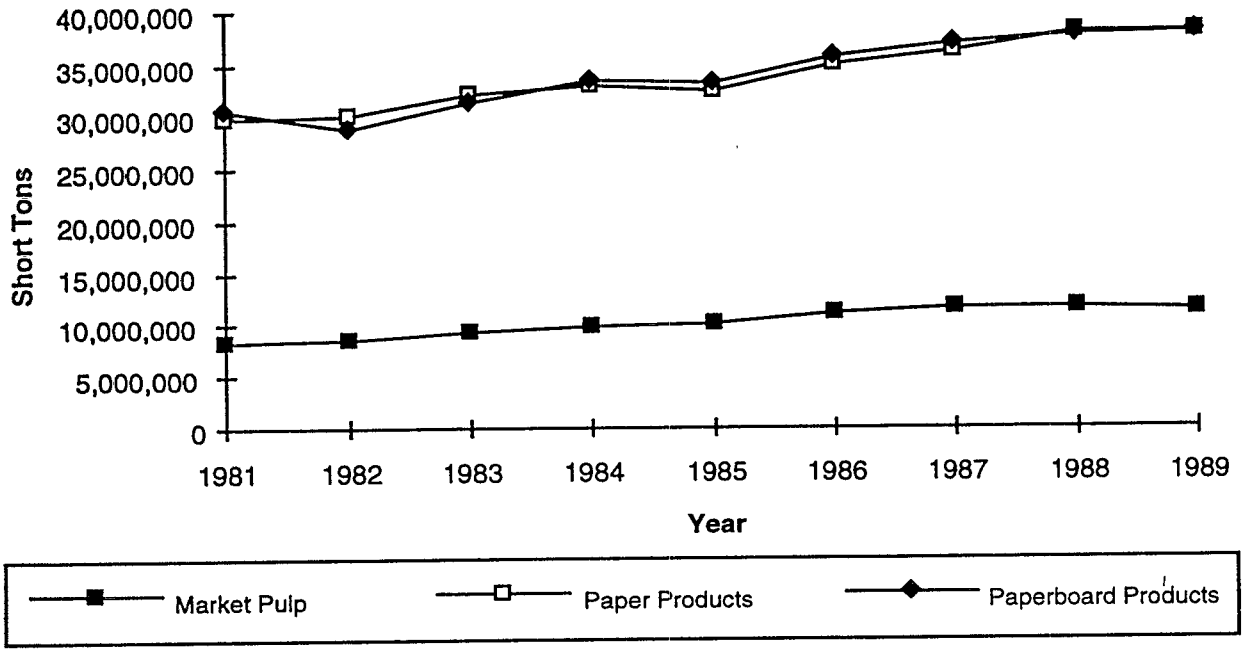


Figure A-2 U.S. quantities shipped of pulp, paper, and paperboard products: 1981-1989

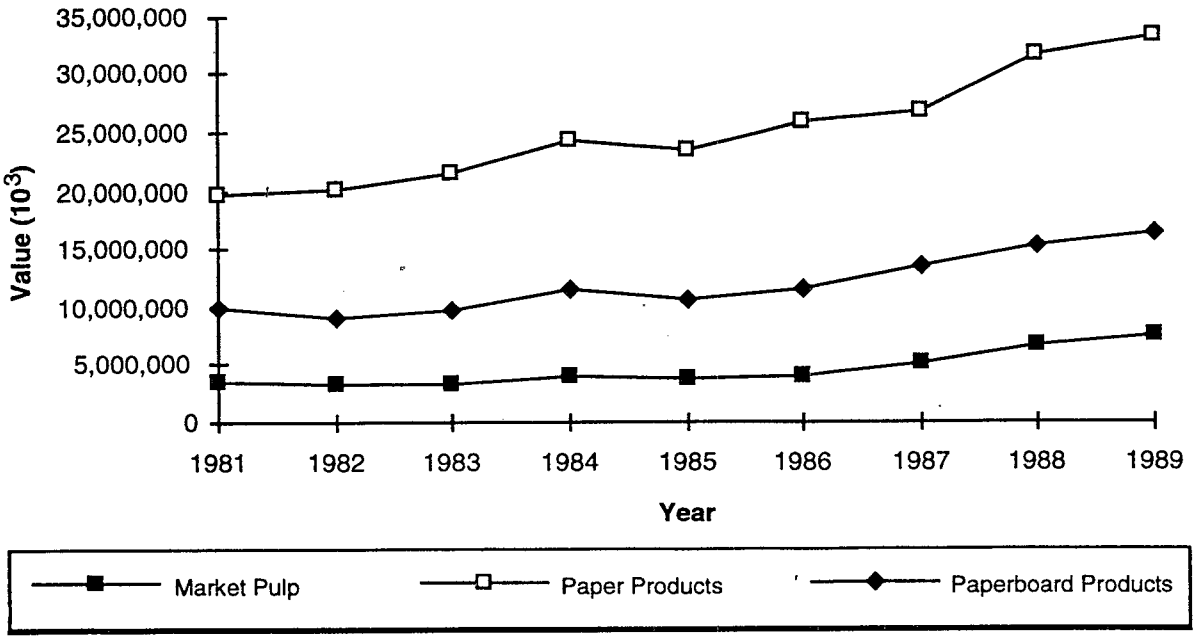


Figure A-3. U.S. value of shipments of pulp, paper, and paperboard products: 1981-1989

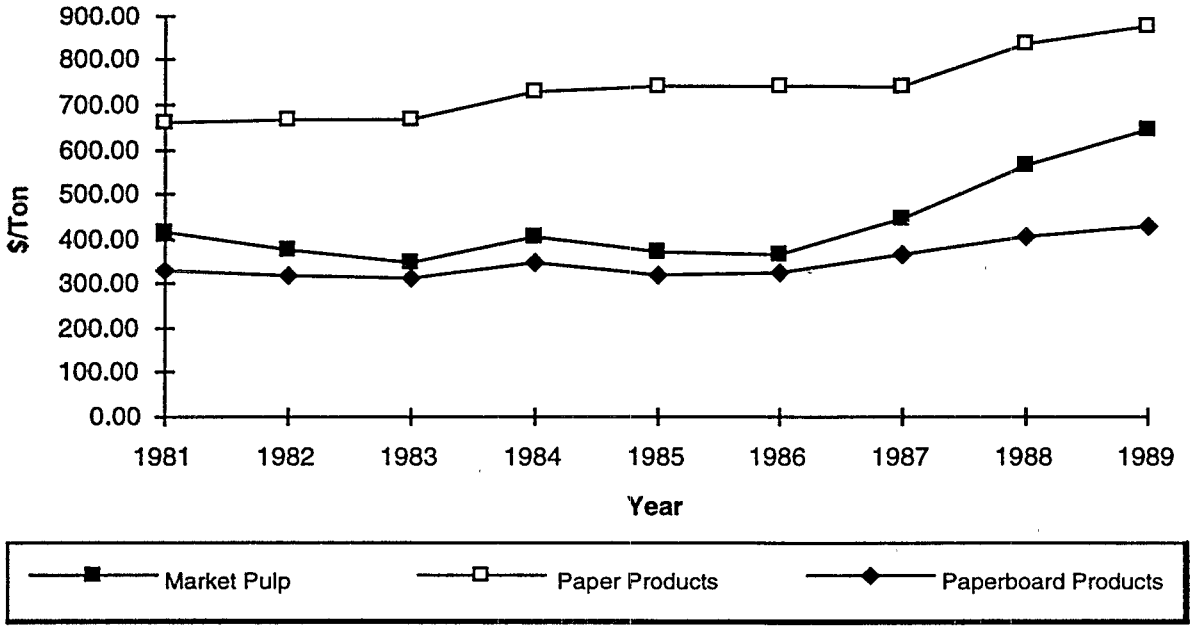


Figure A-4. Price per ton for U.S. pulp, paper, and paperboard products: 1981-1989

TABLE A-2

U.S. PRODUCTION OF PAPER PRODUCTS: 1981-1989[9, 10, 11, 12, 13]

Year	Quantity Shipped Short Tons	Value Shipped (10^3)	Price/Ton
Total Paper Products			
1981	29,815,913	19,607,188	657.61
1982	30,150,893	20,157,769	668.56
1983	32,205,274	21,399,481	664.47
1984	32,989,205	24,271,824	728.72
1985	32,317,371	23,550,366	739.62
1986	34,859,400	25,782,800	739.62
1987	36,133,517	26,835,126	742.67
1988	38,005,856	31,719,331	834.59
1989	38,073,553	33,302,931	874.70
Printing and Writing Paper			
1981	20,790,643	13,339,811	641.63
1982	20,986,247	13,553,318	645.82
1983	22,662,033	14,504,942	640.05
1984	23,924,514	17,135,025	708.58
1985	23,514,596	16,661,865	694.42
1986	25,448,416	17,671,871	694.42
1987	26,799,576	19,090,537	712.34
1988	27,948,521	22,833,368	816.98
1989	27,878,961	23,334,857	837.01
Packaging and Industrial Converting Paper			
1981	4,994,353	2,717,212	544.06
1982	4,873,388	2,766,858	567.75
1983	5,096,948	2,917,972	572.49
1984	4,975,517	3,118,102	605.40
1985	4,686,169	2,836,997	624.29
1986	4,642,574	2,898,312	624.29
1987	4,437,607	3,173,890	715.23
1988	4,874,730	3,746,612	768.58
1989	4,743,575	3,910,349	824.35

printing and writing paper products were valued at $23.3 billion, and packaging and industrial converting paper products were valued at $3.9 billion. In 1989, value of shipments increased almost 70 percent over 1981. The largest increase in growth was in the printing and writing papers sector, which increased almost 75 percent in 1989 over 1981. Shipments of paper products in 1989 totaled 38.1 million tons. The average prices of paper products per ton from 1981 to 1989 are compared with average prices for pulp and paperboard products in Figure A-4. The average estimated price per ton for paper products was $875 (Table A-2). Printing and writing and packaging and industrial paper products had lower average values per ton: $837 and $824, respectively. The two market segments had a lower average price per ton than the total paper market throughout the 9-year period. Individual products with a higher price per ton than the average included cotton fiber writing paper, $2,040; special industrial paper, $1,718; and glassine, greaseproof, and vegetable parchment, $1,359. The lowest priced paper product was newsprint at $490 per ton. Other paper products valued less than $700 per ton included unbleached kraft packaging paper, shipping sack, and uncoated groundwood paper.

Table A-3 shows quantity and value shipped for paperboard products from 1981 to 1989 (see Figures A-2 and A-3). Total shipments of paperboard were almost $16.3 billion, which represents an increase of 63 percent over the 1981 value. As Figure A-2 and Table A-3 illustrate, quantities shipped of paperboard dipped in 1982 and 1985 slightly but otherwise rose steadily over the 1981 to 1989 period, reaching 38 million tons in 1989. Paperboard products had a price per ton less than that of paper products in 1989 at an average of $427 per ton (Table A-3 and Figure A-4). The lower value per ton for paperboard products is illustrated by the fact that in 1989 paperboard products accounted for approximately half (38 million tons) of all paper and paperboard products shipped but accounted for only 33 percent of the value shipped. All of the bleached packaging and industrial paperboard products had a higher than average price per ton. The highest average prices per ton for individual products were molded pulp products, $1,196; folding carton boxboard, $721; and milk carton board, $719. Hardboard and insulating board had the lowest price per ton with $337 and $338, respectively.

TABLE A-3

U.S. PRODUCTION OF PAPERBOARD PRODUCTS: 1981-1989[14, 15, 16, 17, 18]

Year	Quantity Shipped Short Tons	Value Shipped (10^3)	Price/Ton
1981	30,566,254	9,993,099	326.93
1982	28,912,522	9,138,993	316.09
1983	31,470,079	9,738,689	309.46
1984	33,514,510	11,572,125	345.29
1985	33,030,693	10,562,943	319.79
1986	35,613,237	11,452,177	321.57
1987	36,989,614	13,531,922	365.83
1988	37,762,521	15,235,749	403.46
1989	38,047,313	16,256,939	427.28

A.2.5 Foreign Trade

In 1989, the United States was a net importer of total pulp, paper, and paperboard products. Imports in 1989 totaled $10.2 billion. The majority of U.S. pulp imports come from Canada and secondly Latin America. The top three countries exporting paper and paperboard products to the U.S. are Canada, Finland, and Sweden. In 1989 the U.S. exported approximately $6.6 billion in pulp, paper, and paperboard products. The two largest importing countries of U.S. pulp products are Japan and Germany. Major importers of U.S. paper and paperboard products are Canada, Japan, and the U.K.[19]

As shown in Table A-4 and Figure A-5, the U.S. was a net exporter of pulp products in 1989 and had been since 1986. In 1989, exports totaled $3.6 billion, approximately 48 percent of the domestic value of shipments. Imports were 41 percent of the domestic value of shipments and totaled almost $3.0 billion. Total quantities of pulp exported and imported were about 6.4 and 5 million tons, respectively. Bleached and semi-bleached sulphate and soda woodpulp were the pulp products imported and exported in the greatest amount.[20]

The U.S. was a net importer of paper products in 1989, as it was for the eight years prior to 1989 (see Table A-5 and Figure A-6). Exports represent 3.6 percent of the domestic value of shipments whereas imports represent 20.7 percent. Imports to the U.S. were mainly from the printing and writing paper segment; newsprint was the number one imported paper product. Imports of printing and writing paper were over 27 percent of the domestic value of printing and writing paper shipped. In 1989, major imports in the printing and writing group were newsprint and uncoated groundwood paper. Exports were led in this segment by newsprint and clay coated printing papers. In the packaging and industrial segment, imports were led by the glassine, greaseproof, and vegetable parchment product group. Shipping sack was the product exported in the largest quantity.[25]

Exports and imports of paperboard products for 1981 to 1989 are shown in Table A-6 and Figure A-7. As with pulp, the U.S. is a net exporter of these products, exporting $1.7 billion, or about 10 percent of the value of pulp shipments in 1989. Imports were $3.3 million, or less than 2 percent of the value of total pulp shipments. However, by 1989 imports increased by a

TABLE A-4

FOREIGN TRADE OF MARKET PULP: 1981-1989[21, 22]

Year	Export Quantity Short Tons	Export Value (10^3)	Export Price/Ton	Import Quantity Short Tons	Import Value (10^3)	Import Price/ Tons
1981	3,809,545	1,746,506	458.46	4,086,698	1,764,287	431.71
1982	3,499,208	1,486,885	424.92	3,655,786	1,493,241	408.46
1983	3,746,826	1,431,827	382.14	4,093,436	1,472,478	359.72
1984	3,678,468	1,565,493	425.58	4,490,081	1,844,766	410.85
1985	3,902,326	1,425,560	365.31	4,465,746	1,520,907	340.57
1986	4,615,769	2,073,541	449.23	4,581,760	1,601,378	349.51
1987	5,071,332	2,350,742	463.54	4,850,238	2,069,394	426.66
1988	5,729,859	3,026,445	528.19	5,038,158	2,663,424	528.65
1989	6,353,213	3,613,114	568.71	5,004,366	2,980,197	595.52

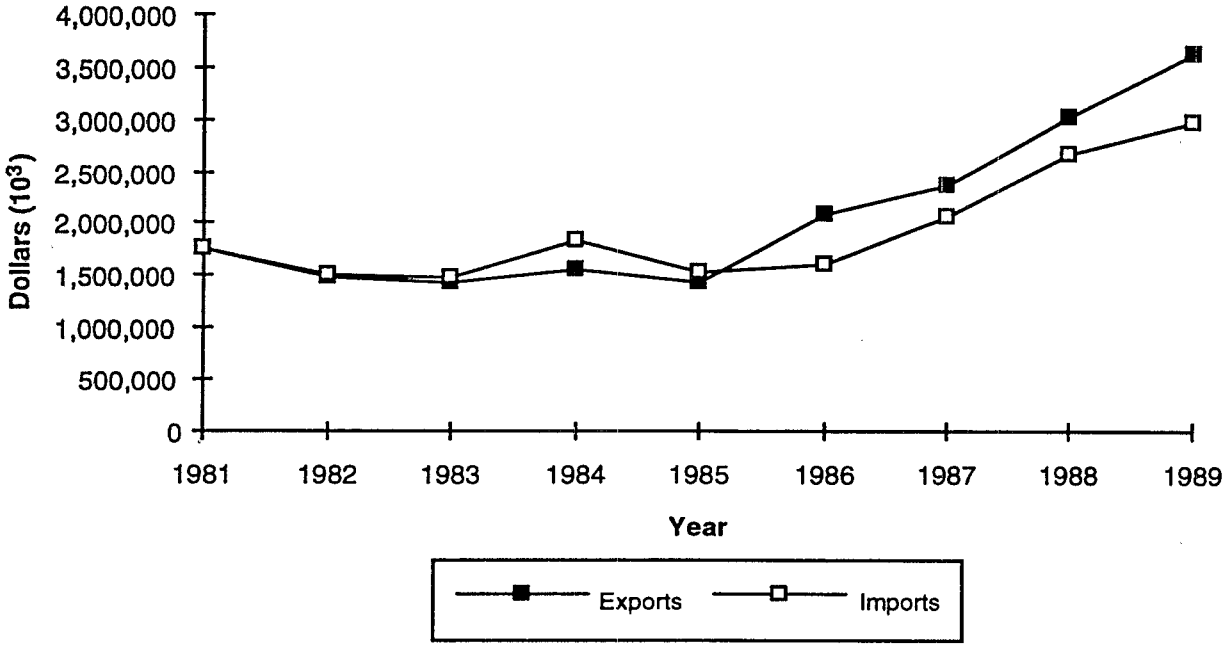


Figure A-5 U.S. foreign trade of market pulp: 1981-1989

TABLE A-5

FOREIGN TRADE OF PAPER PRODUCTS: 1981-1989[23, 24]

Year	Export Quantity Short Tons	Export Value (10^3)	Export Price/ Ton	Import Quantity Short Tons	Import Value (10^3)	Import Price/ Tons
Total Paper Products						
1981	1,008,409	846,775	839.71	7,716,284	3,247,846	420.91
1982	840,445	679,069	807.99	7,381,252	3,226,307	437.09
1983	773,760	599,557	774.86	8,189,498	3,428,868	418.69
1984	810,933	632,493	779.96	10,113,718	4,592,641	454.10
1985	779,000	594,337	762.95	10,637,427	4,906,913	461.29
1986	883,768	642,728	727.26	10,925,453	5,051,916	462.40
1987	921,419	776,226	842.42	11,765,207	5,768,703	490.32
1988	1,102,489	988,031	896.18	12,063,790	6,799,044	563.59
1989	1,465,752	1,233,526	841.57	11,814,260	6,900,798	584.11
Printing and Writing Paper						
1981	653,777	494,310	756.08	7,615,656	3,171,894	416.50
1982	554,274	325,423	587.12	7,294,771	3,157,203	432.80
1983	496,690	325,423	655.18	8,070,359	3,344,950	414.47
1984	509,723	353,889	694.28	9,937,922	4,469,714	449.76
1985	517,211	333,223	644.27	10,409,435	4,754,971	456.79
1986	582,909	379,825	651.60	10,616,810	4,862,153	457.97
1987	588,865	452,732	768.82	11,396,765	5,533,785	485.56
1988	714,503	608,521	851.67	11,661,032	6,518,760	559.02
1989	1,102,998	822,549	745.74	11,286,377	6,375,753	564.91
Packaging and Industrial Converting Paper						
1981	354,632	352,464	993.89	100,628	75,954	754.80
1982	286,171	296,971	1,037.74	86,481	69,104	799.07
1983	277,370	274,134	988.33	119,138	83,919	704.38
1984	301,210	278,604	924.95	175,796	122,927	699.26
1985	261,789	261,114	997.42	227,992	151,942	666.44

TABLE A-5 (cont.)

Year	Export Quantity Short Tons	Export Value (10^3)	Export Price/ Ton	Import Quantity Short Tons	Import Value (10^3)	Import Price/ Tons
1986	300,859	262,903	873.84	308,643	189,763	614.83
1987	332,554	323,494	972.76	368,442	234,918	637.60
1988	387,986	379,510	978.15	402,758	280,284	695.91
1989	362,754	410,977	1,132.94	527,883	525,045	994.62

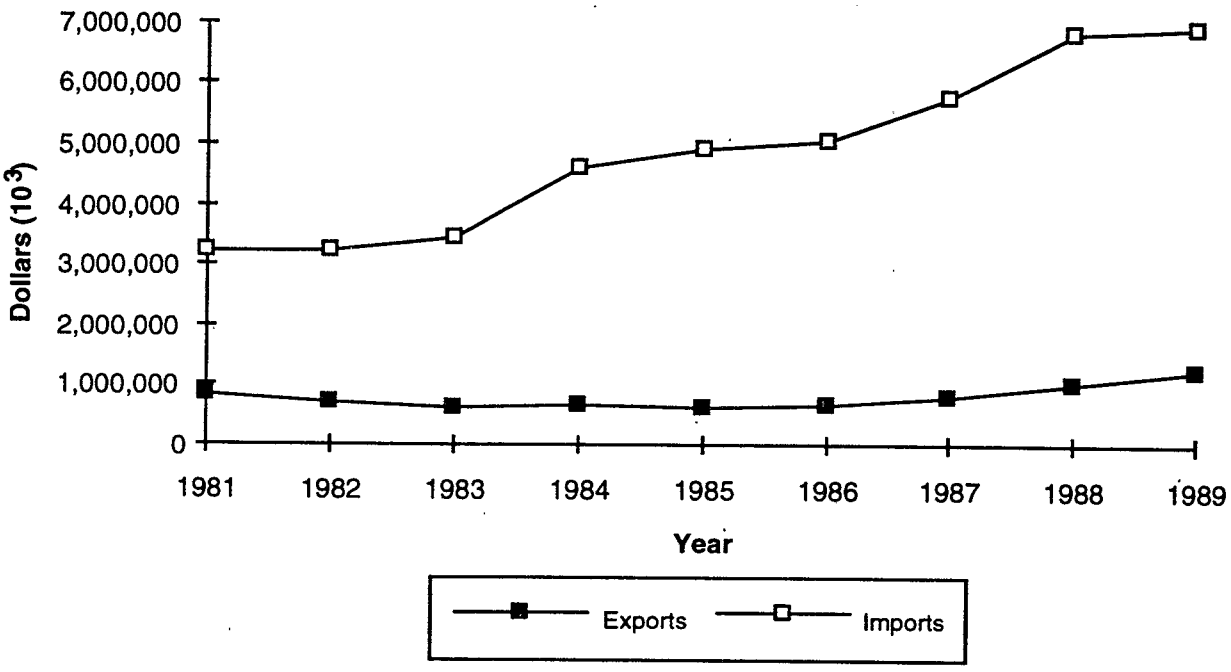


Figure A-6 U.S. foreign trade of paper products: 1981-1989

TABLE A-6

FOREIGN TRADE OF PAPERBOARD PRODUCTS: 1981-1989[27, 28]

Year	Export Quantity Short Tons	Export Value (10^3)	Export Price/Ton	Import Quantity Short Tons	Import Value (10^3)	Import Price/ Tons
1981	3,025,579	1,233,162	407.58	528,658	114,041	215.72
1982	2,829,968	1,075,284	379.96	536,165	117,898	219.89
1983	3,210,777	1,118,478	348.35	645,069	153,424	237.84
1984	3,008,283	1,157,019	384.61	742,272	189,989	255.96
1985	2,801,547	991,898	354.05	600,667	167,600	279.02
1986	3,276,516	1,211,020	369.61	621,093	195,211	314.30
1987	3,657,633	1,504,195	411.25	670,279	226,419	337.80
1988	3,774,075	1,713,375	453.99	663,456	238,584	359.61
1989	3,793,982	1,749,159	461.04	723,211	330,851	457.48

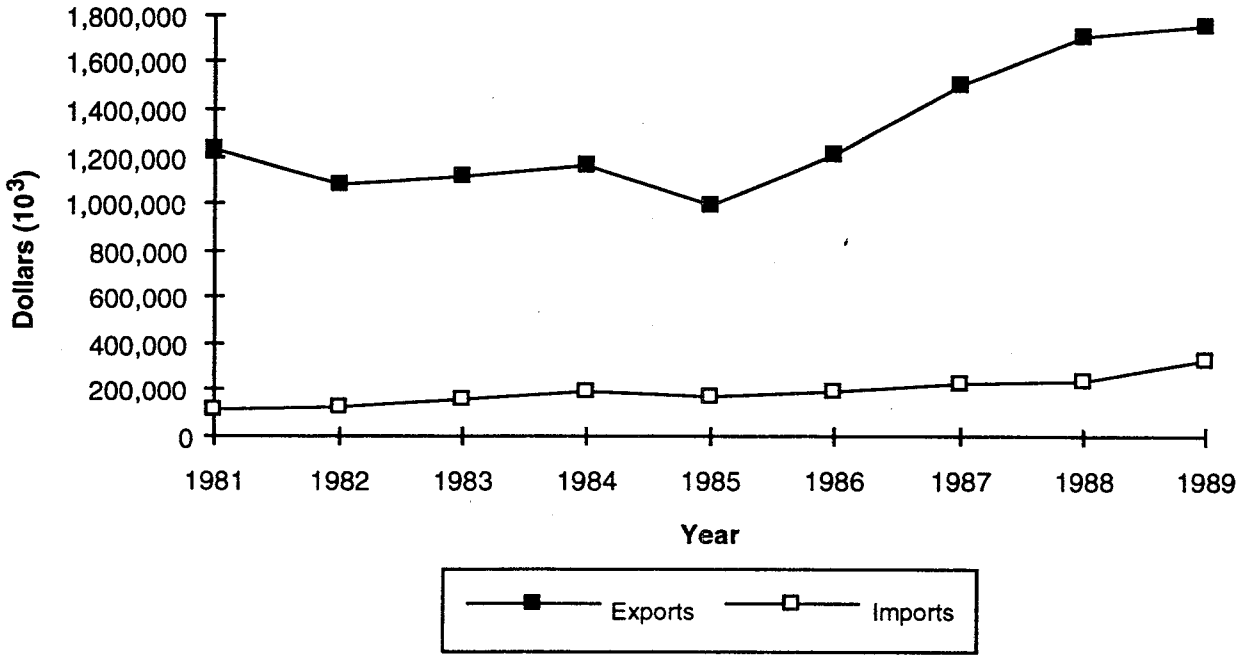


Figure A-7 U.S. foreign trade of paperboard products: 1981-1989

greater percentage than exports over 1981 values. The total quantity exported in 1989 was almost 3.8 million tons: the main products were milk carton board and linerboard. Imports totaled 723,000 tons and were led by construction paper, unbleached kraft packaging and paperboard, recycled paperboard, and semichemical paperboard.[26]

A.3 MODELING MARKET ADJUSTMENTS

Implementing regulations to control air and water pollutants from pulp and paper manufacturers will affect the costs of production in the U.S. pulp and paper industry. As shown in Section 4.2 of this report, the costs of the regulations will vary across the many different mills in the industry, depending on the production processes currently employed. Mill-level production responses to these additional costs will determine the market impacts of the regulations. Specifically, the cost of the regulations may induce some mills, or product lines within mills, to close or to change their current level of production. These choices affect, and in turn are affected by, the market price for market pulp, paper, and paperboard products.

This section examines the impact of the regulations that affect the production costs for facilities in the U.S. pulp and paper industry. It provides an overview of the basic economic theory of the effect the regulations may have on facility production decisions and of the concomitant effect on pulp, paper, and paperboard prices.

An economic impact analysis should assess the market-, facility-, small business-, and community-level impacts of proposed regulatory alternatives. A variety of approaches may be used to quantify and evaluate economic impacts; they reflect a variety of underlying paradigms. The neoclassical model provides the state-of-the-art paradigm for regulatory analysis and establishes the framework for subsequent empirical modeling. The paradigm appropriate for this industry is described below. It is based, in part, on the industry profile information presented in Section 2 of this report and followed by the description of an integrated approach to implementing the conceptual model.

We employed standard microeconomics concepts to model the supply of pulp, paper, and paperboard products and the impacts of the regulations on production costs and facility output decisions. The three main elements of the analysis are regulatory effects on the manufacturing facility, market responses, and facility-market interactions.

A.3.1 Facility-Level Effects

At any point in time, the costs that a firm faces can be classified as either unavoidable (sunk) or avoidable. In the former category, we include costs to which the firm is committed and that must be paid regardless of any future actions of the firm. For instance, debt incurred to construct a production facility must be repaid regardless of the facility's production plan and even if the facility ceases operation prior to full repayment, unless the range of viable alternatives includes declaring bankruptcy by the owners. The second category, avoidable costs, describes any costs that are foregone by ceasing production. These costs can be further refined to distinguish between costs that vary with the level of production and those that are independent of the production level. For example, production factors such as labor, materials, and capital (except in the short run) vary with the level of output, whereas expenditures for facility security and administration may be independent of production levels but avoidable if the facility closes down. Determining both the avoidability and the variability of firms' costs is essential to the analysis of economic responses to the proposed regulations.

Figure A-8 illustrates the derivation of a facility supply function for a market pulp, paper, or paperboard product from the classical U-shaped structure of production costs with respect to output. Let AVAC be the facility's average variable (avoidable) cost curve and ATAC the average total (avoidable) cost curve for producing the product. The vertical distance between ATAC and AVAC is the per-unit average cost of nonvariable avoidable costs, and it approaches zero as the number of units of output increases. MC is the marginal cost of producing paper, paperboard, or market pulp, which intersects AVAC and ATAC at their respective minimum points. All these curves are conditional on input prices and the technology in place at the facility.

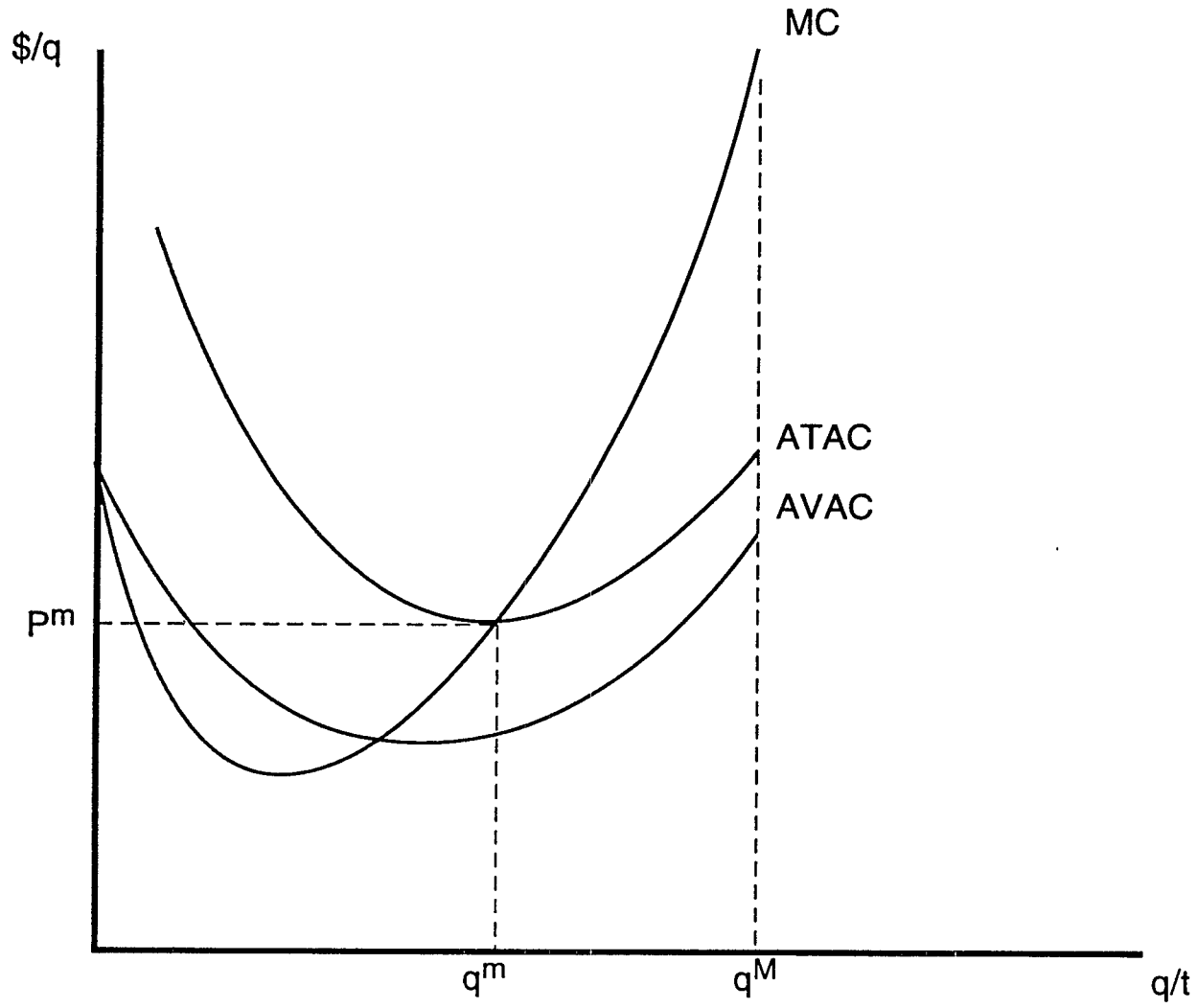


Figure A-8 Product supply function at facility

The facility supply function is the section of the marginal cost curve bounded by the quantities q^m and q^M. q^M is the largest feasible production rate that can be sustained at the facility given the technology and other fixed factors in place, regardless of the output price. q^m is the minimum economically feasible production rate determined by the minimum of the AVAC curve, which coincides with the price p^m. Suppose the market price of paper is less than p^m. In this case, the firm's best response is to close the facility and not produce paper because $P <$ AVAC implies that total revenue would be less than variable costs if the facility operated at the associated output levels below q^m.

The nature of the pulp and paper production process typically implies that the manager prefers to operate the plant at full capacity when producing output. This may at first seem to contradict the notion of the U-shaped cost structure discussed above; however, rather than being logically inconsistent, it is actually just a matter of what period of time is being considered in the decision. We will describe the manager's decision of whether to operate at full capacity or not at all as a very short run problem (daily or weekly), whereas the decision of how much to produce over a longer period of time (e.g., a year) is an aggregation of these very short run decisions.

Since our model uses a year as the time unit of observation, it is the latter model we are interested in. In order for that model to be consistent with U-shaped costs, successive very short run operating decisions must involve successively higher operating costs beyond a certain point. The reason average variable costs, and thus marginal costs, might rise with the number of production days per year is found in the law of diminishing marginal returns—the classic cause of U-shaped cost curves in economic theory. Beyond a certain level of operation (expressed in terms of duration of days or level of production), the marginal product of variable inputs to production diminishes given fixed plant and capital equipment. The corresponding marginal costs therefore increase beyond that level of output or operating days.

In the case of the pulp and paper industry, factors contributing to this notion of rising marginal costs might include the increased likelihood of machine failure—and thus reduced productivity—as less down-time is available for maintenance, the potential for raw material

shortages with less time to accumulate inventories, or reduced service lives of the physical capital through higher rates of utilization, thus requiring more rapid replacement of the capital stock.

Now consider the effect of the proposed regulatory control costs. These control costs fall into one of two categories: avoidable variable and avoidable nonvariable. We characterized these proposed costs as avoidable because a firm can choose to cease operation of the facility and thus avoid incurring the costs of compliance. The variable control costs include the O&M costs of the controls, and the nonvariable costs include compliance capital equipment.

The effect of these additional costs is illustrated in Figure A-9. The facility's AVAC and MC curves shift upward (to AVAC' and MC') by the per-unit variable compliance costs. In addition, the nonvariable compliance costs increase total avoidable costs and thus the vertical distance between ATAC' and AVAC'. The facility's supply curve shifts upward with marginal costs, and the new (higher) minimum operating level ($q^{m'}$) is determined by a new (higher) $p^{m'}$.

Now consider the effect of compliance costs on the derived demand for inputs at the regulated facility. Paper and paperboard manufacturing facilities are market demanders of pulp. We can employ a similar neoclassical analysis to the one above to demonstrate the effect of compliance costs on the demand for the market pulp input. Figure A-10 illustrates the paper and paperboard manufacturing facility demand function for market pulp. Each point on the derived demand curve equals the firm's maximum willingness to pay for the corresponding marginal input. This is typically referred to as the input's value of marginal product (VMP), which is equal to the price of the output (P) less the per-unit compliance costs (c) times the input's "marginal physical product" (MPP), which is the incremental output attributable to the incremental input. Ignoring any effect on the output price for now, an increase in per-unit compliance costs due to the regulations will lower the VMP of all inputs by the unit amount of the additional compliance costs, leading to a downward shift in the derived demand curve in Figure A-10 (a) from D_i to D'_i.

The paper and paperboard manufacturing facility demand curve for market pulp is downward sloping in this example, indicating that the marginal physical product of market pulp diminishes as more is used to produce paper and paperboard, and substitution possibilities exist

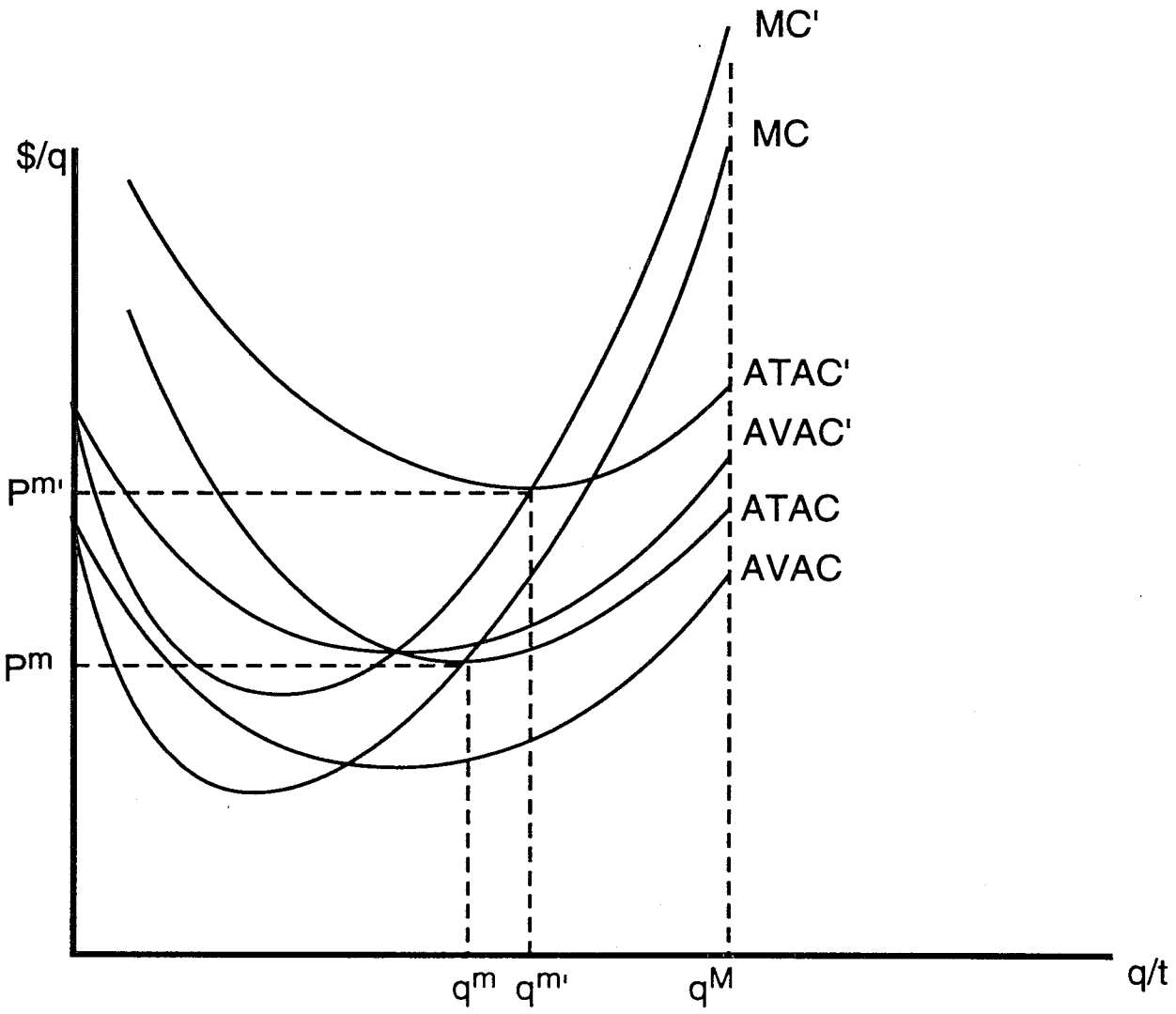
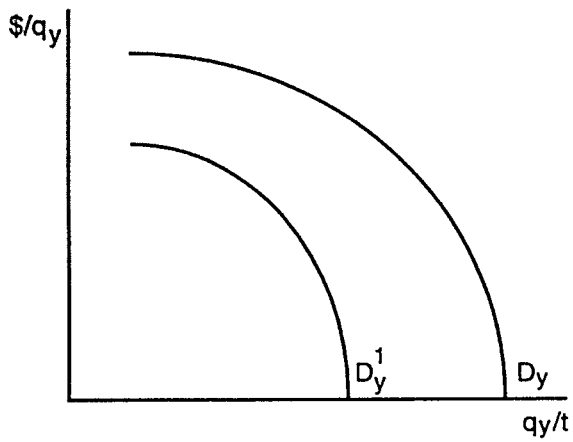
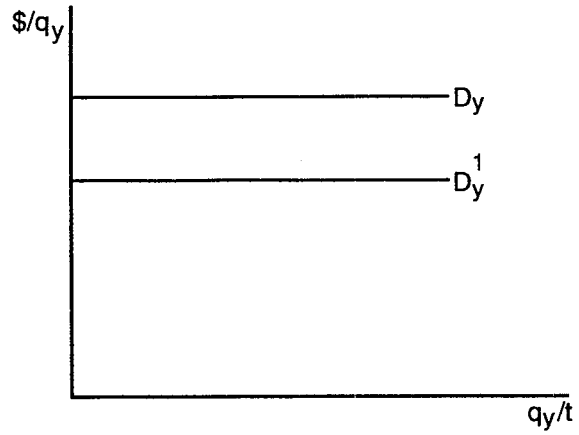


Figure A-9 Effect of compliance costs on product supply function at facility



a) Without Fixed Input Coefficients



b) With Fixed Input Coefficients

Figure A-10 Effect of compliance costs on derived demand for market pulp at regulated facility

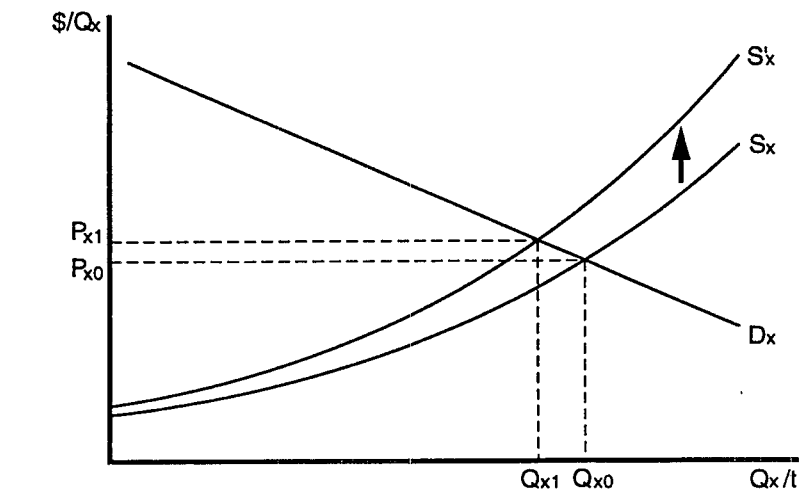
with other inputs. If, as is assumed in this model, the input-output relationship between the market pulp and the final paper and paperboard product is strictly fixed, not only by product specification but also by constant efficiency of use at all input levels, then the VMP of the market pulp is constant and the derived demand curve is horizontal with the constant VMP as the vertical intercept, as shown in Figure A-10 (b).

The regulations will affect the costs of producing both market pulp and paper and paperboard products. Because the markets are interrelated, paper and paperboard market prices and quantities will be affected by changes in the market price and quantity of market pulp and vice versa. These market linkages are described below.

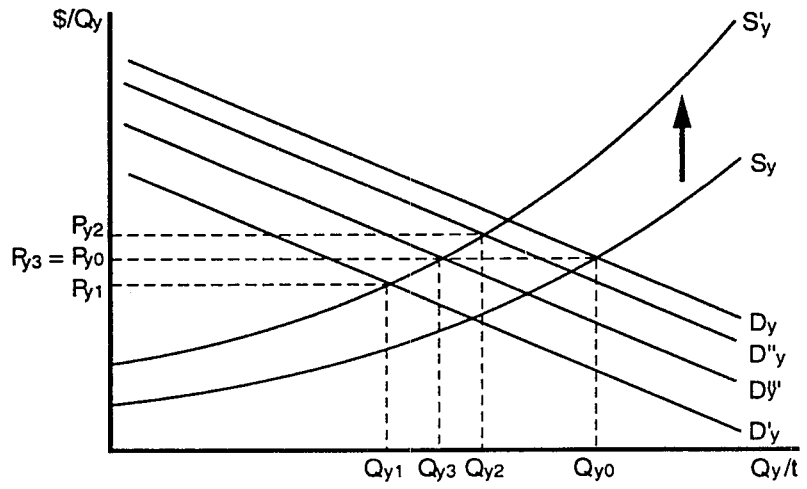
A.3.2 Market-Level Effects

For the purposes of this example, consider the relationship depicted in Figure A-11 between the markets for a single paper or paperboard product, Q_x, and a market pulp input, Q_y. Q_y, along with other inputs, such as labor, energy, and chemicals, is used in the production of Q_x. The competitive structure of the market is an important determinant of the regulations' effect on market price and quantity. Below we show the market effects under the assumption of perfectly competitive market structure for the pulp and paper industry.

We assumed that prices for the respective commodities are determined in competitive markets (i.e., individual facilities have negligible power over the market price of the commodities and thus take the price as "given" by the market). Under perfect competition, market prices and quantities are determined by the intersection of market supply and demand curves. A market supply curve is the sum of all facility supply curves, and a market demand curve is the sum of the demand curves for all demanders of the commodity. The demanders of paper or paperboard product, Q_x, are final product consumers, and the demanders of market pulp, Q_y, are the individual facilities that purchase market pulp for producing paper and paperboard products. Without the proposed compliance costs, the market quantity and price of paper or paperboard product, Q_x (Q_{x0}, P_{x0}), are determined by the intersection of the market demand curve (D_x) and



(a) Market for Paper or Paperboard Product, Q_x



(b) Market for Pulp, Q_y

Figure A-11 Market equilibria with and without compliance costs

the market supply curve (S_x), and the market quantity and price of market pulp, Q_y (Q_{y0}, P_{y0}), are determined by the intersection of the market demand curve (D_y) and market supply curve (S_y).

Imposing the regulations increases the costs of producing pulp and, thus, paper and paperboard, shifting the market supply function for both commodities upward to S'_x and S'_y, respectively (see Figure A-11). The supply shift in the market for paper and paperboard products causes the market quantity of each to fall to Q_{x1} and the market price to rise to P_{x1} in the new equilibrium. In the market for pulp, the drop in the market quantity is unambiguous; however, the direction of the change in the market price can only be determined if we know the relative magnitudes of the demand and supply shifts. If the downward demand effect dominates, the price will fall (e.g., P'_{y1}), if the upward supply effect dominates, the price will rise (e.g., P_{y2}), and if the effects just offset each other, the price remains unchanged (e.g., $P_{y3} = P_{y0}$).

The sign (positive or negative) of the effect of these market adjustments on commodity prices and quantities is summarized in Figure A-12; the magnitude of these effects is an empirical matter. The supply shifts for market pulp, paper, and paperboard cause the market price to rise and market quantity to fall for these commodities at the new equilibrium. However, the downward shift in the demand curve for market pulp will have an offsetting effect on price leaving the total effect ambiguous, while exacerbating the effect on quantity resulting in an even lower quantity produced. In both cases, the producers that are unaffected by the regulations receive the higher price for their products without the associated increase in compliance costs and thus increase their production levels.

Alternatively, if production cost savings are attributed to implementing pollution controls, downward supply shifts for market pulp and paper and paperboard products and upward shifts in the demand curve for market pulp are possible. The downward supply shifts will cause the market price to fall and market quantity to rise for these commodities at the new equilibrium, as displayed in Figure A-13. However, the upward shift in the demand curve for market pulp will have an offsetting effect on price, leaving the total effect ambiguous, while exacerbating the effect on quantity, resulting in an even higher quantity produced. In this scenario, the producers that are unaffected by the regulations receive lower prices for their products and thus reduce their production levels.

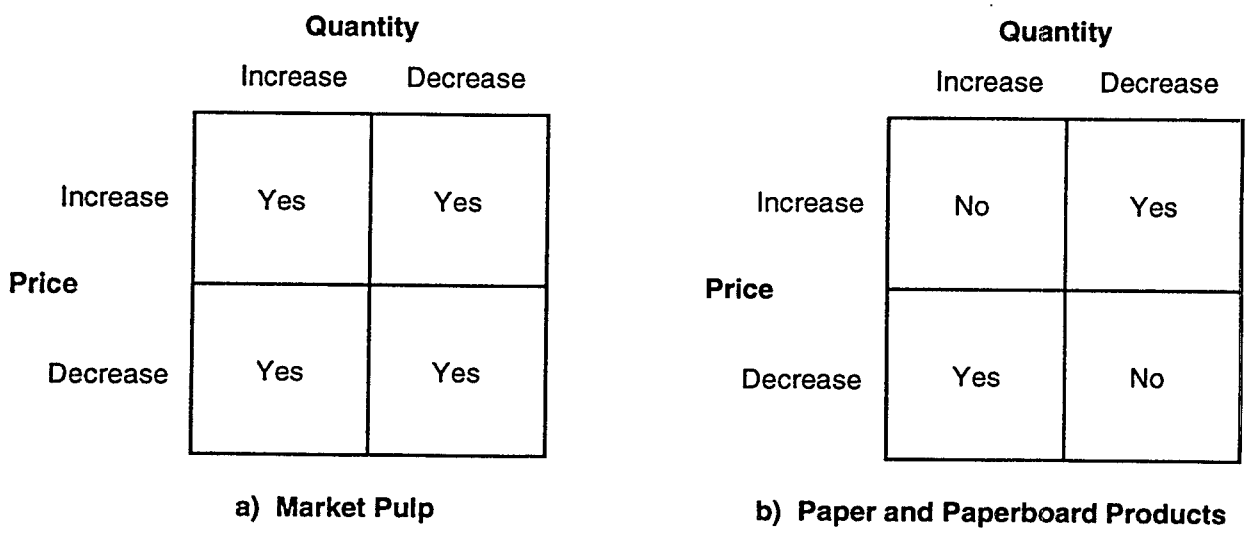
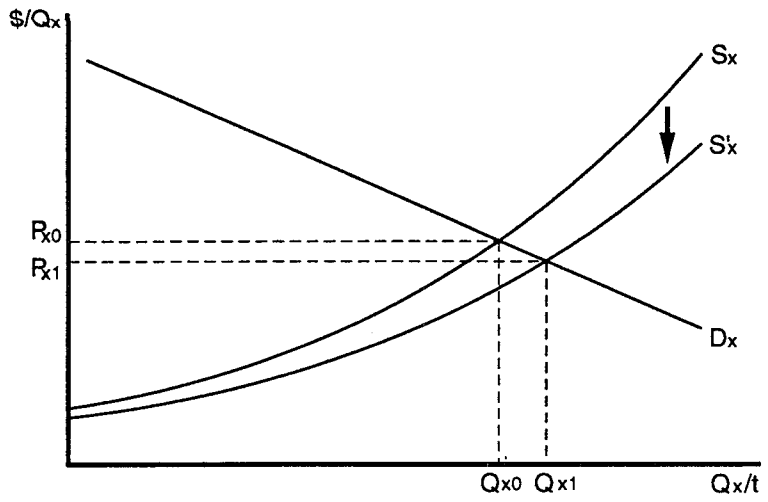
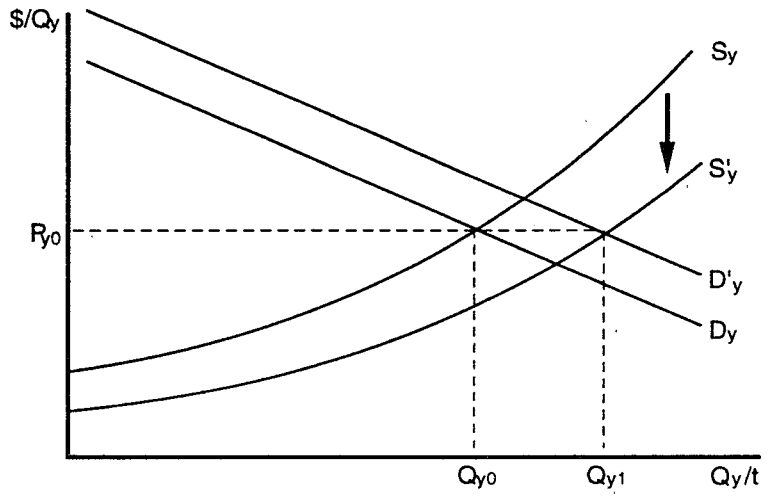


Figure A-12 Market adjustments for market pulp, paper and paperboard products



(a) Market for Paper or Paperboard Product, Q_x



(b) Market for Pulp, Q_y

Figure A-13 Market equilibria with and without compliance costs: cost savings attributed to regulation

A.3.3 Facility-Level Response to Control Costs and New Market Prices

In evaluating the market effects for pulp, paper, and paperboard products, we must distinguish between the initial effect of the regulations and the net effect after all markets have adjusted. Initially, assuming no production cost savings attributed to the pollution controls, all affected facilities' supply curves for market pulp, paper, and paperboard shift upward by the unit variable costs of the regulation. As a result, all affected facilities' derived demand curves for market pulp shift downward by the unit variable control costs. However, the upward shift in the industry supply curves for paper and paperboard pushes up the prices of those commodities, which subsequently raises the VMP of the market pulp and, thus, puts upward pressure on the derived demand for that commodity. In general, the initial upward shift in supply at the facility will be greater than the subsequent increase in market price so that the mill reduces supply of market pulp, paper, or paperboard. The initial downward shift in demand will typically dominate the subsequent upward shift so that the net shift is downward and the mill reduces demand for market pulp. However, determining which shift dominates for a particular mill is difficult: it depends on the relative magnitude of the facility-specific unit variable costs of the regulation and the changes in market prices.

Given changes in market prices and costs, mills will elect to either

- Continue to operate, adjusting production and input use based on new revenues and costs, or
- Close the facility if revenues do not exceed total avoidable costs.

This decision can be extended to the multi-product facility where product lines may be closed if product revenues are less than product-specific avoidable costs, and the entire facility may be closed if total revenues from all products (market pulp, paper, and paperboard) do not exceed facility-specific avoidable costs.

Thus, after considering the interaction of facility and market forces, we can derive the production responses at each individual facility. The facility-level output effects can be aggregated by mill type (pulp, paper, or integrated) to assess the distribution of production

changes across different segments of the industry. Facility output effects can also provide information on the employment impacts of the proposed regulations.

This approach to modeling the facility closure decision is based on conventional microeconomic theory. It compares the ATAC—which includes all cost components that fall to zero when production discontinues—to the expected post-regulatory price. Figure A-9 illustrates this comparison. If price falls below the ATAC, total revenue would be less than the total avoidable costs. In this situation, the owner's cost-minimizing response is to cease production.

An additional aspect of the facility-level impacts is the quantity adjustments. Changes in costs will change producers' output rates. However, some of this effect is mitigated when prices are increased. Of course, facility and product-line closures directly translate into quantity reductions. However, the output of operating facilities will also change as will supply from foreign sources. Affected facilities that continue to produce may increase or decrease their output levels depending on the relative magnitude of the unit variable control costs and the changes in market prices. Unaffected facilities will not face an upward shift in their product supply curves, so their response to higher product prices is to increase production. This response is illustrated in Figure A-14 as an upward movement along the facility's supply curve for the product. Foreign producers, which do not incur higher production costs because of the regulations, will respond in the same manner as these unaffected U.S. mills.

As mentioned earlier, if production cost savings are attributed to pollution control measures at a facility, the facility's product supply curve will shift downward. This response is illustrated in Figure A-15. The facility will enjoy lower costs of production because of the regulations and will respond by increasing production, given current market prices. In addition, recall that facility and market forces interact to determine the ultimate market adjustments and facility responses. The changes in the price of market pulp, an input into the production of paper and paperboard, will also affect the supply curves of facilities that produce paper and paperboard (i.e., paper mills and integrated mills that purchase market pulp). These indirectly affected mills will face upward shifts in product supply curves if market pulp prices increase—a result similar to mills facing increased production costs due to the regulations. Further,

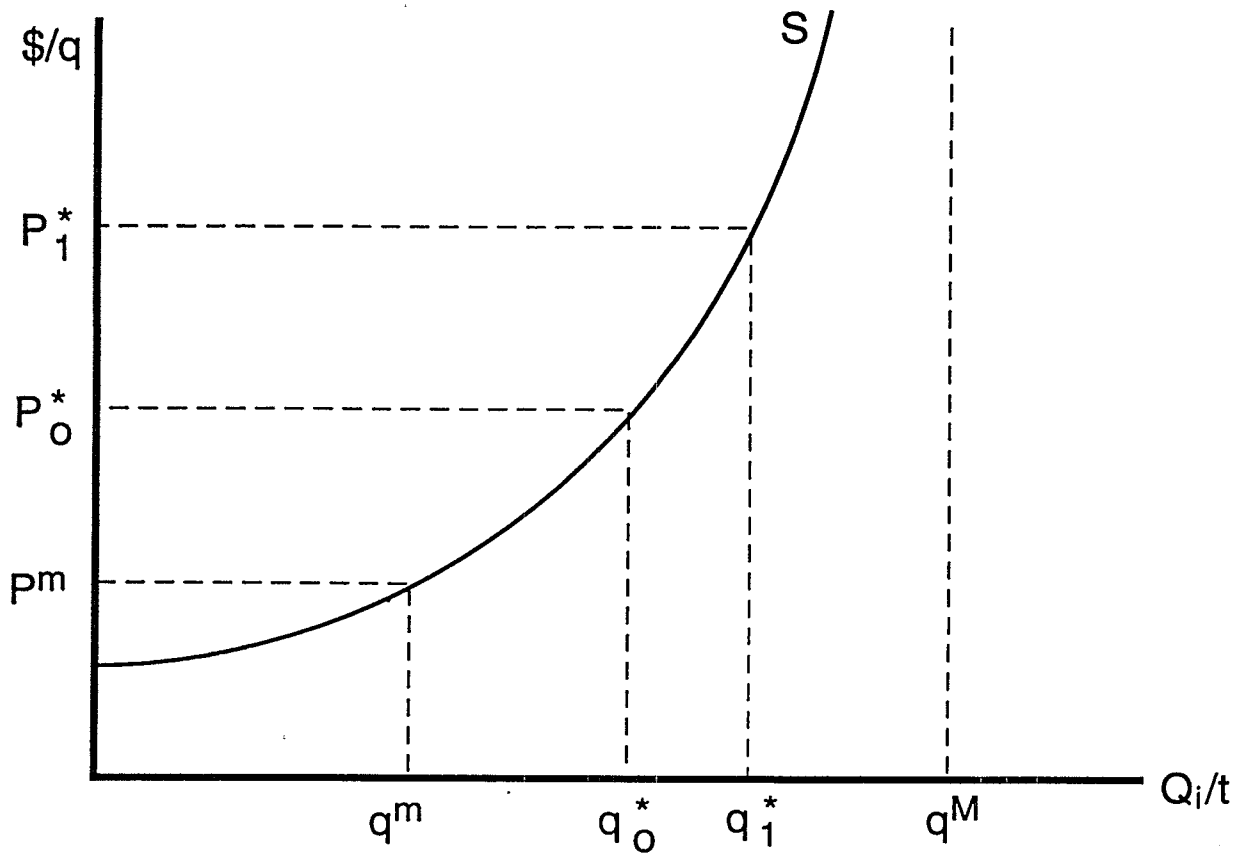


Figure A-14 Movement along the product supply function

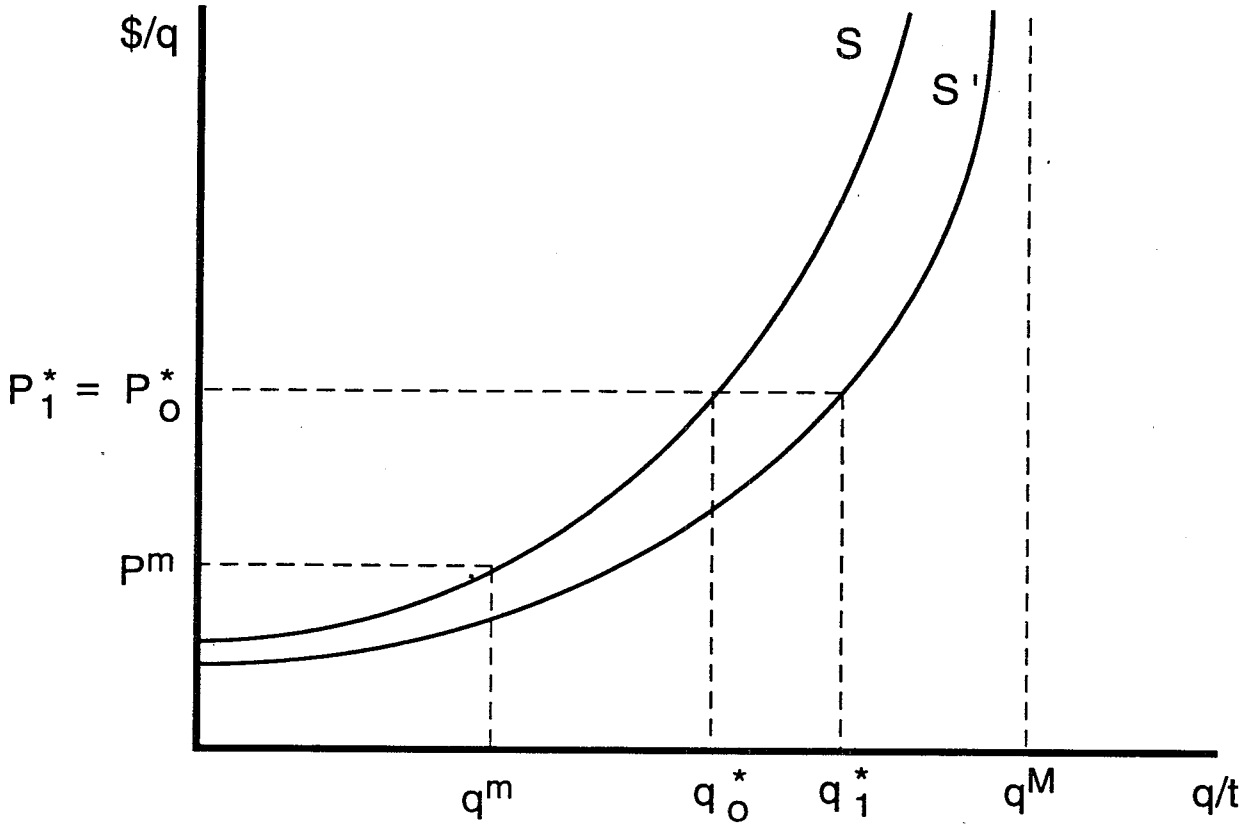


Figure A-15 Shift downward in the product supply function

indirectly affected mills will face downward shifts in product supply curves if market pulp prices decrease—a result similar to mills facing decreased production costs due to the regulations.

The approach described above provides a comprehensive view of the effect of the regulations on responses at the facility level as well as the corresponding effect on market prices and quantities for the affected commodities. This approach is a substantial improvement over analytical methods that do not account for facility-level responses such as quantity adjustments, input adjustments, and closure of product lines or methods that ignore the effect of these regulations on market prices when determining the change in revenues and costs at the facility level. Methods that do not allow for production adjustments at the facility level essentially assume that firms cannot or will not adjust to changes in production costs. No credible model for changes in market prices exists unless it accounts for responses at the facility level. In reality, firms do respond to market conditions and market price changes respond to regulations.

A.4 OPERATIONALIZING THE MODEL

To estimate the economic impacts of the regulations, we operationalized the competitive market model of the pulp and paper industry outlined above. The purpose of the model is to provide a structure for analyzing the economic impact of regulations to control the release of air and water pollutants from chemical pulping and bleaching operations.

The model is a multi-dimensional Lotus spreadsheet incorporating the facility-specific information on production obtained from the EPA's *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities* and model parameters characterizing domestic and foreign (export) demands as well as foreign supply (imports). The model incorporates various data sources to provide an empirical characterization of the U.S. pulp and paper industry and product markets for a base year of 1989. We chose this base year of analysis because it is the last year for which facility-specific production and technical data were available from the *National Census* and for which supporting economic data were readily available. The model analyzes market adjustments for 31 paper and paperboard product markets and 6 market pulps by employing a process of **tatonnement** whereby prices approach equilibrium through successive correction—

modeled as a Walrasian auctioneer. Integrated facilities and paper-making facilities constitute those facilities supplying final paper products; the pulp mills and those integrated mills involved in the market for pulp, either as a supplier or demander, constitute those facilities included in the model for market pulps. The model also includes a foreign trade sector with which to assess the impact of international trade responses on market outcomes and vice versa.

To implement this model, we identified commodities and facilities to be included in the analysis, specified the supply and demand side of the market and associated response parameters, specified the foreign trade sector and provided the corresponding response parameters, incorporated demand and supply specifications into a market model framework, and evaluated market adjustments due to imposing regulatory compliance costs and estimated the impacts. This section discusses these activities.

A.4.1 Model Dimensions

Clearly the analysis must account for all marketable commodities involved in producing pulp and paper, as well as all producers of these commodities. Figure A-16 illustrates the modeled interactions between commodities and producers. The first marketable product is pulp, either bleached or unbleached; the second marketable product is the final paper or paperboard product. The model analyses the market adjustments for 6 market pulps and 31 paper and paperboard products. All of these products are consumed and produced domestically, as well as traded internationally. Therefore, domestic producers export some pulp and paper products to other countries, and foreign producers supply their products to U.S. markets.

The pulp and paper industry is characterized by both nonintegrated and vertically integrated mills. Nonintegrated mills include pulp mills that produce market pulp as well as paper mills that purchase market pulp to produce paper and paperboard products. Vertically integrated mills rely mostly on their own production of pulp to produce paper and paperboard products. Those vertically integrated mills without enough internally produced pulp are also demanders of market pulp, and those that produce an excess supply pulp of are suppliers of

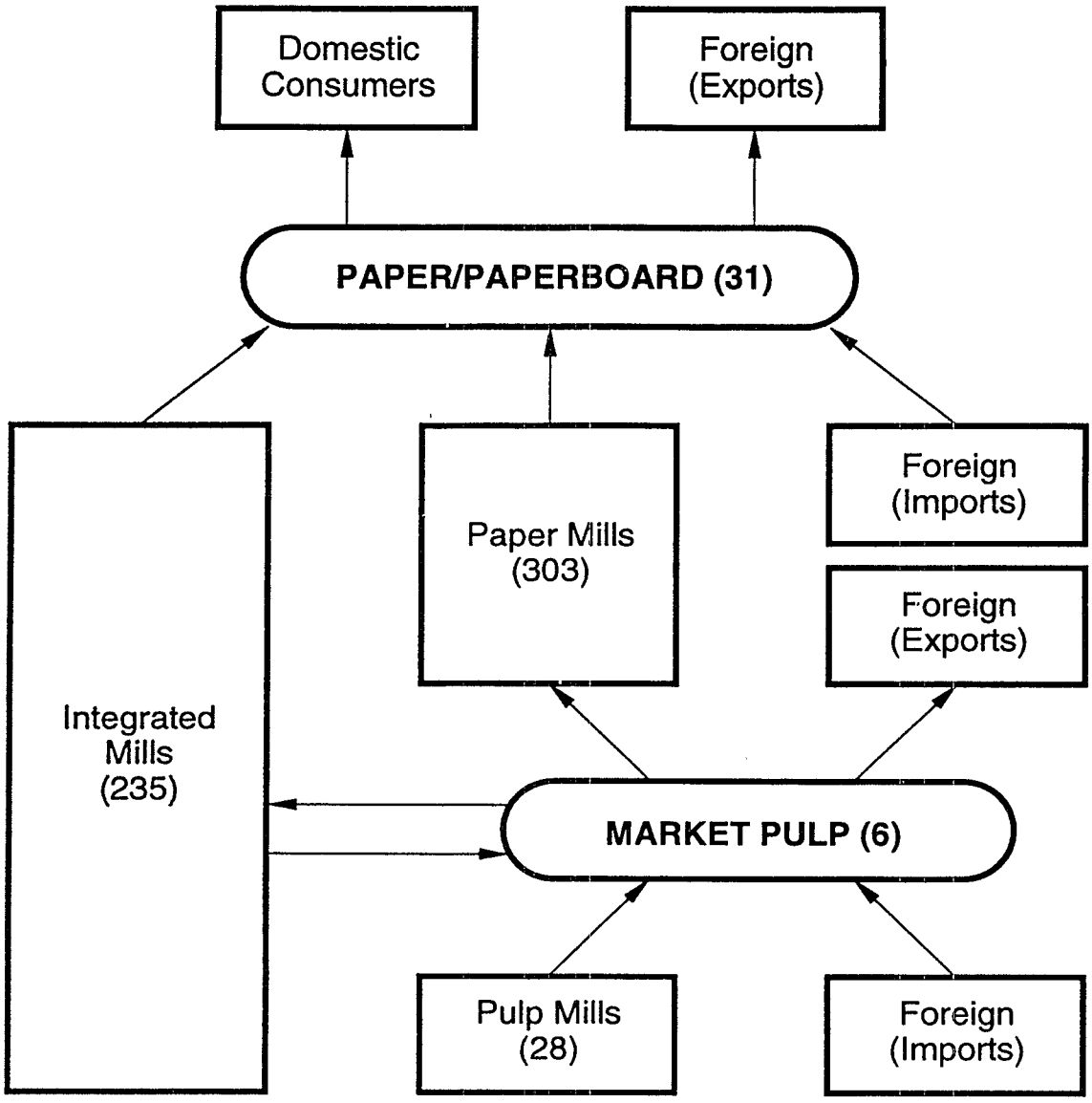


Figure A-16 Interactions between commodities and producers

market pulp. We modeled the production from 566 pulp, paper, and paperboard manufacturing facilities, including 28 pulp mills, 303 paper mills, and 235 integrated mills.

A.4.1.1 Commodities

EPA's *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities* identifies the mills existing in 1989 that may be affected by the air and water pollution regulations. The detailed production data obtained from this source on each mill form the basis for characterizing the commodities included in the model. Table A-7 lists the products with a description of each product and its product code.

The *National Census* identifies 42 product markets to analyze—33 final paper and paperboard products and 9 pulp products. However, *National Census* data on facility-level production indicate no U.S. production of either other shipping sack (product code 32) or hardboard (product code 52) in 1989. The markets for these product groups are not included in the model; therefore, the model analyzes 31 paper and paperboard product markets.

Although some of the pulp product categories provided by the *National Census* distinguish between bleached and unbleached pulps, not all pulp categories have this distinction. Consequently, as shown in Table A-8, the pulp product categories were expanded to 17 to account for bleached and unbleached versions of each pulp by matching the pulp category with pulp process codes from the *National Census*. Bleached and unbleached pulps were categorized using *National Census* data on the fiber source indicated by the pulp process codes and the percentage of the fiber that is bleached and unbleached. Distinguishing the pulp products by these features—pulping process and bleaching—is particularly important because the regulations are aimed primarily at chemical pulping and bleaching. Thus, the model includes 17 pulp inputs into the production of paper and paperboard.

Some subset of the 17 pulps described above are sold on the market (i.e., market pulps). A number of the pulp inputs are only produced at integrated facilities for in-house production of paper and paperboard products and are consequently not marketed. In addition, because some

TABLE A-7

PULP, PAPER, AND PAPERBOARD PRODUCTS[29, 30, 31, 32]

Product (Code)[a]	Product Description
Pulp	
Special Alpha and dissolving woodpulp (1)	Chemical pulp from wood and other fibers with a very high alpha cellulose content, readily adaptable for uses other than paper and paperboard making.
Sulfate-bleached (2) Sulfate-unbleached (3)	Made from an alkaline pulp manufacturing process that cooks chips in a pressure vessel using a liquor of primarily sodium sulfide and sodium hydroxide with sodium sulfate and lime being used to replenish these chemicals in recovery operations (also kraft).
Sulfite-bleached (4) Sulfite-unbleached (5)	Made from acid pulp manufacturing process that cooks chips in a pressure vessel using a liquor composed of calcium, sodium, magnesium, or ammonia salts of sulfurous acid.
Groundwood-bleached (6) Groundwood-unbleached (7)	Slurry produced by mechanically abrading fibers from barked logs through forced contact with the surface of a revolving grindstone. Used as newsprint and publication paper.
Thermomechanical-bleached (8) Thermomechanical-unbleached (9)	Pulp made by presteaming chips and reducing them into their fiber components during an initial mechanical treatment in refiners under elevated temperature and pressure. Subsequent refining done at atmospheric pressure.
Semichemical-bleached (10) Semichemical-unbleached (11)	Lower quality pulp made by cooking fibrous materials in a neutral sodium sulfite-sodium carbonate liquor followed by a final separation of the fiber using unpressurized mechanical means.
Defibrated or exploded-bleached (12) Defibrated or exploded-unbleached (13)	Pulp made by thermomechanical process in which woodchips are pretreated with a chemical, usually sodium sulfite, either prior to or during presteaming as an aid to subsequent mechanical processing in refiners.
Secondary-bleached (14) Secondary-unbleached (15)	Any type of paper- and paperboard-making fiber obtained from wastepapers and other used, reclaimable fiber sources.
Cotton and rag pulp-bleached and unbleached (16)	Pulp made from rags or cotton linters by a conventional cooking process with lime and sodium hydroxide, followed by refining and bleaching.

TABLE A-7 (cont.)

Product (Code)[a]	Product Description
All other fiber, n.e.c. (17)	Pulps other than wood such as pulp of fibrous vegetable material (e.g., straw, reed, bagasse, bamboo, etc.); or synthetic and semi-synthetic sources (e.g., glass, fiberglass, rayon, nylon, combinations).
Paper	
Newsprint (20)	Light, inexpensive grade made largely from mechanical pulps and some unbleached sulfite or other chemical pulps.
Uncoated groundwood paper (21)	A higher grade than newsprint that is smoother and brighter and used in newspaper inserts, catalogs, paperback books, and directories.
Clay coated printing and converted paper (22)	Printing and converting papers that contain a layer of coating material, such as clay or pigment, in combination with an adhesive.
Uncoated free sheet (23)	Contains no more than 10% mechanical pulps including most grades of business paper, including forms, bond, stationary, tablet, envelope, xerox, and computer paper, and cover and text grades used in printing.
Bleached bristols (24)	High quality cardboards used for products such as index tags, cards, file folders, and postcards.
Cotton fiber writing paper and thin paper (25)	Papers in which cotton or other non-wood fibers comprise 25% or more of the total (e.g., bond, ledget, specialty papers [also, rag]).
Unbleached kraft packaging and industrial converting paper (26)	Various types of paper used for industrial or commercial purposes, such as wrapping papers, bag and sack stock, specialty papers.
Special industrial paper, except specialty packaging (27)	Special industrial papers such as photographic sensitizing paper, blotting paper, filter paper.
Tissue (28)	Light, fairly transparent, strong, absorbable, easily disposable paper characterized by its gauze-like texture made from mainly bleached kraft and sulfite pulps. Used for sanitary products.
Wrapping (30)	Grade of non-sanitary tissue, all M.G. and M.F. wrapping papers, treated and untreated butcher papers and miscellaneous wrapping.

TABLE A-7 (cont.)

Product (Code)[a]	Product Description
Shipping sack (31)	Paper made mainly from sulfate or soda, unbleached or bleached woodpulp characterized by toughness and strength, used in the manufacture of shipping sacks.
Other shipping sack (32)	Rope and combination kraft and rope shipping sack paper.
Other bag and sack (33)	All other kraft wrapping paper made mainly from sulfate or soda, used in the manufacture of grocery bags and bags other than shipping sacks.
Other bag and sack paper for conversion (34)	Used for conversion in liquor, millinery, notion, or other variety bags.
Waxing stock (35)	Packaging paper with weight over 29.4 g/m^2
Other (36)	Other packaging and industrial converting paper such as asphalting and creping stocks, coating and laminating, gummed, twisting and spinning stocks (weight over 29.4 g/m^2)
Specialty packaging (37)	Packaging paper of weight not more than 150g/m^2.
Glassine, greaseproof and vegetable parchment (38)	Papers made from pure chemical woodpulp or from mixtures of chemical woodpulp, cotton fiber pulp, treated by highly hydrated or hand beaten to render the resulting paper resistant to oil, grease, and water.
Paperboard	
Unbleached kraft (40)	High strength paperboard made from sulfate pulp, usually with a naturally brown color from unbleached pulp.
Semichemical paperboard (41)	Made from semichemical pulp, mostly used for corrugating medium, which forms the inner, fluted layer of cardboard and corrugated containers.
Recycled paperboard (42)	Made from a combination of recycled fibers from various grades of paper stock, used for folding boxboard; core, can, and tube grades, corrugating medium; and gypsum linerboard.
Wet machine board (43)	Paper board manufactured using a paper machine consisting essentially of a wire-covered cylinder rotating in a vat of pulpstock on which a mat of varying thickness is formed by drainage, such as binder's board and shoe board.
Construction paper (50)	Heavy paper used for watercolor and crayon artwork, made in various colors primarily from groundwood pulp.

TABLE A-7 (cont.)

Product (Code)[a]	Product Description
Hardboard (51)	Paperboard made resistant to water and ink penetration by exposure to high degree of sizing treatments.
Insulating board (52)	Paperboard used for insulating electric cables.
Bleached linerboard (60)	Kraft paperboard used to line or face corrugated core board to form shipping boxes and various other containers.
Folding carton type board (61)	Type of boxboard made of bleached chemical woodpulp and used in the manufacture of "folding type" containers which are formed, filled, and closed by the user.
Milk carton board (62)	Special grade of bleached boxboard capable of being converted into containers for milk, cream, and other beverages.
Heavyweight cup and round nested food container (63)	Bleached paperboard used in the manufacture of cups and other nested cylindrical containers, used for hot and cold drinks and in packaging moist, liquid, and oily foods.
Plate, dish, and tray stock (64)	Bleached paperboard hard-sized for moisture resistance and strength qualities.
Bleached paperboard for miscellaneous packaging (65)	Paperboard for miscellaneous packaging purposes such as non-folding board for shipping cases and set-up boxboard.
Other solid bleached board (66)	Single-ply, homogeneous types of paperboards, made from the same stock throughout the sheet structure, including paperboard for moist, oily, and liquid foods.
Molded pulp products (70)	Products including fruit and vegetable packs and egg cartons.

[a]For all products termed bleached or unbleached: bleaching is the process if chemically treating fibers to reduce or remove coloring matter so that the pulp is improved in terms of whiteness or brightness and unbleached is produced without being treated with bleaching agents.

TABLE A-8

PULP PRODUCTS, PRODUCT CODES, AND PROCESS CODES

Pulp Product	Pulp Product Code	National Census Process Codea
Special Alpha and dissolving woodpulp	1	A, D
Sulfate-bleached	2	C, W
Sulfate-unbleached	3	C, W
Sulfite-bleached	4	B
Sulfite-unbleached	5	B
Groundwood-bleached	6	H, J
Groundwood-unbleached	7	H, J
Thermomechanical-bleached	8	G
Thermomechanical-unbleached	9	G
Semichemical-bleached	10	E
Semichemical-unbleached	11	E
Defibrated or exploded-bleached	12	I, F
Defibrated or exploded-unbleached	13	I, F
Secondary-bleached	14	K, L, M, N, O, P, R, S, T, U, Y, Z
Secondary-unbleached	15	K, L, M, N, O, P, R, S, T, U, Y, Z
Cotton and rag pulp-bleached and unbleached	16	V
All other fiber, n.e.c.	17	Q, X, SS

[a]Process codes taken from Subappendix, Table AA-1.

of these pulps are traded in small quantities by a small number of suppliers, data were insufficient to derive prices for some of these market pulp products. The U.S. Department of Commerce's *Current Industrial Reports: Pulp, Paper, and Board* does not contain data on value of product shipments and quantity of product shipped for a number of pulps because of disclosure concerns. Thus, the model analyzes six market pulps:

- Special Alpha and dissolving woodpulp
- Bleached sulfate
- Unbleached sulfate
- Bleached sulfite
- Bleached secondary fiber
- Unbleached secondary fiber

A.4.1.2 Facilities

The pulp and paper industry is characterized by both nonintegrated and vertically integrated mills. Nonintegrated mills include pulp mills that produce market pulp as well as paper mills that purchase market pulp to produce paper and paperboard products. Vertically integrated mills rely mostly on their own production of pulp to produce paper and paperboard products. Mills producing low-value products are usually integrated, and mills making specialized, high-value products are usually nonintegrated. Technical integration (i.e., the integration of pulp and paper manufacturing processes) can lead to savings in costs by reducing pulp processing costs, transportation costs, and collective mill departmental and administrative costs.

Each type of facility, integrated or nonintegrated, has a different decision to make regarding production of pulp, paper, and paperboard. Accounting for the differences across mills and modeling the decisions correctly for each type of mill allow for a more realistic portrayal of the facility and, thus, market responses to the regulatory compliance costs. In this model,

facilities are classified as either integrated or nonintegrated, and nonintegrated mills are broken down further into pulp mills and paper mills. Therefore, we account for and operationalize the different production decisions at each type of facility.

Integrated mills must determine optimal output given the market prices for all paper products they produce, which will determine the amount of internal pulp to produce. Excess supply of pulp will spillover into the market, while excess demand will cause the facility to demand market pulp. For nonintegrated paper mills, the market prices for pulp inputs and final paper and paperboard outputs will determine the optimal level of output to produce, and then, the corresponding market pulp to purchase. For pulp mills, the price of market pulp will determine the optimal supply of market pulp. The market supply of pulp is the sum of supply from all market pulp suppliers, and the market demand for pulp is the sum of demand from all market pulp demanders. The same is true for paper and paperboard products.

The economic model includes 566 pulp, paper, and paperboard manufacturing facilities for which 1989 production and technical data were available from the *National Census*. As mentioned in Section A.2.3, a total of 331 mills, or 58.5 percent, are nonintegrated. Paper-only mills make up the vast majority of the nonintegrated classification (303 mills), leaving only 28 mills classified as pulp-only mills. The remaining 235 mills are considered integrated facilities producing both pulp and paper on-site. This segment of the industry accounts for 41.5 percent of all mills operating in 1989.

A.4.2 Domestic Supply of Pulp and Paper Products

Mills have the ability to vary output in the face of production cost changes. To allow for mills to vary output in the face of regulatory control costs, we developed facility-specific, upward-sloping supply curves for each product. The supply curves are specified over a productive range with an upper bound given by facility productive capacity and a lower bound given by the minimum economically viable output level at the facility.

We describe the technology characterizing pulp and paper production at U.S. mills and the corresponding supply functions and discuss the econometric estimation of the supply relationships. We provide details on defining the product-specific production range at each facility and explain how we incorporated the regulatory control costs into the model structure.

A.4.2.1 Production Technology and Supply Functions

For our analysis, we assumed the generalized Leontief technology to characterize pulp and paper production at all mills. This formulation allows for estimating supply curves at the mill level for each final good produced. Specification of the model includes 31 final paper products, q_i, with market price, p_i; 17 fixed-proportion pulp inputs, q_k; however only 6 are marketable with price r_k; and an aggregate measure of variable-proportion inputs—x, which represents the variable inputs labor, energy, and chemicals with price I.

We assumed a Leontief, fixed-proportion relationship between paper and pulp—that is, each unit of paper product q_i requires α_{ik} units of q_k. This fixed-proportions relationship between the q_is and the q_ks implies that the firm's profit function, supply functions, and derived demand functions depend on p_i and r_i only insofar as they depend on net price

$$\phi_i = [p_i - \sum_{k=1}^{n} \alpha_{ik} r_k] \quad .$$

Further, we assumed that the variable proportions input combines with pulp according to a generalized Leontief technology, which is not fixed proportion. The supply functions for the generalized Leontief technology may be derived via Hotelling's lemma by differentiating the profit function with respect to product price (see Varian[33]).

In general, the supply function for paper products resulting from the generalized Leontief technology with the assumption of no substitutability across final products (i.e., cross-price elasticity of supply equal to zero for all mill outputs) is

where γ_{ji} and β_i are model parameters to be estimated econometrically, i indexes products, and j indexes facilities. The theoretical restrictions on the model parameters that ensure that the

$$q^s_{ji} = \gamma_{ji} + \frac{\beta_i}{2}\left[\frac{I_{ji}}{\phi_i}\right]\frac{1}{2} \qquad (1)$$

profit function is convex in ϕ and I and that the mill's supply curves are upward sloping are $\gamma_{ji} > 0$ and $\beta_i < 0$.

Equation (1) sets out the generalized Leontief functional form that is used to estimate supply relations for three types of facilities: pulp mills, paper mills, and integrated mills. The own-price variable is written as ϕ and is different for the three types of facilities. For a pulp mill, the relevant supply price is r, the unadjusted price of market pulp. For integrated mills and nonintegrated paper mills, the appropriate supply price is the net price,

$$\phi_i = \left[p_i - \sum_{k=1}^{n} \alpha_{ik} r_k\right] \quad .$$

The net price specification follows from assuming that a fixed amount of market pulp is required for each unit of paper produced. The treatment of integrated mills views the internally consumed pulp as an unobservable intermediate stage of production—the supply price is net of market purchases of pulp. Thus, if the integrated mill purchased no market pulp, the appropriate supply price is p, the unadjusted price of paper.

A.4.2.2 Econometric Estimation of Supply Relationships

The upward-sloping product supply curve for each facility is econometrically estimated using facility-specific data on production from the *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities* and market prices obtained from U.S. Department of Commerce data. Assuming generalized Leontief technology, as detailed above, the specification of the supply function for a particular product to be estimated by ordinary least squares is

$$q_{jt} = \gamma_j + \beta\frac{1}{2}\left[\frac{I_{jt}}{P_t}\right]\frac{1}{2} + \nu_{jt}, j = 1, \ldots, N \qquad (2)$$
$$t = 1985, 1988, 1989$$

where q_{jt} is production at facility j of the product in time period t, p_t is the market price of the product at time t, I_{jt} is a cost-share weighted index of the three components of variable costs (labor, energy, and chemicals) that varies across facilities j and time periods t. Finally, let ν_{jt} represent the effects of unobserved variables that vary over j and t. The parameters to be estimated are the facility-specific intercept (γ_j) and the product-specific coefficient (β) on the cost-price variable. Note that j is an index for facility, not product whose subscript has been suppressed. This specification allows intercepts to vary across facilities but restricts their slopes to be the same. The procedure can be thought of as pooling many (N) three-observation regressions to estimate β.

A.4.2.2.1 Facility-level production data. Production data in off-machine tons (OMT) of market pulp, paper, and paperboard products at each facility in the industry for the years 1985, 1988, and 1989 were obtained from the *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities*.[34] The production data for each mill were cross-checked with other data available from the *National Census* to ensure accuracy. Such data included the fiber furnish used in production, the bleached component of the fiber furnish, inter-facility product transfers, and reported product shipments.

A.4.2.2.2 Market price data. Prices for market pulp, paper, and paperboard product were imputed using data on value of product shipments and quantity of product shipped obtained from the U.S. Department of Commerce's *Current Industrial Reports: Pulp, Paper, and Board*.[35, 36, 37] Market prices for the relevant years (1985, 1988, 1989) were calculated as

$$\text{Market Price} = \frac{\text{Value of Shipments}}{\text{Quantity Shipped}} \quad .$$

The market prices used for bleached and unbleached secondary fiber and molded pulp were not derived from this source. Instead the prices for these products were imputed from *National Census* data using the above formula. For each year, we summed the value of shipments for all mills producing the product and divided by the sum of all product shipments

across those same mills. For each mill, the product of interest was the only marketed good produced—ensuring that the calculations do not include the value or shipments of any other products.

A.4.2.2.3 Cost-share weighted variable production cost index. The cost-share weighted index of variable production costs, I_{jt}, was constructed from an average regional wage variable computed as earnings per employee (w_{jt}); the producer price index for fuels, related products, and power (e_t); and the producer price index for chemicals and allied products (c_t). The I_{jt} variable varies across time, as does each cost component, and across facilities, because of the regional wage variable. The cost shares used to weight the variable cost components vary by the three product types—pulp, paper, and paperboard. We computed the shares for each product type from input-output accounts from the U.S. Department of Commerce as shown in Table A-9.

Before computing the cost-share weighted index, we normalized the producer price indices for energy and chemicals to 1989 and converted the regional wage variable into a wage index arbitrarily normalized to the southern region in 1989. This transformation allows each variable to be measured in terms of a relative index for use in deriving the cost-share weighted variable production costs index. The index was computed as

$$I_{jt} = S^w w_{jt} + S^e e_t + S^c c_t \qquad (3)$$

where S^w is the cost share for labor in the production of the product (pulp, paper, or paperboard), while S^e and S^c are the corresponding cost shares for energy and chemicals. The cost shares vary according to product (pulp, paper, or paperboard); thus, the index differs across pulp, paper, and paperboard products. In addition, it is normalized relative to the southern region in 1989 so that the index for mills located in the South in 1989 is equal to 100. Table A-10 provides the indices used in the econometric estimation for each product by region and year.

A.4.2.2.4 Facility-specific supply intercepts. Different intercepts were estimated for each facility because of the lack of other independent variables to explain variation across mills in production levels. Variables such as production capacity, mill size and age, productive efficiency,

TABLE A-9

COST-SHARES OF VARIABLE PRODUCTION FACTORS FOR PULP, PAPER, AND PAPERBOARD PRODUCTS[38]

	Actual Cost Share (%)	Modified Cost Share[a] (%)
Pulp		
Labor	20.5	39.4
Chemicals	12.6	24.2
Energy	18.9	36.4
Total	52.0	100.0
Paper		
Labor	21.1	52.5
Chemicals	5.5	13.6
Energy	13.7	33.9
Total	40.3	100.0
Paperboard		
Labor	21.1	46.0
Chemicals	6.2	13.6
Energy	18.6	40.4
Total	45.9	100.0

[a]Calculated as actual cost share for factor divided by total cost-share of all variable production factors.

TABLE A-10

COST-SHARE WEIGHTED INDEX OF VARIABLE PRODUCTION COSTS BY PRODUCT REGION AND YEAR

Product/Region	1985	1988	1989
Pulp			
South	101.909	94.503	100.000
Midwest	98.298	91.054	98.356
Northeast	97.589	91.537	97.227
West	105.166	97.115	102.289
Paper			
South	101.777	94.948	100.000
Mid-west	96.965	90.351	97.809
Northeast	96.020	90.995	96.305
West	106.116	98.428	103.050
Paperboard			
South	103.999	94.568	100.000
Mid-west	99.792	90.549	98.084
Northeast	98.966	91.112	96.770
West	107.793	97.610	102.667

capital intensity, and investment would all be helpful in explaining the differences across mills, but these variables or reliable proxies were not available from the *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities* or any other industry source at the facility level. Therefore, we employed facility dummies to capture those otherwise unexplained differences in production levels across facilities that are not accounted for through variation in variable production costs and prices.

A.4.2.2.5 Supply parameters. A closer look at the econometric supply specification requires interpreting the model parameters. Although the parameter β for each product does not have an intuitively appealing interpretation, it is related to the facility's supply elasticity for the product—a well-known model parameter. The facility's supply elasticity for a particular product, ξ_{ji}, can be expressed as

$$\xi_{ji} = \frac{\partial q_{it} / q_{it}}{\partial p_t / p_t} = \frac{\partial q_{it} / \partial p_t}{q_{it} / p_t} \qquad (4)$$

or

$$\xi_{ji} = \frac{\partial q_{it}}{\partial p_t} \cdot \frac{p_t}{q_{it}} \qquad (4')$$

where $\frac{\partial q_{jt}}{\partial p_t}$ is the derivative of quantity supplied by the mill with respect to price.

Thus, to provide the relationship between ξ_{jt} and β, we took the derivative of the facility supply function (equation [1]) with respect to price, which is

$$\frac{\partial q_{jt}}{\partial p_t} = -\beta \frac{1}{4} p_t^{-1} \left[\frac{I_{jt}}{p_t} \right]^{\frac{1}{2}} \qquad (5)$$

Multiplying this expression by $\frac{p_t}{q_{jt}}$ results in an expression for the supply elasticity of

$$\frac{\partial q_{it}}{\partial p_t} \cdot \frac{p_t}{q_{it}} \xi_{ji} = -\beta \frac{1}{4} \left[\frac{1}{q_{jt}}\right] \left[\frac{I_{jt}}{p_t}\right]^{\frac{1}{2}} \qquad (6)$$

or

$$\xi_{jt} = -\beta \left[\frac{1}{2q_{jt}}\right]^{\frac{1}{2}} \left[\frac{I_{jt}}{pt}\right]^{\frac{1}{2}} \quad . \qquad (6')$$

Because economic theory dictates that the supply elasticity is positive (i.e., $\xi_{jt} > 0$), and q_{jt}, p_t, and I_{jt} are all positive, equation (6') above indicates that the parameter β is negative (i.e., $\beta < 0$) for all products. Finally, the solution for β from equation (6') reveals the following expression:

$$\beta = -\xi_{jt} \; 4 \; q_{jt} \left[\frac{I_{jt}}{P_t}\right]^{-\frac{1}{2}} \quad . \qquad (7)$$

Therefore, although the supply elasticity is not directly estimated by the econometric specification of the supply function, we were able to derive the facility-specific supply elasticity for each product via equation (6') given the estimated β, market price, variable production cost index, and facility's production level of the product. Unlike the product-specific β, the elasticity is not constant but varies for a facility with q_{jt}, p_t, and I_{jt}.

An additional parameter provided by the econometric estimation of the supply function is the intercept, γ_{ji}, which varies across facilities. This parameter does not influence the facility's production responsiveness to price changes as does the β parameter. Therefore, the γ_{ji} parameter was used to establish production levels from the supply function (to be employed in the economic model) that are consistent with those observed in the base year of analysis, 1989. Thus, γ_{ji} was used to calibrate the model so that each facility's supply equation is exact using 1989 data. We explain the details of the calibration in Section A.4.5.

A.4.2.2.6 Results. The results of the econometric estimation of supply parameters are summarized in Table A-11. For 29 of the 36 product supply specifications, the estimated β is

TABLE A-11

REGRESSION ANALYSIS OF SUPPLY FUNCTION PARAMETERS

Product (code)	Observations	F-Value	Adjusted R^2	Constant	Price Ratio[a]
Market Pulp					
Special Alpha and dissolving woodpulp (1)	30	85.129	0.9667	231,044 (8.704)[d]	-408,318 (-3.236)[d]
Sulfate-bleached (2)	152	11.792	0.7847	161,617 (3.856)[d]	-292,665 (-1.663)[d]
Sulfate-unbleached (3)	17	155.417	0.9830	24,824 (1.346)	-84,012 (-1.303)
Sulfite-bleached (4)	24	125.739	0.9799	25,744 (2.158)[c]	-86,665 (-1.865)[b]
Secondary (14/15)	13	11.258	0.8368	108,814 (5.410)[d]	-239,065 (-3.029)[c]
Paper					
Newsprint (20)	59	116.514	0.9766	226,214 (3.270)[d]	-669,183 (-2.292)[c]
Uncoated groundwood paper (21)	60	103.946	0.9746	102,015 (1.907)[b]	-333,516 (-1.214)
Clay coated printing and converted paper (22)	142	48.469	0.9439	839,553 (6.763)[d]	-3,736,643 (-4.832)[d]
Uncoated free sheet (23)	278	151.797	0.9816	147,346 (7.630)[d]	-438,893 (-4.539)[d]
Bleached bristols (24)	33	129.560	0.9812	160,717 (3.616)[d]	-907,294 (-3.518)[d]

TABLE A-11 (cont.)

Product (code)	Observations	F-Value	Adjusted R^2	Constant	Price Ratio[a]
Cotton fiber writing paper and thin paper (25)	75	257.402	0.9894	6,200 (0.496)	-50,616 (-0.472)
Unbleached kraft packaging and industrial converting paper (26)	72	166.938	0.9849	83,346 (3.527)[d]	-197,787 (-2.124)[c]
Special industrial paper, except specialty packaging (27)	177	44.111	0.9409	44,558 (3.282)[d]	-332,276) (-3.143)[d]
Tissue (28)	210	187.589	0.9853	125,956 (4.621)[d]	-777,387 (-4.461)[d]
Wrapping (30)	42	27.561	0.9120	8,131 (1.171)	10,415 (0.280)
Shipping sack (31)	12	13.139	0.8466	54,285 (2.781)[c]	-238,335 (2.475)[c]
Other shipping sack (32)	N/A	N\A	N\A	N/A ( )	N/A ( )
Other bag and sack (33)	17	43.224	0.9548	-64,047 (1.180)	405,238 (-1.428)
Other bag and sack paper for conversion (34)	18	20.472	0.8891	137,346 (2.968)[c]	-458,630 (-1.870)[b]
Waxing stock (35)	18	35.629	0.9422	3,592 (0.956)	11,857 (0.516)
Other (36)	32	43.809	0.9472	16,326 (2.377)[c]	-108,326 (-2.363)[c]
Specialty packaging (37)	25	334.679	0.9921	56,305 (3.413)[d]	-356,807 (-3.135)[d]

TABLE A-11 (cont.)

Product (code)	Observations	F-Value	Adjusted R^2	Constant	Price Ratio[a]
Glassine, greaseproof and vegetable parchment (38)	16	4.602	0.5903	-12,424 (-0.405)	120,901 (0.541)
Paperboard					
Unbleached kraft (40)	128	68.623	0.9608	495,114 (10.971)d	-1,079,860 (-7.535)d
Semichemical paperboard (41)	91	40.916	0.9342	372,531 (12.308)d	-401,789 (-4.190)d
Semichemical paperboard (41)	91	40.916	0.9342	372,531 (12.308)d	-401,789 (-4.190)d
Recycled paperboard (42)	356	158.548	0.9830	174,383 (17.017)d	-260,179 (-7.471)d
Wet machine board (43)	23	111.291	0.9783	-37,532 (-0.894)	229,314 (1.097)
Construction paper (50)	44	129.416	0.9827	63,953 (1.825)b	-233,717 (-1.660)b
Hardboard (51)	N/A	N/A	N/A	N/A ( )	N/A ( )
Insulating board (52)	10	29.978	0.928	57,749 (0.722)	-129,821 (-0.436)
Linerboard (60)	25	43.96	0.9416	89,754 (0.861)	-392,619 (-0.853)
Folding carton type board (61)	38	23.085	0.8858	429,852 (4.747)d	-1,480,241 (-3.407)d

TABLE A-11 (cont.)

Product (code)	Observations	F-Value	Adjusted R^2	Constant	Price Ratio[a]
Milk carton board (62)	21	185.332	0.9847	199,208 (3.123)d	-815,179 (-2.527)c
Heavyweight cup and round nested food container (63)	31	8.643	0.7370	-27,114 (-0.440)	150,788 (0.506)
Plate, dish, and tray stock (64)	22	66.886	0.9617	14,107 (0.628)	-865 (-0.008)
Bleached paperboard for miscellaneous packaging (65)	23	821.198	0.9970	-105,683 (-2.115)b	561,878 (2.302)c
Other solid bleached board (66)	21	50.215	0.9451	-4,314 (-0.166)	79,918 (0.670)
Molded pulp products (70)	37	53.252	0.9587	6,729 (1.043)	-46,986 (-1.132)

[a]Defined as 0.5 $(I/P)^{0.5}$, where I is the cost-share weighted variable cost index (varies across facility and time) and P is the product's price (varies across time).
[b]Estimate statistically significant at 10 percent level.
[c]Estimate statistically significant at 5 percent level.
[d]Estimate statistically significant at 1 percent level.

NOTE: t-statistics of parameter estimates are in parentheses beneath these estimates.

negative and consistent with the theoretical value expected for this parameter. Furthermore, 17 out of the 29 estimates (58.6 percent) are significantly negative—as measured at an 80 percent confidence level. With as many product groups as there are in the data set, sampling error is certain to cause some estimated supply curves slope downward. Those products with positive estimates for β all suffer from a limited number of observations—all less than 30 observations. Only one positive estimate of β, that for bleached paperboard for miscellaneous packaging (65), is significant at any reasonable level of significance.

The positive estimates of β are not acceptable as inputs into the economic model because they imply negatively sloped supply functions, which would lead to perverse model simulation results. The method employed to provide acceptable β parameters was to substitute the production-weighted average market supply elasticity for successfully estimated products in the same product code groupings (i.e., the 30s, the 40s, and the 60s). We then calculated the β parameters for products with positive econometric estimates by incorporating the appropriately weighted market supply elasticity in equation (7). A summary of the β coefficients used in the economic model for each product and the corresponding market supply elasticity are provided in Table A-12.

A.4.2.3 Estimating Product-Specific Production Ranges at Facilities

Figure A-17 illustrates a product supply function at the facility, which is the section of the marginal cost curve bounded by the maximum and minimum quantities q^M and q^m. q^M is the largest feasible production rate that can be sustained at the facility given the technology and other fixed factors in place, regardless of the output price. q^m is the minimum economically feasible production rate that is determined by the minimum of the AVAC curve, which coincides with the price p^m. If the market price of the paper product is less than p^m, the firm's best response is to close the product line because $p < AVAC$. This relationship implies that total revenue from producing the paper product would be less than the corresponding total variable costs of production at any level of output.

TABLE A-12

PRODUCT-SPECIFIC BETA COEFFICIENTS AND SUPPLY ELASTICITIES

Product (code)	β	Supply Elasticity[a]
Market Pulp		
Special Alpha and dissolving woodpulp (1)	-408,318	0.2009
Sulfate-bleached (2)	-292,665	0.1856
Sulfate-unbleached (3)	-84,012	0.2674
Sulfite-bleached (4)	-86,665	0.2320
Secondary-bleached(14)	-239,065	0.7641
Secondary-unbleached(15)	-239,065	0.8211
Paper		
Newsprint (20)	-669,183	0.2939
Uncoated groundwood paper (21)	-333,516	0.3304
Clay coated printing and converted paper (22)	-3,736,643	1.6530
Uncoated free sheet (23)	-438,893	0.3087
Bleached bristols (24)	-997,887	1.2102
Cotton fiber writing paper and thin paper (25)	-50,616	0.1 192
Unbleached kraft packaging and industrial converting paper (26)	-197,787	0.1858
Special industrial paper, except specialty packaging (27)	-332,276	0.9965
Tissue (28)	-777,387	0.8156
Wrapping (30)	-163,636	1.6309
Shipping sack (31)	-238,335	1.2618
Other shipping sack (32)	N/A	N/A
Other bag and sack (33)	-655,300	1.6309
Other bag and sack paper for conversion (34)	-458,630	2.2533
Waxing stock (35)	-222,059	1.6309
Other (36)	-108,326	1.2049
Specialty packaging (37)	-356,807	1.6586
Glassine, greaseproof and vegetable parchment (38)	-262,312	1.6309

TABLE A-12 (cont.)

Product (code)	β	Supply Elasticity[a]
Glassine, greaseproof and vegetable parchment (38)	-262,312	1.6309
Paperboard		
Unbleached kraft (40)	-1,079,860	0.3158
Semichemical paperboard (41)	-401,789	0. 2757
Recycled paperboard (42)	-260,179	0.4928
Wet machine board (43)	-31,802	0.3545
Construction paper (50)	-233,717	0.8820
Hardboard (51)	N/A	N/A
Insulating board (52)	-129,821	0.7406
Linerboard (60)	-392,619	1.0139
Folding carton type board (61)	-1,480,241	0.7481
Milk carton board (62)	-815,179	0.4430
Heavyweight cup and round nested food container (63)	-271,920	0.6807
Plate, dish, and tray stock (64)	-195,233	0.6807
Bleached paperboard for miscellaneous packaging (65)	-404,756	0.6807
Other solid bleached board (66)	-270,147	0.6807
Molded pulp products (70)	-46,986	0.2382

[a]The product-specific supply elasticities were derived using equation (6') with the corrresponding product-specific beta coefficient, product quantity (q) equal to the mean production level across all mills in 1989, and the cost-share weighted index of variable production costs (I) equal to the mean index across all mills in 1989.

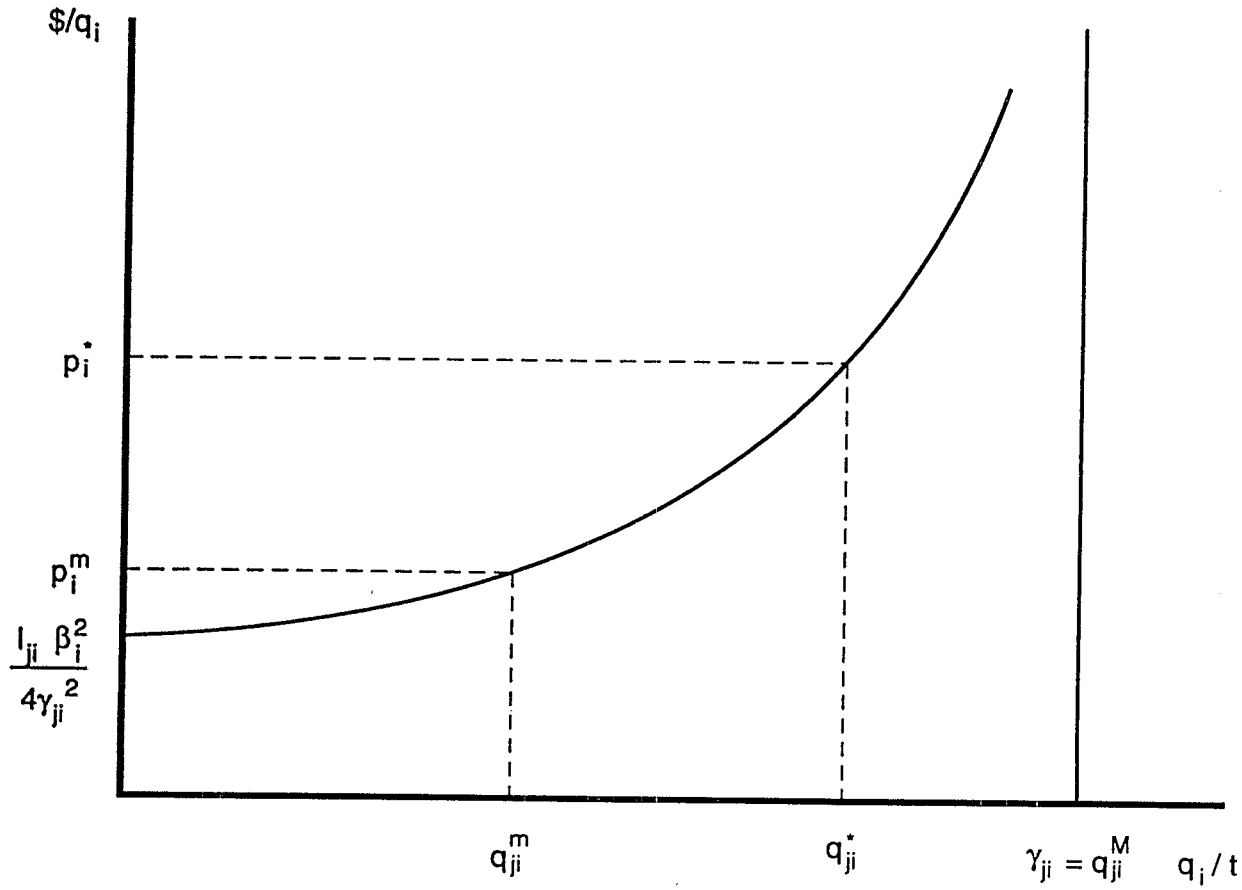


Figure A-17 Econometrically estimated supply function at facility

A.4.2.3.1 Product-specific maximum capacity at facility. The facility and product-specific intercept, γ_{ji}, is the natural choice for the maximum production level of each product i at the facility, q_i^M. It represents the limiting value of quantity supplied as price becomes infinite,

$$p_i \underset{\rightarrow}{lim} \infty \; q_{ji} = p_i \underset{\rightarrow}{lim} \infty \left[\gamma_{ji} + \hat{\beta} \frac{1}{2} \left(\frac{I_{ji}}{p_i} \right) \frac{1}{2} \right] = \gamma_{ji}$$

because the value of the second term in the limit goes to zero as price approaches infinity. This limiting value is shown in Figure A-17 as $q_{ji}^M = \gamma_{ji}$.

A.4.2.3.2 Product-specific minimum prices and quantities at facility. The area under the product supply curve at the facility represents the facility's total variable costs of producing that product. This area can be expressed as

$$VC_i = f_i(q_i^*) q_i^* + \int_{q_i^*}^{q_i^*} f_i(q_i) \, dq_i \qquad (8)$$

where VC_i is the total variable cost of producing product i, q_i^* is the level of production of product i at the facility, $f_i(q_i)$ is the inverse supply function, and q_i^m is the minimum economically feasible production level at the facility, which corresponds to the price P_i^m. The sum of VC_i for all final products produced at the facility represents the facility's total variable costs of production (i.e., $VC_{mill} = \sum_i VC_i$ for all products i) or

$$VC_{mill} = \sum_I \left[f_1 \left(q_1^* \right) q_1^* + \int_{q_1^*}^{q_1^*} f_1 \left(q_1 \right) \, dq_1 \right] \quad . \qquad (9)$$

q_i^m is unobserved but may be chosen, for each product, to calibrate the shutdown points with reported cost data. Specifically, the total manufacturing cost of producing pulp, paper, and

paperboard is reported by each mill in the EPA's *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities*.[39] This figure represents the facility's total variable costs of production, and integrating under the generalized Leontief supply function,[1] given the above relationships, we can express it as a function of q_i^* and q_i^m:

$$VC_{mill} = \sum_i \frac{\beta_i^2 I_i}{4} \left[\frac{q_i^m}{(q_i^m - \gamma_i)^2} + \frac{1}{(q_i^m - \gamma_i)} - \frac{1}{(q_i^* - \gamma_i)} \right] \qquad (9')$$

where q_i^* is known, while q_i^m is unknown. This is one condition in as many unknowns (q_i^m) as there are products at the facility.

The problem can be reduced further if we assume that q_i^m is proportional to base year output, q_i^*, by a factor k, so that

$$q_i^m = k\, q_i^*, \text{ for all } i. \qquad (10)$$

The factor k is not related to product capacity at the mill; therefore, it is not a determinant of the capacity utilization rate. This factor simply posits the minimum economically achievable level of output to be the same fraction of current output for each product at the mill.

Thus, the facility's total variable costs can be expressed as

$$VC_{mill} = \sum_i \frac{\beta_i^2 I_i}{4} \left[\frac{kq_i^*}{(kq_i^* - \gamma_i)^2} + \frac{1}{(kq_i^* - \gamma_i)} - \frac{1}{(q_i^* - \gamma_i)} \right] . \qquad (9'')$$

Product-specific q_i^m and p_i^m at the facility may be derived by solving equation (9") for the unknown variable k and then backsolving through equation (10) to solve for q_i^m and using that result with the inverse supply function to solve for p_i^m.

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[1]See equation (1) in Section A.4.2.

Applying this technique to the questionnaire data for each mill resulted in three different outcomes, as summarized in Figure A-18. First, as shown in Figure A-18 (a), the value for k is determined to be greater than zero and less than one (i.e., $0 < k < 1$). Thus, the total variable costs as measured by the area under the facility's product supply function matches the value reported in the *1990 National Census* for that facility. Second, in Figure A-18 (b), the value for k is zero so that the minimum economically achievable output level also equals zero. Thus, the total variable cost as measured by the area under the facility's product supply function is greater than the value reported in the *1990 National Census* for that facility. With k equal to zero, this area represents the smallest possible value for total variable costs, which precludes matching the reported number. Lastly, in Figure A-18 (c), the value for k is greater than one so that the minimum economically achievable output and price levels are higher than the current output and price levels. Thus, the total variable cost as measured by the area under thefacility's product supply function is less than the value reported in the *1990 National Census* for that facility. If k equals one, this area represents the largest possible value for total variable costs, which again precludes matching the reported number.

The first scenario calls for no adjustments because the calculated cost figure exactly replicates the reported number at the mill. This scenario is true for 325 out of 566 mills included in the analysis, or 57.4 percent. However, the other two cases necessitate some adjustment because the calculated number does not replicate the reported number at the mill. For the situation shown in Figure A-18 (b) with $k = 0$, the adjustments to fixed costs and other revenue discussed below ensure consistency of the model cost estimates with reported cost estimates from the *1990 National Census*. This situation is true for 147 mills, or 26 percent of the total.

For the situation shown in Figure A-18 (c), we assumed that the minimum economically achievable level of output equals zero (i.e., $k = 0$) to calculate the area under the facility's product supply curve. This assumption avoids erroneous baseline closure of product lines (current output level less than shutdown level), as well as the selection of some arbitrary value for k that will be instrumental in determining product line closures. We dismissed setting the minimum economically achievable output level equal to the current output level after observing profit levels for these mills from the *1990 National Census* that were inconsistent with the zero

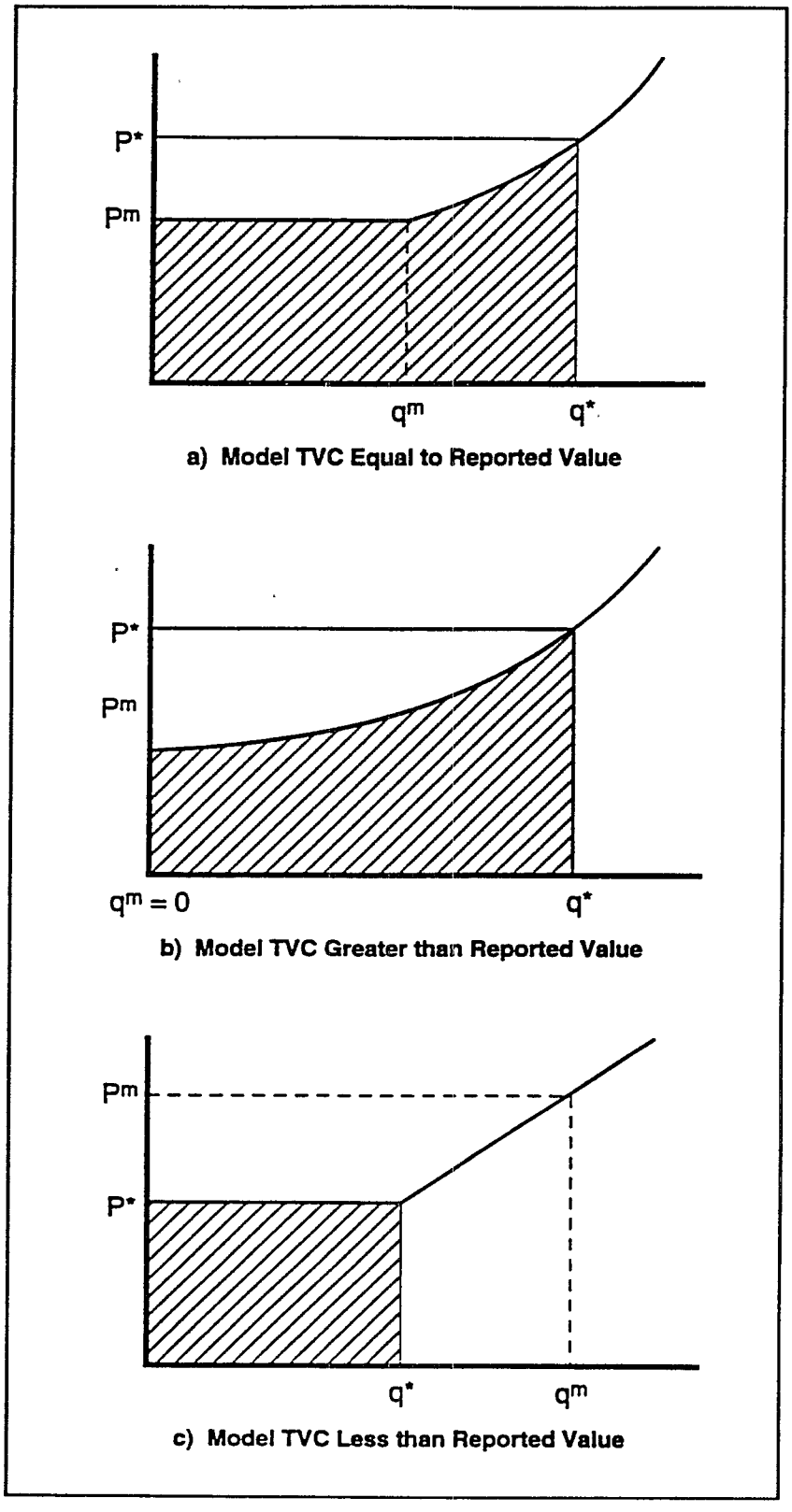

Figure A-18 Comparison of total variable cost measures

profit condition implied by operating all product lines at the shutdown point. As before, after setting k = 0, the adjustments to fixed costs and other revenue discussed below ensure consistency of the model cost estimates with reported cost estimates from the *1990 National Census*. This situation applies to 94 mills, or 16.6 percent of the total.

A.4.2.4 Incorporating Regulatory Control Costs into Model Structure

The starting point for assessing the impact of the regulations on the markets for pulp and paper products is to incorporate the regulatory control costs of each mill producing the products. The compliance costs for each mill are estimated by Agency engineers and include the total capital investment, the annual general and administrative costs, and the annual O&M costs (variable costs).

The primary focus of incorporating regulatory control costs into the model structure is to appropriately assign the O&M costs to the pulp products directly affected by the incidence of control costs. In some cases this assignment is straightforward, such as the case of bleach plant process changes or the case of bleach plant process vent controls. In these cases, the O&M costs are shared by each bleached pulp product. Other cases are not as straightforward, such as the case of end-of-pipe effluent controls. Because the costs of these controls are not readily attributable to any specific production area of the mill, the costs are assumed to be shared by all pulp products. The result of assigning the O&M costs to the pulp products produced by each mill is a mill-specific per-unit production cost change for each of the 17 pulp products described in Table A-8.

The secondary focus of incorporating regulatory control costs into the model structure is to calculate the annual nonvariable cost of regulation-imposed controls. The annual nonvariable control costs are determined from the net present discounted value (NPDV) of the stream of after-tax cash outflows: the cash outflows are the total capital investment and the annual general and administrative costs. The length of the stream of cash outflows corresponds to the average length of the capital investment, which is estimated as 15 years, and the costs are discounted using the facility-specific discount rate found in the *National Census*. The annual nonvariable

control cost is then computed by annualizing the NPDV over the lifetime of the investment at the facility-specific rate of discount. The annual nonvariable control costs enter the model at the facility level, while the per-unit variable control costs enter at the product level for all facilities affected by the regulations.

A.4.2.4.1 Product-level supply decisions at facility. The production decisions at the three types of facilities—integrated paper mills, nonintegrated paper mills, and pulp mills—are affected differently by the variable costs of control (i.e., the annual O&M costs). These direct costs are borne by pulp producers, both suppliers of pulp to the market and to integrated mills that produce and consume their own pulp. Because of the direct costs of control, market pulp prices will rise, leading to indirect costs borne by nonintegrated paper mills and integrated paper mills who purchase market pulp. The nonvariable control costs do not directly affect product-level supply decisions except in the case of facility closure where supply is reduced to zero (see Section A.4.2.4.2).

For integrated mills the variable costs of control associated with on-site production of pulp will be borne at the level of paper and paperboard production. These costs, c_{jk}, are expressed per unit of pulp and can be transmitted up to the paper product through the input ratios. For example, the control costs at the paper level equal the sum of each pulp input's control cost weighted by the on-site input ratio (α^{O}_{jik}) that is, $\sum_{k=1}^{n} \alpha^{O}_{jik} c_{jk}$ for all internally produced pulps used in the production of paper or paperboard product i. In addition, the integrated mills will be indirectly affected by increases in the price of market pulp inputs. These increases in pulp prices, Δr_k, are transmitted through the purchased input ratios (α^{P}_{jik}) that is, $\sum_{k=1}^{n} \alpha^{P}_{jik} \Delta r_k$ for all market pulps used in the production of paper product i. Therefore, the supply function for integrated mills is

$$q_{ji}^{s} = \gamma_{ji} + \frac{\beta_i}{2}\left[\frac{I_{ji}}{p_i - \left[\sum_{k=1}^{n} \alpha_{jik}^{p} r_k + \sum_{k=1}^{n} \alpha_{jik}^{p} \Delta r_k + \sum_{k=1}^{n} \alpha_{jik}^{o} c_{jk}\right]}\right]^{\frac{1}{2}} . \qquad (11)$$

Further, although some nonintegrated paper mills may not be directly affected by the control costs, they will be indirectly affected through the changes in the prices of market pulp inputs to paper production. The supply function for nonintegrated paper mills is therefore expressed as

$$q_{ji}^{s} = \gamma_{ji} + \frac{\beta_i}{2}\left[\frac{I_{ji}}{p_i - \left(\sum_{k=1}^{n} \alpha_{jik}^{p} r_k + \sum_{k=1}^{n} \alpha_{jik}^{p} \Delta r_k\right)}\right]^{\frac{1}{2}} . \qquad (12)$$

Pulp mills will be directly affected by the regulatory control costs, c_{jk}, which enter as a net price change to pulp producers (i.e., $r_k - c_{jk}$). Thus, the supply function for pulp mills, assuming the same generalized Leontief production technology is

$$q_{ji}^{s} = \gamma_{jk} + \frac{\beta_k}{2}\left[\frac{I_{jk}}{r_k - c_{jk}}\right]^{\frac{1}{2}} . \qquad (13)$$

The empirical specification of the market pulp supply equations of integrated mills and pulp mills uses the unadjusted price of market pulp, which is the conceptually proper variable. However, because of data limitations, the empirical specification of the paper and paperboard supply equations of integrated and nonintegrated paper mills used the unadjusted paper and paperboard prices rather than the price net of purchased pulp inputs. The effect this has on the estimated supply parameters for paper and paperboard products depends on the relationship between the variation in unadjusted price (Δp_i) and adjusted price

$(\Delta \phi_i = \Delta p_i - \sum_{k=1}^{n} \alpha_{ik} \Delta r_k)$ over the period of observation.

If the variation in unadjusted price is equal to the variation in adjusted price, then the paper and paperboard supply equations of integrated and nonintegrated paper mills fully captures the quantity response to the observed paper price and the unobserved market pulp price. Intuitively, the variation is the same when the share of purchased pulp in production is equal to zero (i.e., $\sum_{k=1}^{n} \alpha_{ik} = 0$) and\or market pulp prices are constant over this period of time (i.e.,$\Delta r_k = 0$). Thus, the largest component of variation in the true net price must be attributed to the change in observed paper price, Δp_i, as opposed to the change in the share-weighted market pulp prices, $\sum_{k=1}^{n} \alpha_{ik} \Delta r_k$.

If an integrated mill purchases no market pulp, the appropriate supply price is p_i, the unadjusted price of paper. However, integrated mills may purchase some portion of their fiber furnish. Model data derived from the *National Census* indicate that integrated mills, as a group, purchase 9 percent of their fiber furnish. Thus, the effect of using unadjusted price in their supply relation is limited by the small amount of purchased pulp used in the production of paper and paperboard products. Nonintegrated paper mills, by definition, purchase their entire fiber furnish so that the appropriateness of the supply equation is determined by the variation in market pulp prices. Although market pulp prices varied over this time period, the overall effect on any one mill's supply relation may be mitigated by the combined effect of low (high) input shares for purchased pulps with large (small) price changes. In addition, data on price changes for individual market pulps over this time period indicate that offsetting price changes across all purchased pulps used in production is also possible at nonintegrated mills.

Therefore, both the direct and indirect costs of control can be incorporated into the supply relations as follows:

Integrated paper mills:

$$q_{ji}^{s} = \gamma_{ji} + \frac{\beta_i}{2}\left[\frac{I_{ji}}{p_i - \left[\sum_{k=1}^{n} \alpha_{jik}^{p} \Delta r_k + \sum_{k=1}^{n} \alpha_{jik}^{o} c_{jk}\right]}\right]^{\frac{1}{2}}$$

Nonintegrated paper mills:

$$q_{ji}^{s} = \gamma_{ji} + \frac{\beta_i}{2}\left[\frac{I_{ji}}{p_i - \left[\sum_{k=1}^{n} \alpha_{jik}^{p} \Delta r_k\right]}\right]^{\frac{1}{2}}$$

Pulp mills:

$$q_{ji}^{s} = \gamma_{ji} + \frac{\beta_k}{2}\left[\frac{I}{r_k - c_{jk}}\right]^{\frac{1}{2}}.$$

A.4.2.4.2 Facility closure decisions. The discussion above assumes that producing pulp and paper is profitable. However, a facility's optimal choice could be to produce zero output (i.e., close the facility). The facility may not always find complying with the regulation feasible and thus may shutdown the pulp and paper manufacturing operations because it is no longer profitable. We define the sufficient condition for production at the mill as nonnegative net earnings before interest, depreciation, and taxes (EBIDT) (Π), that is,

$$\Pi = TR - TC \geq 0 \qquad (14)$$

where total revenue (TR) is the sum of product revenue (R(q)) and other revenue (R^O), and total cost (TC) is the sum of total variable production costs (C(q)) and total avoidable fixed costs (F^A). Post-regulatory net EBIDT are

$$\Pi^R = R(q) + R^O - C(q) - C^v(q) - F^A - E^{KC}$$

where $C^V(q)$ represents the variable compliance costs at the mill and E^{KC} represents the annualized expenditure for compliance capital. The decision to operate requires non-negative post-regulatory net EBIDT, i.e., $\Pi^R \geq 0$, which occurs when

$$R(q) + R^O - C(q) - C^V(q) - F^A - E^{KC} \geq 0 \qquad (15)$$

or

$$R(q) + R^O - C(q) - F^A \geq C^V(q) + E^{KC} \quad . \qquad (15')$$

In other words, a mill's net EBIDT before regulation must exceed the annual cost of compliance (variable and nonvariable). This decision does not include an annualized value for the liquidation opportunity cost, which is equivalent to assuming that the opportunity cost is offset by costs of closing the facility.

A.4.2.5 Adjustments to National Census Facility-Level Data

The data reported in the *1990 National Census* for a number of economic variables at each mill had to be adjusted so that mill-level EBIDT in the model were consistent with that imputed from the *National Census*. The economic model calculates 1989 revenue from pulp and paper production for each mill as

$$R(q)_{mill} = \sum_{i=1}^{31} p_i q_{ji} + \sum_{k=1}^{6} r_k \, q_{jk}$$

where the market prices for paper and paperboard products, p_i, and market pulp, r_k, were taken from the U.S. Department of Commerce's *Current Industrial Reports: Pulp, Paper, and Board*[40] and the facility-level production of paper and paperboard products, q_{ji}, and market pulp, q_{jk}, were taken from the *National Census*. This estimate of product revenue is very similar to the reported

values from the *National Census*. In fact, the Pearson[2] correlation coefficient, which reflects the extent of a linear relationship between two data sets ranging from a value of -1 and 1, has a value of 0.949 for these two variables. This value indicates a strong positive relationship between the two measures of product revenue at each mill—a value of 1 would indicate that the measures are exact (see Figure A-19).

In addition, the economic model calculates 1989 variable costs of production at each mill according to the method outlined in Section A.4.2.3.2. Although we made every effort to replicate the reported values in the *National Census* for variable production costs at each mill, the two measures are not exact. The value of the Pearson correlation coefficient is 0.964 for these two measures of variable production costs at each mill. As is the case for product revenue, this value indicates a strong positive relationship between the two measures (see Figure A-20).

Given the 1989 values at each mill for product revenue and variable production costs, we adjusted other revenue (from sources other than pulp and paper products) and total fixed costs at each mill to approximate their reported EBIDT from the *National Census*. We derived reported EBIDT from the *National Census* in the following way:

$$\begin{matrix}\textit{Pulp and Paper}\\ \textit{Product}\\ \textit{Revenue}\end{matrix} + \begin{matrix}\textit{Other}\\ \textit{Revenue}\end{matrix} - \begin{matrix}\textit{Total}\\ \textit{Manufacturing}\\ \textit{Costs}\end{matrix} - \begin{matrix}\textit{Total}\\ \textit{Nonmanufacturing}\\ \textit{Costs, less}\\ \textit{depreciation}\end{matrix}$$

Using the reported value of other revenue at each mill in conjunction with the previous estimates of product revenue and variable production costs, we calculated the implied base year value of total fixed costs so that the profit at each mill in the economic model will exactly match the reported EBIDT from the *National Census*. If the resulting estimate of total fixed costs is

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[2]Given N observations of two variables x and y, the Pearson, or product moment, coefficient (r) can be computed as

$$r = \frac{cov(x,y)}{\sqrt{var(x)}\ \sqrt{var(y)}}$$

where cov (x,y) is the sample covariance of x and y, and $\sqrt{var(x)}$ and $\sqrt{var(y)}$ are the sample standard deviations of each variable.

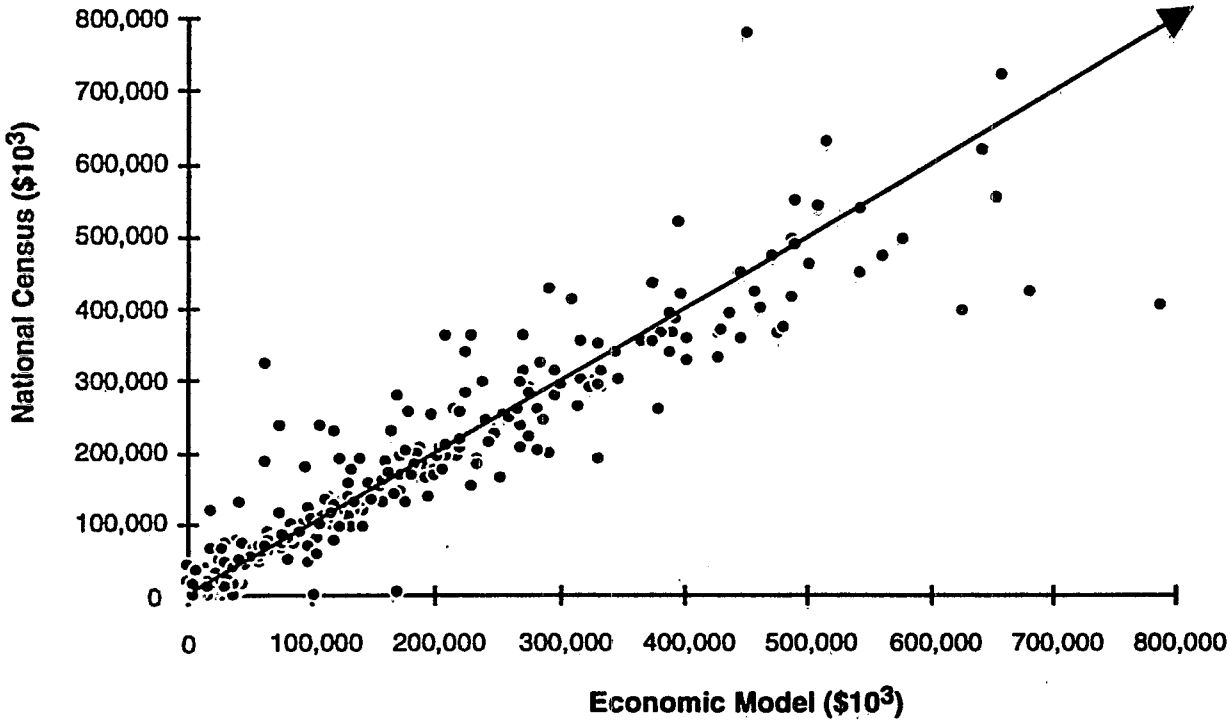

Figure A-19 Production Revenue

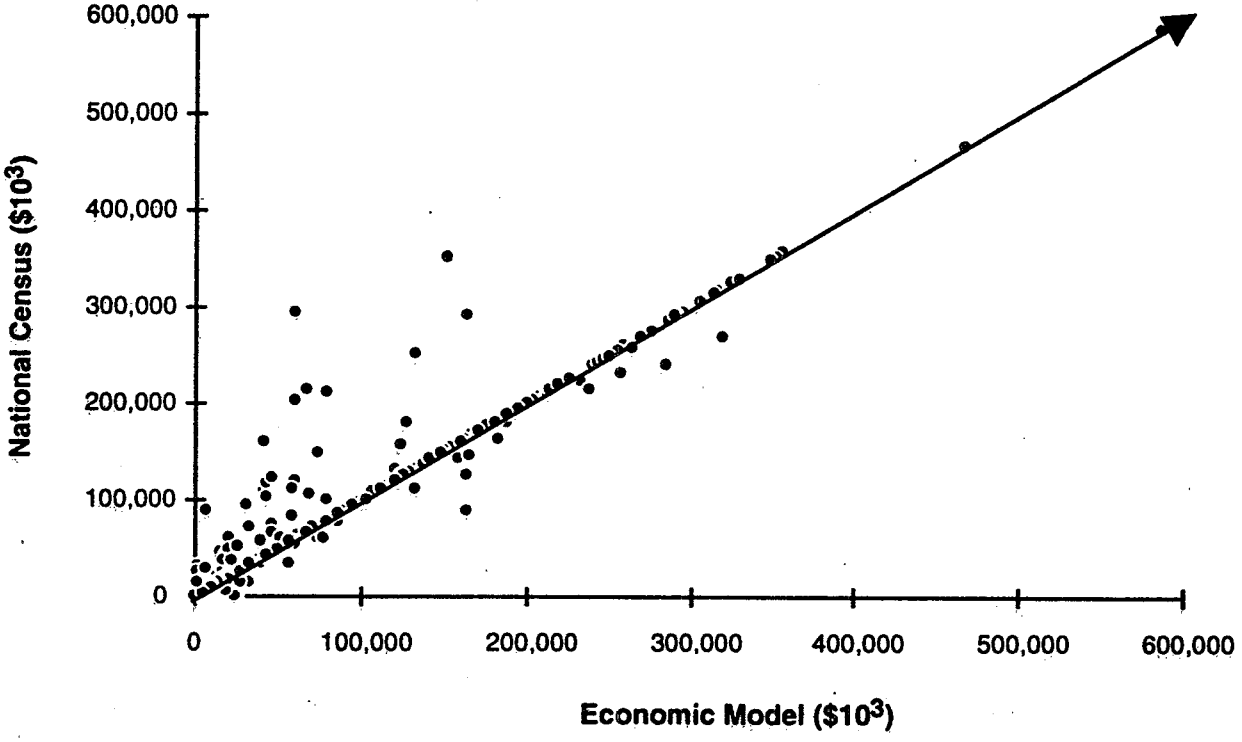

Figure A-20 Total Variable Costs

negative (to match reported EBIDT), then total fixed costs are set to zero, and the absolute value of the negative estimate of total fixed costs is added to other revenue in a lump sum fashion. Thus, the base year value of total fixed costs at each mill as included in the economic model is restricted to be greater than or equal to zero.

Furthermore, a number of mills lacked revenue and cost data from the *National Census* to impute EBIDT. For these 41 mills, we calculated profit as the difference between 1989 revenue from pulp and paper production and 1989 variable costs of production. Thus, other revenue and fixed cost at each of these mills are reported to be zero.

The resulting total revenue and total cost estimates in the economic model (after adjusting other revenue and total fixed costs at each mill) are very similar to the *National Census* values reported for each mill. The Pearson correlation coefficient has a value of 0.966 for the two measures of total revenue at each mill (see Figure A-21) and a value of 0.934 for the two measures of total costs at each mill (see Figure A-22). These values indicate a strong positive relationship for each variable (i.e, the economic model closely resembles the characterization of each mill as determined by the *National Census*).

A.4.3 Domestic Demand For Pulp And Paper Products

A.4.3.1 Market Pulp

The model does not specify an exogenous demand function for market pulps because that demand is derived from the paper supply decisions at the integrated and paper mills.[3]

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[3]Special Alpha and dissolving woodpulp is not only an input into the production of paper and paperboard products, but also in the production of other commodities. We solved for the consumption of this pulp by industries other than the pulp and paper industry using the following equation:

$$\textit{Consumption by Other Industries} = \textit{U.S. Production} - \textit{Exports} + \textit{Imports} - \textit{Consumption by the Pulp and Paper Industry}\ .$$

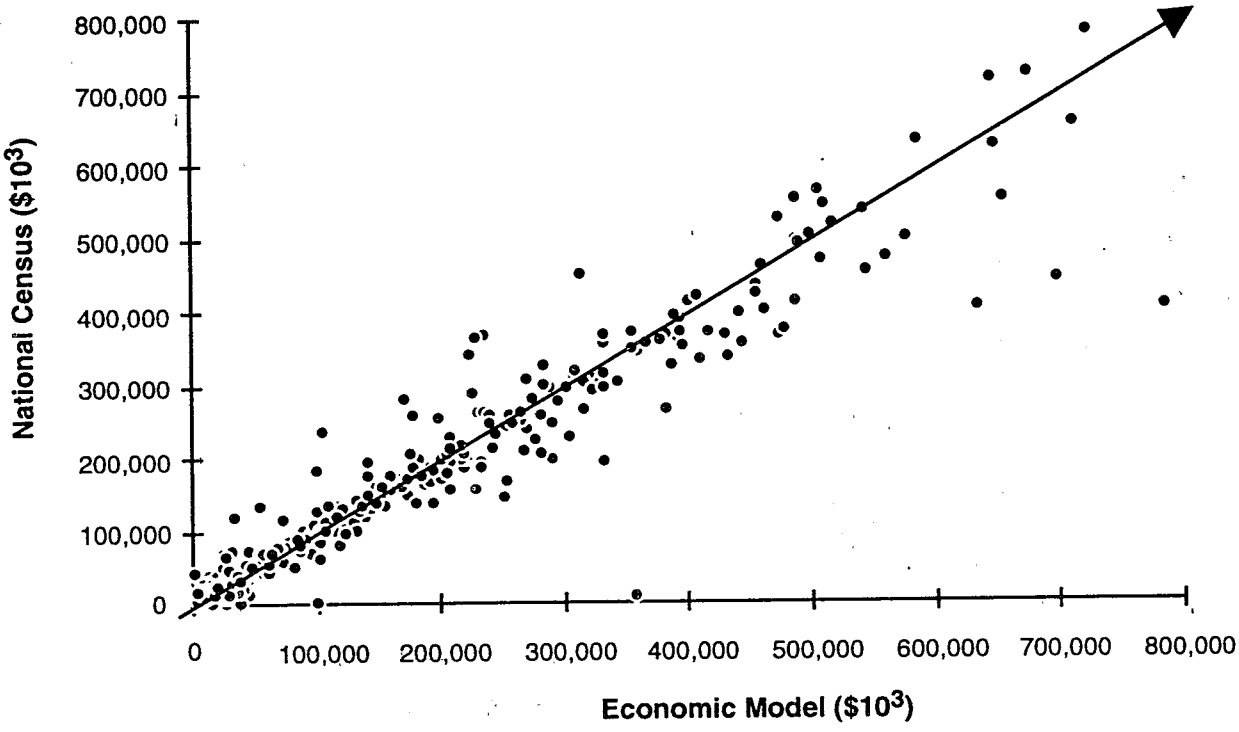

Figure A-21 Total Revenue

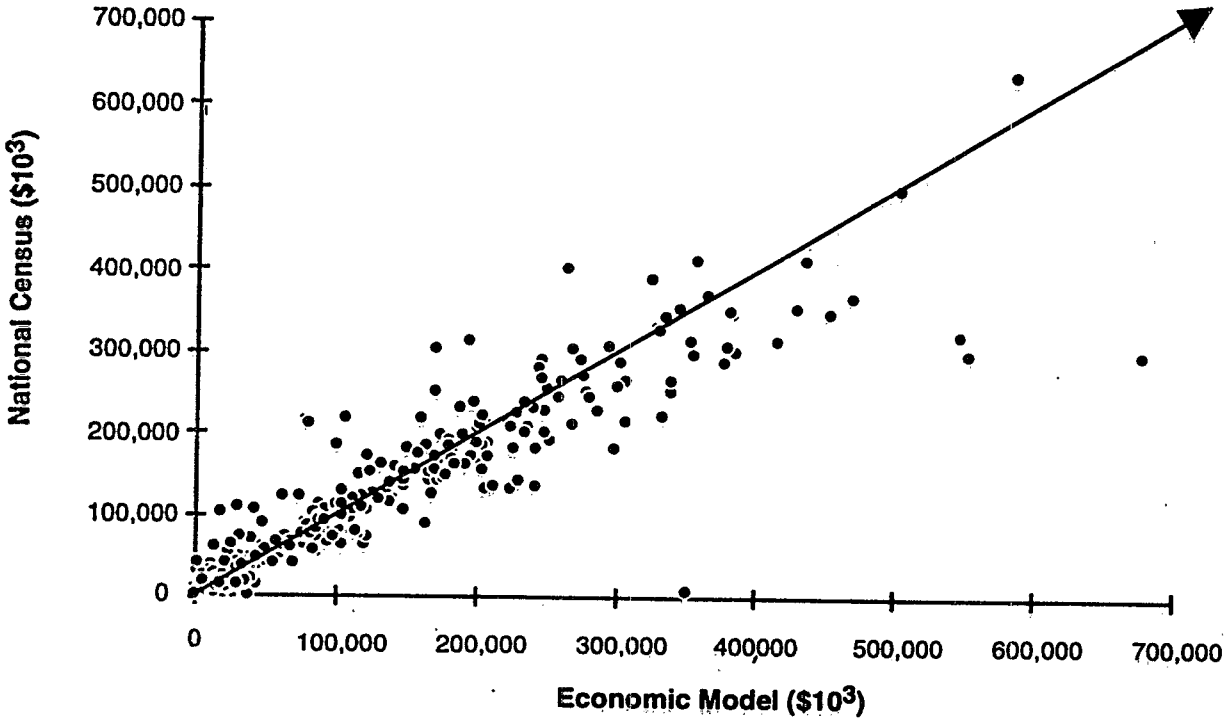

Figure A-22 Total Costs

Therefore, once the paper and paperboard production decisions (q_{ji}^{S}) at each mill have been made, the mill-specific purchased input ratios for each market pulp (α_{jik}^{p}) will determine the domestic demand for each market pulp q_k^d as

$$q_k^d = \sum_j \sum_i \alpha_{jik}^{p} q_{ji}^{S} \quad . \tag{16}$$

Internal consumption of pulp is determined by mill-specific on-site input ratios for each pulp input (α_{jik}^{o}). These on-site input ratios also form the basis for transmitting the variable compliance costs expressed per unit of pulp produced at the mill (c_{jk}) to per-unit variable compliance costs at the level of paper and paperboard products (c_{ji}), that is,

$$C_{ji} = \sum_{k=1}^{n} \alpha_{jik}^{0} c_{jk} \text{ for all paper and paperboard products } (i) \; . \tag{17}$$

We derived the mill-specific purchased input ratios for each market pulp and the mill-specific on-site ratios for each pulp input from technical production data obtained from the *National Census*. We assumed these ratios to be constant throughout the analysis, thereby restricting each mill to produce paper and paperboard products with the same combination of fiber sources, in the same relative amounts, both before and after imposing the regulations.

The model assumes the integrated mills that met all pulp input needs through on-site production in 1989 will not be active on the markets for pulp and will continue to satisfy all pulp requirements internally after imposing the regulation. Thus, these mills are neither suppliers nor demanders in the markets for pulp. However, the model does account for the interaction of those integrated facilities that were active in the pulp markets during 1989, by specifying supply relationships for market pulp suppliers, or by specifying purchased pulp input ratios for market pulp demanders.

This approach indicates that 634,286 (short) tons of this woodpulp were consumed by other industries in the United States. The domestic demand is determined as in equation (18) with the domestic demand elasticity estimate reported in Table A-14 and the constant parameter solved for in a similar fashion as that for paper and paperboard products.

A.4.3.2 Paper and Paperboard Products

The model specifies a general formula for the domestic demand for each paper and paperboard product (q_i^d), that is,

$$q_i^d = A_i \left[p_i\right]^{\eta_i^d} \tag{18}$$

where A_i is a positive constant and η_i^d, the demand elasticity, is negative. This specification is consistent with a constant elasticity demand curve that is derived via simultaneous equation estimation in logarithmic form. Thus, we used the econometric estimate of the demand elasticity, η_i^d, for each paper and paperboard product in this demand specification and determines the responsiveness of quantity demanded to changes in paper product price. The product-specific demand parameters, A_i, were determined through backsolving techniques to calibrate the model so that base year supply equals base year demand for all paper and paperboard products as discussed in Section A.4.5.2.

A.4.3.2.1 Econometric estimation of domestic demand relationships. Recall from our discussion of the "auctioneer" market model that each time the mythical auctioneer offers a new price for each product, each firm offers its profit-maximizing quantity at that price. Summed across firms, this quantity equals the market supply response to the price. On the demand side of the market, we need to adjust the quantity demanded in response to the new price. This adjustment can be expressed in terms of a demand function

$$Q^d = Q^d\,(P,Z)$$

where quantity demanded, Q^d, is a function of price, P, and Z, other demand factors such as income or the price of substitute goods. The responsiveness of quantity demanded to a change in price can be characterized by the demand elasticity

This demand elasticity measures the proportional change in quantity demanded given a proportional change in price. Economic theory suggests that η is negative (i.e., a rise in price

$$\eta = \frac{\frac{dQ^d}{Q^d}}{\frac{dP}{P}} \quad .$$

should induce a reduction in quantity demanded, all else equal). The absolute value of a product's demand elasticity measure is often compared to a benchmark value of one. An absolute value of η greater (less) than one indicates that demand is elastic (inelastic) with respect to price.

In this section we describe the underlying model of product demand, the econometric method used to estimate the product demand functions, the data employed in the analysis, and the resulting product demand elasticities.

A.4.3.2.1.1 Specifying the demand function. We generated values of η for each paper and paperboard product by specifying a market demand function for each product, with quantity demanded as a function of price and other factors, and by econometrically estimating the direct effect of price on quantity demanded through this functional specification. The general form of the demand function is specified

$$Ln(Q_{it}^d) = \beta_{i0} + \beta_{i1}\, Ln\,(P_{it}) + \sum_{j=1}^{m} \beta_{ij}\, Ln\,(Z_{ijt}) + \nu_{it} \quad . \tag{19}$$

The i subscript indicates the product, the t subscript indicates the time period of observation, and the j subscript indexes m, other demand variables. The error term, ν_{it}, reflects the nonsystematic random factors that affect observed demand quantities in each period. Because we specified the natural log of the quantity as a linear function of the natural log of the price, the value we derived for the parameter, β_{i1}, gives an estimate of the demand elasticity, η_i.

A.4.3.2.1.2 Estimating the demand function. At first glance, estimating the demand function seems like a simple procedure of regressing the observed market quantities on the

observed market prices and other demand determinants indicated in equation (19). Unfortunately the task is not so straightforward. We must account for the fact that the observed prices and quantities are **equilibrium** values, which are determined by the simultaneous solution of the separate market demand and supply functions. We elaborate on this point here to correctly specify the system for econometric estimation.

A partial equilibrium market supply and demand model is specified as a system of interdependent equations in which the price and output of a product are simultaneously determined by the interaction of producers and consumers in the market. We can define the supply and demand system for a particular product as follows:

$$Q_i^d = f(P_i, Z_i) + u_i \tag{20}$$

$$Q_i^s = g(P_i, W_i) + v_i \tag{21}$$

$$Q_i^d = Q_i^s \tag{22}$$

Equation (20) is analogous to equation (21), representing quantity demanded as a function of price, P_i; an array of demand factors, Z_i; and an error term, u_i. Equation (21) represents quantity supplied as a function of price and other supply factors, W_i (e.g., input prices), and an error term, v_i. Equation (22) specifies the equilibrium condition: quantity supplied equals quantity demanded. Thus we have a system of three equations, which include three variables. The interaction of the specified market forces solves this system, generating equilibrium values for the variables, P_i^* and $Q_i^* = Q_i^{d*} = Q_i^{s*}$.

Variables that are determined within a system, such as P_i^* and Q_i^*, are said to be **endogenous** to that system, while those that are determined outside of the system, such as Z_i and W_i, are called **exogenous**. In simultaneous equation models, endogenous variables are correlated with the error terms through solution of the system. As a result of the interdependence of the endogenous variables and the error terms, we must modify the application of standard regression techniques to estimate the effect of an endogenous right-hand side (regressor) variable (i.e., equilibrium price) on the endogenous left-hand side quantity demanded (or supplied) variable.

In general, ordinary least-squares estimation of the individual equations in the market model leads to biased and inconsistent parameter estimates when a regressor is endogenous.

An additional consideration is that the supply and demand equations must be econometrically **identified**, which means that the relevant values of the structural parameters (e.g., the price elasticity of demand in this case) can be obtained from the estimated equation. To identify an equation in a simultaneous system, the number of exogenous variables excluded from the equation must exceed the number of included endogenous variables minus one. This situation is referred to as the **order condition** for identification. Because both equations (21) and (22) have two included endogenous variables (P_i and Q_i), the order condition requires that each equation must also include at least one exogenous variable that is not included in the other equation. This condition is satisfied by the distinction between exogenous demand factors, Z_i, and exogenous supply factors, W_i in equations (20) and (21). Note that the order condition is a necessary, but not sufficient, condition for identification. The sufficient condition for identification is the **rank condition**, which tests whether the equation in question could be constructed from a linear combination of other equations in the system. If so, then the equation is not uniquely identified.

Endogeneity bias is corrected by applying the two-stage least squares (2SLS) regression procedure for each equation estimated (see, for example, Pindyck and Rubinfeld[41]). Because the objective was to generate estimates of the demand elasticities, we estimated only the demand function for each market. In the first stage of the 2SLS method, the price observations were regressed against all exogenous variables (Z_i,W_i) in the system. This regression produced fitted (or predicted) values for the price variable that are, by definition, highly correlated with the true endogenous variable and the observed price and uncorrelated with the error term. In the second stage, these fitted values were employed as observations of the right-hand side price variable in the demand function. This fitted value is uncorrelated with the error term by construction and thus does not incur the endogeneity bias previously mentioned. The second-stage parameter estimate for price provides the elasticity estimate indicated by equation (19).

For the purposes of domestic demand estimation, the dependent variable is domestic consumption of product i (in tons), which equals domestic production less exports plus imports:

$$Q_i^C = Q_i^P - Q_i^X + Q_i^M \quad . \tag{23}$$

Likewise, the value of domestic consumption equals the value of domestic shipments less value of exports plus value of imports:

$$V_i^C = V_i^P - V_i^X + V_i^M \quad . \tag{24}$$

We computed the consumption price of the product as domestic consumption value divided by domestic consumption quantity:

$$P_i = (V_i^C / Q_i^C) \quad .$$

In general, imports and exports are reported at higher levels of aggregation than the product groups identified in the *National Census*. For instance, paper products 30 through 37 are summed together in the import and export data, as are products 40 and 42 and 60 through 66. Because we needed domestic production, import, and export values to compute domestic consumption, we aggregated the domestic production data according to these import and export aggregations.

Once the product groups were aggregated, we computed the prices and quantities as specified above. As discussed above, the first stage of the 2SLS procedure involved regressing the observed price against supply and demand variables that are exogenous to the market. On the demand side, these variables included GNP and population for the U.S. while the supply-side variables included the separate prices of labor, materials, and energy faced by the paper and paperboard industry. All prices employed in the estimation process were deflated by the consumer price index (CPI) to reflect real, rather than nominal, prices.

In addition to price, other potential demand variables included CPI-deflated Gross National Product as a measure of economic activity and separate price indices for fuels, plastics and rubber, and lumber as measures of substitute product prices. The right-hand side variables are not the same for all equations, which allows for some product-specific differences. For example, the fuels price index is specified as a demand factor for insulating board (product 52),

and the plastics and rubber price index is included in the demand equations for packaging and industrial converting paper (products 30 through 37) as a proxy for the price of substitute packing materials.

A.4.3.2.1.3 Data sources. Annual value of shipments and quantities produced by domestic producers for each of the product groups are reported in the U.S. Department of Commerce's, *Current Industrial Reports: Pulp, Paper, and Board.*[42, 43, 44, 45, 46][4] The domestic shipments data are available for the years 1981 through 1989. The corresponding annual values for imports and exports are reported in *Statistics of Paper, Paperboard, and Wood Pulp*, published by the American Paper Institute.[50, 51]

The labor price facing the paper and paperboard industry was derived using annual data from the *Annual Survey of Manufactures*[52, 53, 54, 55, 56] for the paper sector (SIC-2621) and paperboard sector (SIC-2631). We computed this value by dividing total compensation (including mandated and other employer-paid benefits) by total labor hours. Total annual labor hours equals the sum of production hours and nonproduction hours, the latter estimated as the number of nonproduction employees multiplied by 2000. The Producer Price Index for intermediate supplies and materials served as a proxy for materials price for the paper and paperboard industry, while the producer price index for fuels served as the proxy for energy price.[57] Annual figures for the Producer Price Indices of substitute commodities, as well as the CPI were taken from the *Handbook of Labor Statistics* and the *Survey of Current Business.*[58, 59] U.S. Gross National Product figures were also taken from the *Survey of Current Business.*[60]

A.4.3.2.1.4 Results. Because the domestic shipments data for these categories are only available for 1981 through 1989, we were limited to nine observations for each equation. This

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[4]Production data for product category 70, molded pulp, are from the *1982* and *1987 Census of Manufactures: Converted Paper and Paperboard Products, Except Containers and Boxes* (years 1981 - 1986)[47, 48] and the *1990 Annual Survey of Manufactures, Value of Product Shipments* (years 1987 - 1989).[49]

situation constrained the number of explanatory variables we specified for each equation because of statistical inference considerations related to the **degrees of freedom** of the estimated model.

Table A-13 provides domestic demand elasticity estimates along with the associated t-statistics, marginal significance levels (i.e., probability values for the t-statistics), and list of regressors. Note that a number of closely related products share the same elasticity estimate because of the data aggregation discussed above. Various specifications of the demand functions for products 24 and 26 performed poorly in estimation and are not reported here. Because of a lack of data, we provide no estimate for product 70. Consequently the estimates for similar products are used in place of direct estimates for these three product groups. The estimate for product 25 is used for product 24, the estimate for 27 is used for 26, and the estimates for products 60 through 66 are used for product 70. The elasticity estimates for all products are of a magnitude similar to other industrial commodities, ranging from -0.232 for product 23 to -2.930 for product 52: most estimates fall in the -0.5 to -1.5 interval. The t-statistics are fairly strong for a large number of the products. This level of significance is particularly true for the paperboard estimates (40-66), most of which are significant at an 85 percent level of significance or better.

A.4.4 Foreign Sector

The importance of including a foreign sector in the economic model is highlighted by the significant level of international trade of products manufactured by facilities in the U.S. pulp and paper industry. Section A.2.5 provides detailed information on the extent of foreign supply of pulp and paper products to the U.S. (imports) and foreign demand for U.S.-produced pulp and paper products (exports).

The model specifies a general formula for the foreign supply for each market pulp (q_k^I) and paper and paperboard product (q_i^I):

TABLE A-13

DOMESTIC DEMAND ELASTICITIES--PAPER AND PAPERBOARD PRODUCTS

Product Code[a]	Elasticity Estimate	t-statistic	Prob-val	Regressors
Paper				
20	-0.301	-1.087	0.32	P, GNP
21	-1.135	-1.192	0.28	P, GNP
22	-1.839	-3.371	0.02	P, GNP
23	-0.232	-0.987	0.37	P, GNP
24	-0.647	-1.055	0.3 3	P, GNP
25	-0.647	-1.055	0.33	P, GNP
26	-1.907	-0.920	0.40	P, GNP
27	-1.907	-0 .920	0.40	P, GNP, time
28	-0.574	-0.517	0.63	P, GNP, PPI-plastics
30-37	-1 .937	-1.630	0.16	P, GNP, PPI-plastics
38	-0.894	-2.770	0.03	P, GNP
Paperboard				
40, 42	-0.235	-1.407	0.22	P, GNP, PPI-lumber
41	-0.353	-2.198	0.07	P, GNP
43	-1.032	-4.644	0.01	P, GNP
50	-0.940	-1.760	0.13	P, GNP
51	-0.259	-0.718	0.50	P, GNP
52	-2.930	-0.981	0.38	P, GNP, PPI-fuels
60-66	-0.752	-2.280	0.07	P, GNP, PPI-plastics
70	-0.752	-2.280	0.07	P, GNP, PPI-plastics

[a]Product names and descriptions corresponding to the product code are given in Table A-7.

$$q_k^I = B_k^I [r_k]^{\xi_k^I} \tag{25}$$

and

$$q_i^I = B_i^I [p_i]^{\xi_i^I} \tag{26}$$

where B_k^I and B_i^I are positive constants and ξ_k^I and ξ_i^I are positive measures of the foreign supply elasticities for market pulp (k) and paper and paperboard products (i).

The model also specifies a general formula for the foreign demand for each market pulp (q_k^x) and paper and paperboard product (q_i^x):

$$q_k^x = A_k^x [r_k]^{\eta_k^x} \tag{27}$$

and

$$q_i^x = A_i^x [p_i]^{\eta_i^x} \tag{28}$$

where A_k^x and A_i^x are positive constants and η_k^x and η_i^x are negative measures of the foreign demand elasticities for market pulp (k) and paper and paperboard products (i).

Numerically computed, rather than econometrically estimated, elasticities of import supply and export demand for each of the pulp and paper commodities were used in these foreign supply and demand specifications and determined the responsiveness of foreign trade flows to changes in product prices. The multiplicative product-specific foreign supply and demand parameters, A^x and B^I, were determined through backsolving techniques given estimates of the import supply and export demand elasticities, 1989 baseline prices, and product-specific quantities of U.S. imports and exports for 1989 (see Section A.4.5 for further details on model calibration).

The next section describes the methodology for obtaining the key parameters—the import supply and export demand elasticities—necessary for including the foreign sector in the economic model.

A.4.4.1 Computing Import Supply and Export Demand Elasticities

To evaluate the full economic effect of changes in the cost structure for U.S. pulp and paper producers, we must consider the role of international trade. A regulation-induced increase in the U.S. price for a product can be expected to attract imports and reduce exports of that product, all else equal. In this section we describe the methods used to derive the elasticities of import supply and export demand for each defined product.

A.4.4.1.1 Specifying the model. The difficulty of econometrically estimating import and export elasticities from international trade data has long been recognized. Orcutt demonstrated that elasticity estimates derived from regressions of a country's import (export) quantity on historical prices understate the true price responsiveness of imports and exports, typically by a substantial magnitude.[61] Part of the difficulty derives from the identification problem, described above, which is more pronounced given the difficulty in procuring measures of exogenous demand and supply factors for foreign consumers and producers. Orcutt demonstrates how to derive the total elasticity of imports and exports, which accounts for the effect of the change in price on all (foreign and domestic) producing and consuming parties. We develop that method here to numerically compute, rather than econometrically estimate, the elasticities of import supply and export demand for each of the pulp and paper commodities in the study.

For the purposes of this example, consider country A, who internally produces some portion of a product it consumes and imports the rest from country B. Let the U.S. be country A. Country B can either be an aggregate entity (i.e., the "rest of the world") or a specific country such as Canada. Assume here that country B exports to the U.S. only; the rest of production is consumed internally in country B.

Imports to country A equal A's excess demand for the product.

$$Q_m^A = Q_d^A(P) - Q_s^A(P) \tag{29}$$

where P is the price of the good in country A.

Exports from country B equal B's excess supply of the product

$$Q_x^B = Q_s^B(P^B) - Q_d^B(P^B) \tag{30}$$

where P^B is the price in country B. In equilibrium, the home price received by the country B exporter should just equal the net price received from exporting to country A.

$$P^B = XP - t_{AB} \tag{31}$$

where X is the exchange rate and t_{AB} is the transportation cost (and any tariffs) between A and B. In this example, country B's exports must equal country A's imports in equilibrium.

$$Q_x^B = Q_m^A \tag{32}$$

We now want to evaluate the effect of import supply with respect to a change in country A's price (e.g., as a result of regulations on country A's producers). The supply elasticity of imports is defined

$$e_m^A = (dQ_m^A/dP)(P/Q_m^A) \quad . \tag{33}$$

By manipulating the trade equations above, we get the following expression for the import elasticity:

$$e_m^A = [1 + (t_{AB}/P^B)] [e_S^B (Q_s^B/Q_m^A) - e_d^B(Q_d^B/Q_m^A)] \tag{34}$$

where e_S^B and e_d^B, respectively, are the supply and demand elasticities for country B's producers and consumers.

For demonstration, let the following values hold: e_S^B=0.5, e_D^B = -1.0, Q_s^B= 40, Q_d^B=20, which implies Q_m^A = 20. Suppose transport costs to country A are 20 percent of the country B price. Inserting these values into the elasticity equation yields e_m^A = 1.6, which is more than three times the "regular" supply elasticity. This difference would be even more pronounced if a smaller portion of country B's product was exported or if transport costs were a larger portion of the price.

Similarly, we can compute the elasticity of export demand facing country B. Because we are interested in the export demand for U.S. products, country B is the U.S. in this scenario and country A is the foreign entity (rest of the world or a specific country). After manipulating the trade equations, we get the following expression for the export demand elasticity:

$$e_x^B = [P^B/(P^B+t_{AB})]\,[e_d^A\,(Q_d^A/Q_x^B) - e_s^A(Q_s^A/Q_x^B)] \qquad (35)$$

where e_s^A and e_d^B, respectively, are the supply and demand elasticities for country A producers and consumers. Let the supply and demand elasticities be the same in country A as they are in country B (0.5, -1.0), and let country A's demand and supply quantities be Q_d^A=100 and Q_s^A=80, which is consistent with Q_x^B=20.

Inserting these values into the elasticity equation yields e_x^B = -8.75, which is almost nine times the "regular" domestic demand elasticity. This difference would be even more pronounced if a smaller portion of country A's demand was satisfied with exports from country B or if transport costs were a smaller portion of the price.

The underlying message here is that theory strongly suggests foreign trade elasticities are larger than domestic elasticities, much like the elasticity facing a single producer or consumer is larger than the elasticity facing the aggregate of consumers and producers (the market). This theory is borne out in empirical work as well. For instance, a study of the supply of wheat for consumption in Japan estimates that the short-run import supply elasticity for Japan is more than

400 times the magnitude of the "regular" supply elasticity for world wheat producers.[62] We explain the logic behind this using the example of import supply to country A. When the price in country A rises, the A market looks marginally more profitable for B's producers. They will respond by shifting supplies to country A's destinations until marginal supply units are equally profitable for each destination (i.e., a new [higher] equilibrium price is established in Country B) via equation (31). In the transformation to the new equilibrium, country B consumers demand less as the price they pay rises, and country B producers produce more as the price they receive rises. Exports to country A rise by the amount of the increased production by B's producers plus the reduced consumption of B's consumers (i.e., by the growth in excess supply). The proportional effect, as implied by the elasticity in equation (34), is larger if exports from B to A are small relative to B's production (and B's consumption). At the limit, these elasticities are infinite, indicating the textbook case of price-taking in world markets by small open economy producers and consumers.

A.4.4.1.2 Computation procedure. To compute the foreign trade elasticities for the U.S., we must specify who plays the "role" of the foreign entity in the analysis, that is, who are the foreign (country B) producers and consumers in constructing the import supply elasticity, equation (34), and the foreign (country A) producers and consumers in constructing the export demand elasticity, equation (35).

As previously mentioned, the foreign entity can be perceived as one country in the case of bilateral trade or the rest of the world in the case of multilateral trade. For a number of pulp and paper products (e.g., newsprint imports), U.S. trade is almost entirely bilateral with Canada, while for other products (e.g., linerboard exports), U.S. trade is essentially multilateral.[63] In the case of import supply to the U.S., we have

$$e_m = e_m^C S_m^C + e_m^R S_m^R$$

where e_m^C is the import supply elasticity using equation (34) with Canada as country B (the source of U.S. imports), S_m^C is the Canadian share of U.S. imports, e_m^R is the import supply elasticity using equation (34) with the rest of the world as country B, and S_m^R is the rest of the

world share of U.S. imports. For the purposes of this study, the rest of the world includes all OECD countries excluding the U.S. and Canada.

Likewise we computed a weighted average for the demand elasticity for U.S. exports:

$$e_x = e_x^C S_x^C + e_x^R S_x^R$$

where e_x^C is the export demand elasticity using equation (35) with Canada as country A (the destination of U.S. exports), S_m^C is the Canadian share of U.S. exports, e_x^R is the export demand elasticity using equation (35) with the rest of the world as country A, and S_x^R is the rest of the world share of U.S. exports.

A.4.4.1.3 Data sources. Data on production and consumption of pulp and paper commodities by each country in the OECD for 1989 are found in *The Pulp and Paper Industry in OECD Countries*.[64] Tables in that publication report trade flows (imports and exports) to and from each of the member countries and the OECD in aggregate for 30 different pulp, paper, and paperboard product groups. These tables also report total production, consumption, imports, and exports for each country and the OECD aggregate for each product. From these tables we computed the foreign and domestic ratios implicit in equations (34) and (35) to compute the Canadian and rest of world elasticities. The product groups classified by the OECD were matched up with the product categories specified for this study to the extent possible. Because the OECD classification includes fewer groups, sometimes we had to use the foreign and domestic ratios from one OECD category as representative of that ratio for more than one of the product categories defined for this study.

We used the U.S. demand elasticity estimates, described in Section A.4.3.2, as proxies for consumer demand elasticities elsewhere in the OECD. We also constructed estimates of the U.S. domestic supply elasticity for each product using equation (6') for the supply elasticity from Section A.4.2.2.5 computed at the mean production level for facilities supplying the product. The U.S. domestic supply elasticity is similarly used as a proxy for the supply elasticity of other OECD producing countries.

The data for transportation costs from the U.S. to foreign ports were derived from a number of different sources. Transportation costs between Canada and the U.S. for several different pulp and paper products were provided through personal communication with the economics staff at the Forest Products Laboratory of the U.S. Forest Service in Madison, WI.[65] These sources also provided expert opinion estimates for transportation costs from the eastern U.S. to Europe and from the western U.S. to Asia. The latter estimates were verified with data on transport costs of pulp products from Seattle to Japan provided in a report published by the Center for International Trade in Forest Products at the University of Washington.[66]

A.4.4.1.4 Results. Table A-14 presents the numerically computed import supply and export demand elasticities for each product. In addition, we report the domestic demand and supply estimates that were used to construct these estimates, the share of U.S. consumption that is imported from OECD countries, and the share of U.S. production that is exported to OECD countries. The foreign trade elasticity estimates were computed as weighted averages of the bilateral trade elasticities with Canada and multilateral trade elasticities with the rest of the world. We concentrated on trade with OECD countries because OECD was the only data source that could provide information on the countries of origin for U.S. imports and countries of destination for U.S. exports by any meaningful product classifications. The origin and destination data were needed to compute the international trade elasticities (see import supply and export demand equations above). Note that the shares reported in Table A-14 were used for the purpose of computing the international trade elasticities only. The total value and volume of U.S. imports and exports data by product group, the data used to compute total production by U.S. producers and total consumption by U.S. consumers for use in the market model, were derived from *API* data.[685]

In regard to providing model parameters, the OECD data for Canada were more consistent than for other OECD countries so that the foreign trade elasticity for Canada was used in the model if the Canadian share of U.S. imports or exports for a particular product

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[5]Export data for production category 70, molded pulp, are from the *U.S. Department of Commerce*.[69]

TABLE A-14

FOREIGN TRADE ELASTICITIES—PULP AND PAPER PRODUCTS

Product	Domestic Demand Elasticity	Domestic Supply Elasticity[a]	Import Supply Elasticity	Export Demand Elasticity	Import Share of Consumption[b]	Export Share of Production[b]
Pulp						
1	-0.750	0.2009	11.047	-4.377	0.2037	0.2490
2	-0.413	0.1856	5.964	-5.752	0.13 79	0.1087
3	-0.913	0.2674	175.119	-872.206	0.0033	0.0005
4	-1.051	0.2320	20.8 07	-26.652	0.2377	0.1388
Paper						
20	-0.301	0.2939	1.498	-43.172	0.6146	0.0377
21	-1.135	0.3304	17.255	-100.884	0.1105	0.0166
22	-1.839	1.6530	68.951	-299.428	0 .0970	0.0203
23	-0.232	0.3087	6.797	-41.980	0.1226	0.0166
24	-0.647	1.2102	28.2 23	-153.329	0.1060	0.0179
25	-0.647	0.1192	63.408	-367.272	0.1060	0.0179
26	-1.9 07	0.1858	29.041	-141.519	0.1060	0.0179
27	-1.907	0.9965	119.454	-95.968	0.0789	0.0952
28	-0.574	0.8156	65.95 2	-43.445	0.0789	0.0952
30	-1.937	1.6309	457.782	-84.030	0.0065	0.0305
31	-1.937	1.2618	139.176	-213.117	0.0600	0.0304
32	-1.937	N/A	130.776	-200.201	0.0600	0.0 304
33	-1.937	1.6309	28.297	-47.521	0.0670	0.0359
34	-1.937	2.2533	41.849	-70.2 55	0.0670	0.0359
35	-1.937	1.6309	—	-3.896	—	—
36	-1.937	1.2049	—	-2.408	—	—
37	-1.93 7	1.6586	791.116	-145.232	0.0065	0.0305
38	-0.894	1.6309	424.372	-81.303	0.006 5	0.0305
Paperboard						
40	-0.235	0.3158	5.797	-25.232	0.1060	0.0179
41	-0.353	0.2757	11.590	-49.011	0.1060	0.0179

TABLE A-14 (cont.)

Product	Domestic Demand Elasticity	Domestic Supply Elasticity[a]	Import Supply Elasticity	Export Demand Elasticity	Import Share of Consumption[b]	Export Share of Production[b]
42	-0.235	0.4928	13.088	-57.169	0.1060	0.0 179
43	-1.032	0.3545	17.414	-11.118	0.0893	0.1199
50	-0.940	0.8820		—	—	—
51	-0.259	N/A	14.917	-7.758	0.0893	0.1199
52	-2.930	0.7406	57.453	-29.741	0.0893	0.1199
60	-0.752	1.0139	384.651	-29.630	0.0047	0.0427
61	-0.752	0.7481	611.789	-47.093	0.0034	0.0323
62	-0.752	0.4430	485.303	-37.362	0.0034	0.0323
63	-0.752	0.6807	584.004	-44.956	0.0034	0.0323
64	-0.752	0.6807	584.004	-44.956	0.0034	0.0323
65	-0.752	0.6807	584.004	-44.956	0.0034	0.0323
66	-0.752	0.6807	584.004	-44.956	0.0034	0.0323
70	-0.752	0.2382	212.68	-36.559	0.0065	0.0305

[a]Table A-12.
[b]Based on U.S. imports from and exports to OECD countries as reported in OECD[67] for product groups different from those reported here.

group exceeded 25 percent. We provide the foreign trade elasticities incorporated into the model in Table A-15.

Results indicate rather large import supply and export demand elasticities for most products. In these cases, U.S. imports (exports) are a very small portion of total production and consumption in the rest of the world and are, for all practical purposes, price-takers on the world market for these products. The exceptions occur in the categories where foreign trade is a large component of total U.S. consumption or production. For instance, the U.S. imports over 60 percent of the newsprint it consumes (product 20), and 98 percent of these imports are from Canada. Canada exports far more newsprint to the U.S. than it consumes internally. Recalling equation (34), we see that these factors combine to make the import supply elasticity for newsprint relatively low (1.498). Employing the logic from the preceding argument, the U.S. is not a small consumer of Canadian production; therefore, changes in U.S. consumption can have a nontrivial effect on the import price. A similar case is made for U.S. exports of Special Alpha and dissolving woodpulp (product 1), which constitutes 25 percent of domestic production and faces a fairly low export demand elasticity of -4.377.

The results here suggest an inverse relationship between the proportional and absolute effects of a domestic price change on foreign trade. Where foreign trade is a relatively minor component of U.S. consumption or production, elasticities imply that regulation-induced price changes may generate large proportional changes in imports and exports. But these changes may not be so large in absolute value, given the small initial values of foreign trade. On the other hand, price-taking in world markets should dampen the price effects of regulation in U.S. markets by suggesting large potential import supplies at the "world" price and the inability to raise the price of exports on world markets.

A.4.5 Calibration of the Economic Model

To perform the regulatory market analysis, the model must allow for comparing a historical equilibrium generated by existing conditions that is assumed to be observable, and a hypothetical or post-compliance equilibrium that the model produces under a changed policy

TABLE A-15

FOREIGN TRADE ELASTICITIES USED IN ECONOMIC MODEL

Product		Import Supply Elasticity	Export Demand Elasticity
Pulp			
	1	0.7657[a]	-4.377
	2	1.0039[a]	-5.752
	3	29.3906[a]	-20
	4	6.0001[a]	-26.652
	14	10[b]	NA
	15	NA	-10[b]
Paper			
	20	0.466[a]	-44.557[a]
	21	2.012[a]	-18.5029[a]
	22	6.575[a]	-18.8722[a]
	23	1.011[a]	-9.5657[a]
	24	3.688[a]	-24.7128[a]
	25	1.007[a]	-6.9822[a]
	26	2.703[a]	-17.1357[a]
	27	1.389[a]	-0.6798[a]
	28	0.442[a]	-0.1954[a]
	30	13.608[c]	-51.1171[a]
	31	13.608[a]	-24.2047[a]
	32	NA	NA
	33	5.827[a]	-24.3361[a]
	34	6.969[a]	-29.1077[a]
	35	13.608[c]	-1.7128[a]
	36	13.608[c]	-1.7128[a]
	37	13.608[c]	-51.5154[a]
	38	13.608[c]	-36.4688[a]

TABLE A-15 (cont.)

Product	Import Supply Elasticity	Export Demand Elasticity
Paperboard		
40	1.11[a]	-6.624[a]
41	1.16[a]	-6.8143[a]
42	1.572[a]	-9.3803[a]
43	1.5588[a]	-2.356[a]
50	4.1219[d]	-5.5834[d]
51	NA	NA
52	4.1219[a]	-5.5834[a]
60	31.5747[a]	-29.6295
61	44.1675[a]	-9.7706[a]
62	35.8311[a]	-7.9264[a]
63	42.3362[a]	-9.3655[a]
64	42.3362[a]	-9.3655[a]
65	42.3362[a]	-9.3655[a]
66	42.3362[a]	-9.3655[a]
70	67.3917[a]	-14.0005[a]

[a]Value equal to that computed for Canada rather than value reported in Table A-14.
[b]Assumed values, data not available to compute foreign trade elasticities.
[c]Assumed value to be same as that computed for product 31.
[d]Assumed value to be same as that computed for product 52.

regime. The assumption of an "observable" equilibrium leads directly to the need for and construction of a data set that fulfills the equilibrium conditions in a competitive market model of the U.S. pulp and paper industry. The base year of analysis is 1989, the latest year for which facility-level production data are available for all mills included in the *National Census.* The baseline data set for this model is a collection of data from the *National Census,* including data on facility-level output and production processes, and the other sources noted above in estimating supply and demand function parameters.

For the particular functions assumed for supply and demand, we chose parameter values so that the model will exactly reproduce the 1989 equilibrium values as a solution to the model. This procedure is commonly referred to in the computable general equilibrium literature as "calibration." Calibration is augmented by a literature search or econometric estimation for key parameters. Typically, key parameters are more or less synonomous with elasticities. In this case, we used the econometric estimates of the key parameters (βs and elasticities) and assumed functional forms of the supply and demand relations to calibrate the model. This procedure not only guarantees that base year market supply equals market demand for all commodities but also that facility-level supply responses given 1989 market prices are consistent with those observed in the base year. This section describes the data modifications and procedures used in constructing the 1989 baseline data set for analyzing the regulatory impact on the U.S. pulp and paper industry.

A.4.5.1 Supply Parameters

On the supply side, we used the key parameters, that is, βs and import supply elasticities, and the assumed functional forms of domestic and foreign supply relations to "calibrate" the model. This guarantees that facility-level supply and import supply responses given 1989 market prices are consistent with those observed in the base year. This section describes the data modifications and procedures employed on the production, or supply, side of the economic model.

A.4.5.1.1 Domestic supply. Recall that one of the supply parameters provided by the econometric estimation of the supply function is the intercept, γ_{ji}, which varies across facilities. This parameter does not influence the facility's production responsiveness to price changes as does the β parameter. Therefore, we used the γ_{ji} parameter to establish production levels from the supply function (to be employed in the economic model) that are consistent with those observed in the base year of analysis, 1989.

The supply relationship for a particular product for the base year of 1989 can be expressed as

$$q_{j89} = \gamma_{j89} + \hat{\beta} \frac{1}{2} \left[\frac{I_{j89}}{p_{89}} \right]^{\frac{1}{2}} \tag{36}$$

where $\hat{\beta}$ is the econometric estimate for that product's supply function. Solving this equation for the intercept term yields the following equation:

$$\gamma_{j89} = q_{j89} - \hat{\beta} \frac{1}{2} \left[\frac{I_{j89}}{p_{89}} \right]^{\frac{1}{2}} \tag{37}$$

This equation can be solved for each facility producing product j to arrive at the value of γ_{j89} that will ensure that facility, and thus market, quantity supplied is consistent with production levels observed in 1989. Thus, for each facility, the 1989 market price for product j will elicit a production response equal to that level observed for 1989. Backsolving for this parameter to force such a supply response by mills will not bias the results of the model because it has no bearing on their production responses to changes in market price. The price responsiveness is a function of the β parameter or, more intuitively, a function of the facility's implied supply elasticity for the product.

A.4.5.1.2 Foreign supply. Recall that the model specifies a general formula for the foreign supply for each market pulp (q_k^I) and paper and paperboard product (q_i^I):

$$q_k^I = B_k^I [r_k]^{\xi_k^I}$$

and

$$q_i^I = B_i^I [p_i]^{\xi_i^I}$$

where B_k^I and B_i^I are positive constants and ξ_k^I and ξ_i^I are positive measures of the foreign supply elasticities for market pulp (k) and paper and paperboard products (i). The product-specific constants, B_k^I and B_i^I were determined through backsolving techniques to establish production levels from foreign suppliers (to be employed in the economic model) that are consistent with those observed in 1989 as determined by data obtained for each product from the American Paper Institute's *Statistics of Paper, Paperboard, and Wood Pulp, 1990.*[70] Thus, B_k^I and B_i^I were adjusted so that each product's foreign supply equation is exact using 1989 data for market prices and estimates of the foreign supply elasticity.

A.4.5.2 Demand Parameters

On the demand side, we used key parameters (i.e., the purchased input ratios and the domestic and foreign demand elasticities) and assumed functional forms of the derived demand for market pulp and the domestic and foreign demand for paper and paperboard products to "calibrate" the model. This procedure guarantees that market supply equals market demand for all commodities given 1989 market prices. This section describes the data modifications and procedures employed on the consumption, or demand, side of the economic model.

A.4.5.2.1 Domestic demand. The calibration technique differs across product type, specifically market pulp and paper and paperboard products. These data modifications and procedures are described in the following sections.

A.4.5.2.1.1 Market pulps. Recall that the model does not specify an exogenous demand function for market pulps because that demand is derived from the paper supply decisions at the integrated and paper mills. Once the paper and paperboard production decisions (q_{ji}^{S}) at each mill have been made, the mill-specific purchased input ratios for each market pulp (α_{jik}^{p}) will determine the domestic demand for each market pulp (q_k^d) as

$$q_k^d = \sum_j \sum_i \alpha_{jik}^{p} \, q_{ji}^{S} \quad .$$

The mill-specific purchased input ratios for each market pulp (α_{jik}^{p}) were adjusted to establish consumption levels by domestic consumers (to be employed in the economic model) so that for each market pulp

$$\begin{matrix} \textit{Domestic} \\ \textit{Comsumption} \end{matrix} = \begin{matrix} \textit{Domestic} \\ \textit{Production} \end{matrix} + \begin{matrix} \textit{Foreign} \\ \textit{Imports} \end{matrix} - \begin{matrix} \textit{Foreign} \\ \textit{Exports} \end{matrix}$$

Domestic production was determined by summing facility-level production data for each market pulp from the *National Census*, while foreign imports and exports were determined using data obtained for each market pulp from the American Paper Institute's *Statistics of Paper, Paperboard, and Wood Pulp*.[71] The mill-specific purchased input ratios for each market pulp were adjusted by a factor κ across all mills to calibrate the model so that the derived demand for market pulp is exact, given the paper and paperboard production decisions (q_{ji}^{S}) at each mill, that is,

$$q_k^d = \sum_j \sum_i \kappa_k \, \alpha_{jik}^{p} \, q_{ji}^{S}$$

satisfies the identity listed above for each market pulp.

A.4.5.2.1.2 Paper and paperboard products. Recall that the model specifies a general formula for the domestic demand for each paper and paperboard product (q_i^d), that is,

$$q_i^d = A_i \left[p_i\right]^{\eta_i^d}$$

where A_i is a positive constant and η_i^d is the negative measure of the domestic demand elasticity. The product-specific demand parameters, A_i, were determined through backsolving techniques to establish consumption levels by domestic consumers (to be employed in the economic model) that are consistent with the following identity for each marketable product:

$$\begin{matrix} \textit{Domestic} \\ \textit{Comsumption} \end{matrix} = \begin{matrix} \textit{Domestic} \\ \textit{Production} \end{matrix} + \begin{matrix} \textit{Foreign} \\ \textit{Imports} \end{matrix} - \begin{matrix} \textit{Foreign} \\ \textit{Exports} \end{matrix}$$

Domestic production was determined by summing facility-level production data for each product from the *National Census*; foreign imports and exports were determined using data obtained for each product from the American Paper Institute's *Statistics of Paper, Paperboard, and Wood Pulp*.[72] Thus, the A_i parameters were used to calibrate the model so that each product's domestic demand equation satisfies the identity listed above for each paper and paperboard product using 1989 data for market prices and estimates of the domestic demand elasticity.

A.4.5.2.2 Foreign demand. Recall that the model also specifies a general formula for the foreign demand for each market pulp (q_k^x) and paper and paperboard product (q_i^x), that is

$$q_k^x = A_k^x \left[r_k\right]^{\eta_k^x}$$

and

$$q_i^x = A_i^x \left[p_i\right]^{\eta_i^x}$$

where A_k^x and A_i^x are positive constants and η_k^x and η_i^x, the foreign demand elasticities for market pulp (k) and paper and paperboard products (i), are negative. The product-specific foreign demand parameters, A_k^x and A_i^x, were determined through backsolving techniques to establish consumption levels by foreign consumers (to be employed in the economic model) that are consistent with those observed in 1989 as determined by data obtained for each product from the American Paper Institute's *Statistics of Paper, Paperboard, and Wood Pulp*.[73] Thus, A_k^x and A_i^x

were used to calibrate the model so that each product's foreign demand equation is exact using 1989 data for market prices and estimates of the foreign demand elasticity.

A.4.6 Model Baseline Values

This section presents the 1989 baseline data set for analyzing the regulatory impact on the U.S. pulp and paper industry.

A.4.6.1 Market Prices and Output

Table A-16 shows the 1989 equilibrium prices, domestic production, exports, and imports of each market pulp, paper, and paperboard product. These values represent the starting point for imposing the regulations and assessing the impacts. Prices for market pulp, paper, and paperboard products were imputed using data on value of product shipments and quantity of product shipped obtained from the U.S. Department of Commerce's *Current Industrial Reports: Pulp, Paper, and Board*.[74] Domestic production data for market pulp, paper, and paperboard products were derived from facility-level production data for 1989 from EPA's *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities*.[75] For export and import quantities, we used data published by the American Paper Institute in *Statistics of Paper, Paperboard, and Wood Pulp*.[76]

We computed aggregate prices for the three major product groupings: market pulp, paper products, and paperboard products. Each aggregate price is a 1989 market quantity weighted average of the market prices for all products within the major group. The weights used to compute the pre-compliance price level were also used to compute the post-compliance price level, akin to a Laspeyres price index. Key commodities within the market pulp group include bleached sulfite (79 percent of market pulp traded in 1989) and Special Alpha and dissolving woodpulp (12 percent). For the paper product group, uncoated free sheet accounts for 24 percent of paper marketed in 1989 followed closely by clay-coated printing paper (22 percent), newsprint (16 percent), and tissue (14 percent). For the paperboard product group, unbleached

TABLE A-16

PULP AND PAPER PRODUCT MARKETS: BASELINE VALUES, 1989

Product Code	Price ($/ton)	Quantities (10^3 Ton/Yr.)				
			Foreign Trade			
		Domestic Production	Exports	Imports	Domestic Consumption	Market Total
Market Pulp	$635.03	11,593	6,062	5,100	10,631	16,693
1 Special alpha and dissolving woodpulp	$735.33	1,470	836	284	918	1,754
2 Sulfate-bleached	$646.49	9,207	4,678	3,753	8,283	12,960
3 Sulfate-unbleached	$384.37	320	181	87	226	407
4 Sulfite-bleached	$556.77	359	325	358	392	717
14 Secondary-bleached	$444.13	120	0	618	738	738
15 Secondary-unbleached	$416.84	117	41	0	75	117
Paper Products	$843.14	40,246	1,391	11,811	50,666	52,057
20 Newsprint	$490.09	5,678	625	8,553	13,607	14,232
21 Uncoated groundwood paper	$693.14	2,090	88	1,304	3,306	3,394
22 Clay coated printing	$970.31	9,157	169	774	9,762	9,931
23 Uncoated free sheet	$928.35	11,340	122	0	11,219	11,340
24 Bleached bristols	$838.09	779	47	59	792	838
25 Cotton fiber writing paper	$2,040.00	578	41	596	1,133	1,174
26 Unbleached kraft packaging paper	$548.33	2,943	30	239	3,152	3,182
27 Special industrial paper	$1,717.90	1,311	145	126	1,293	1,437

TABLE A-16 (cont.)

Product Code		Price ($/ton)	Quantities (10^3 Ton/Yr.) Domestic Production	Foreign Trade Exports	Foreign Trade Imports	Domestic Consumption	Market Total
28	Tissue	$1,111.30	5,392	21	121	5,492	5,513
30	Wrapping	$816.70	157	9	2	150	159
31	Shipping sack, unbl/bl sulfite	$656.33	93	42	2	54	95
32	Other shipping sack(a)	$738.17	N/A	N/A	N/A	N/A	N/A
33	Other bag/sack,unbl/bl sulfite	$747.30	258	9	2	252	261
34	Other bag/sack paper for conv	$783.48	91	9	2	84	93
35	Waxing stock	$1,245.70	67	9	2	61	70
36	Other	$1,220.60	64	9	2	57	66
37	Specialty packaging	$1,160.70	171	9	2	165	174
38	Glassine,greaseproof,parchment	$1,358.73	75	9	22	89	97
Paperboard Products		$432.67	40,609	3,807	743	37,545	41,351
40	Unbl kraft packaging paperboard	$395.55	19,375	2,463	165	17,077	19,540
41	Semichemical paperboard	$361.50	5,927	31	118	6,014	6,045
42	Recycled paperboard	$381.52	8,796	185	165	8,776	8,961
43	Wet machine board	$629.15	80	3	1	77	80
50	Construction paper	$392.85	667	33	189	823	856
51	Hardboard(a)	$337.35	N/A	N/A	N/A	N/A	N/A

TABLE A-16 (cont.)

Product Code		Price ($/ton)	Quantities (10^3 Ton/Yr.)				
			Domestic Production	Foreign Trade		Domestic Consumption	Market Total
				Exports	Imports		
	Paperboard Products (continued)	$635.03	11,593	6,062	5,100	10,631	16,693
52	Insulating board	$338.32	92	0	0	92	92
60	Linerboard	$543.04	376	283	12	105	388
61	Folding carton type board	$721.33	2,395	194	12	2,213	2,407
62	Milk carton board	$719.37	1,205	529	12	688	1,217
63	Heavyweight cup/container	$700.25	453	10	12	455	466
64	Plate, dish and tray stock	$686.05	226	10	12	228	238
65	Bleached paperboard for misc.	$625.32	530	26	12	517	543
66	Other solid bleached board	$714.75	260	26	12	246	272
70	Molded pulp products	$1,196.29	227	13	19	234	247

kraft packaging board accounts for 43 percent of paperboard traded in 1989 with recycled paperboard and semi-chemical paperboard accounting for 19 and 12 percent, respectively.

The pulp, paper, and paperboard product groups defined in the *National Census* match product definitions put forth by the U.S. Department of Commerce's *Current Industrial Reports* but do not exactly match API's import and export categories. Subappendix Table AA-2 summarizes the system we used to cross-reference pulp and paper product categories between the *National Census*, the *Current Industial Reports*, and API's import and export categories.

A.4.6.2 Foreign Trade

Table A-17 provides the 1989 baseline values of shipments and quantities for all exported and imported products included in the economic model. These values represent the starting values on which we impose the regulations and assess the impacts on international trade.

A.4.6.3 Facilities, Product Lines, and Output

Table A-18 provides the 1989 baseline values for the number of facilities and product lines included in the analysis, as well as industry output by major product group. These baseline values are further broken down by the type of facility: nonintegrated (pulp or paper only) and integrated. These values represent the starting values with which to assess the production and closure impacts.

A.4.6.4 Revenue, Production Cost, and Profit Impacts

Table A-19 provides the 1989 baseline values of industry revenue, cost, and profit separated by type of facility. These values represent the starting values with which to assess the revenue, production cost, and profit impacts.

TABLE A-17

PULP AND PAPER PRODUCT FOREIGN TRADE: BASELINE VALUES, 1989

Produce Code		Exports		Imports		Trade Balance	
		Quantity (10^3 ton/yr)	Value ($10^3/yr)	Quantity (10^3 ton/yr)	Value ($10^3/yr)	Quantity (10^3 ton/yr)	Value ($10^3/yr)
Market Pulp		6,062	3,906,932	5,100	3,142,631	961	764,301
1	Special Alpha and dissolving	836	614,826	284	208,887	552	405,940
2	Sulfate-bleached	4,678	3,023,970	3,753	2,426,438	924	597,532
3	Sulfate-unbleached	181	69,752	87	33,358	95	36,394
4	Sulfite-bleached	325	181,106	358	199,482	(33)	(18,376)
14	Secondary-bleached	0	0	618	274,467	(618)	(274,467)
15	Secondary-unbleached	41	17,278	0	0	41	17,278
Paper Products		1,391	1,148,166	11,811	7,639,310	(10,420)	(6,491,144)
20	Newsprint	625	306,207	8,553	4,191,936	(7,929)	(3,885,729)
21	Uncoated groundwood paper	88	61,035	1,304	903,934	(1,216)	(842,898)
22	Clay coated printing	169	163,534	774	751,041	(605)	(587,507)
23	Uncoated free sheet	122	112,935	0	0	122	112,935

TABLE A-17 (cont.)

	Produce Code	Exports		Imports		Trade Balance	
		Quantity (10^3 ton/yr)	Value ($10^3/yr)	Quantity (10^3 ton/yr)	Value ($10^3/yr)	Quantity (10^3 ton/yr)	Value ($10^3/yr)
24	Bleached bristols	47	39,156	59	49,491	(12)	(10,334)
25	Cotton fiber writing paper	41	84,144	596	1,215,408	(555)	(1,131,264)
26	Unbl kraft packaging paper	30	16,714	239	131,217	(209)	(114,503)
27	Special industrial paper	145	248,872	126	216,607	19	32,266
28	Tissue	21	23,017	121	134,242	(100)	(111,224)
30	Wrapping	9	7,306	2	1,941	7	5,365
31	Shipping sack, unbl/bl sulfite	42	27,243	2	1,560	39	25,683
32	Other shipping sack[a]	N/A	N/A	N/A	N/A	N/A	N/A
33	Other bag/sack,unbl/bl sulfite	9	6,685	2	1,776	7	4,909
34	Other bag/sack paper for conv	9	7,009	2	1,862	7	5,147
35	Waxing stock	9	11,144	2	2,960	7	8,184

TABLE A-17 (cont.)

Produce Code		Exports		Imports		Trade Balance	
		Quantity (10^3 ton/yr)	Value ($10^3/yr)	Quantity (10^3 ton/yr)	Value ($10^3/yr)	Quantity (10^3 ton/yr)	Value ($10^3/yr)
36	Other	9	10,919	2	2,901	7	8,019
37	Specialty packaging	9	10,384	2	2,758	7	7,625
38	Glassine,greasep roof,parchment	9	11,860	22	29,677	(13)	(17,817)
Paperboard Products		3,807	1,809,421	743	326,206	3,064	1,483,215
40	Unbl kraft packaging paperboard	2,463	974,310	165	65,318	2,298	908,992
41	Semichemical paperboard	31	11,265	118	42,721	(87)	(31,456)
42	Recycled paperboard	185	70,561	165	63,001	20	7,560
43	Wet machine board	3	1,818	1	381	2	1,436
50	Construction paper	33	13,116	189	74,295	(156)	(61,179)
51	Hardboard[a]	N/A	N/A	N/A	N/A	N/A	N/A
52	Insulating board	0	0	0	0	0	0

TABLE A-17 (cont.)

	Produce Code	Exports		Imports		Trade Balance	
		Quantity (10^3 ton/yr)	Value ($10^3/yr)	Quantity (10^3 ton/yr)	Value ($10^3/yr)	Quantity (10^3 ton/yr)	Value ($10^3/yr)
60	Linerboard	283	153,742	12	6,598	271	147,144
61	Folding carton type board	194	139,807	12	8,764	182	131,044
62	Milk carton board	529	380,717	12	8,740	517	371,977
63	Heavyweight cup/container	10	7,204	12	8,508	(2)	(1,304)
64	Plate, dish and tray stock	10	7,058	12	8,335	(2)	(1,278)
65	Bleached paperboard for misc.	26	16,157	12	7,597	14	8,559
66	Other solid bleached board	26	18,467	12	8,684	14	9,783
70	Molded pulp products	13	15,199	19	23,264	(7)	(8,065)

[a]Data from the 1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities indicate that no U.S. mill produced this product; therefore, the model does not include this product market.

TABLE A-18

OPERATING FACILITIES, PRODUCT LINES, AND OUTPUT: BASELINE VALUES, 1989

	Operating Facilities	Operating Product Lines	Output (10^3 tons/yr)		
			Pulp Products	Paper Products	Paperboard Products
Nonintegrated mills	331	412	5,743	8,107	8,584
Pulp mills	28	35	5,743	0	0
Paper and paperboard	303	377	0	8,107	8,584
Integrated mills	235	468	5,901	32,140	32,023
Total, all industry	566	880	11,644	40,247	40,607

TABLE A-19

FACILITY-LEVEL REVENUES AND COSTS: BASELINE VALUES, 1989

Facility Type	Total Revenue (10^6/yr)		Total Cost (10^6/yr)		Gross Profit (10^6/yr)	
	Total	Mill Average	Total	Mill Average	Total	Mill Average
Nonintegrated mills	17,957	54	13,061	39	4,896	15
Pulp mills	3,925	140	2,578	92	1,354	48
Paper and paperboard	14,032	46	10,490	35	3,542	12
Integrated mills	47,541	202	34,555	147	12,986	55
Total, all industry	65,498	116	47,616	85	17,882	32

A.4.6.5 Employment

As shown in Table A-20, total employment at nonintegrated and integrated mills included in the economic model is 217,625. This figure includes both production and nonproduction workers as reported in the *National Census.* The *1992 Lockwood-Post's Directory* reports total employment in 1989 at pulp, paper, and board mills as 245,600.[77] The difference may be attributed to the exclusion of "other" production employees reported in the *National Census.*

A number of mills included in the model lacked employment data from the *National Census.* Thus, we imputed employment data for these mills by multiplying baseline output by the average employee to output ratio for similar type mills (i.e., pulp, paper, and integrated). This method was done separately for production workers and total workers with nonproduction workers being the difference. The ratios for pulp mills were 0.00167 for production workers and 0.00192 for total workers. The ratios for production and total workers were 0.0049 and 0.00669 for paper mills and 0.00419 and 0.00554 for integrated mills.

A.4.7 Market Equilibria

This section explains the major components of the model. A complete list of exogenous and endogenous variables, as well as the model equations, is given in Table A-21.

The market supply of pulp (Q_k^S) is the sum of supply from all market pulp producers, that is,

$$Q_k^S = q_k^I + \sum_j q_{jk}^S$$

where q_k^I is foreign supply of market pulp (k) and $\sum_j q_{jik}^s$ is the domestic supply of market pulp (k), which is the sum of market pulp (k) production across all U.S. mills (j). In similar fashion,

TABLE A-20

FACILITY-LEVEL EMPLOYMENT: BASELINE VALUES, 1989

Facility Type	Employment		
	Production	Nonproduction	Total
Nonintegrated mills	51,738	14,840	66,578
Pulp mills	7,386	1,340	8,727
Paper and paperboard mills	44,352	13,499	57,851
Integrated mills	119,221	31,827	151,047
Total, all industry	170,959	46,666	217,625

TABLE A-21

PULP AND PAPER MODEL SUMMARY

Variables	Description
Exogenous	
η_i^d	Demand elasticity for domestic consumers of U.S. paper and paperboard products i=1 to 31.
η_i^x	Demand elasticity for foreign consumers of U.S. paper and paperboard products i=1 to 31 (exports).
η_k^x	Demand elasticity for foreign consumers of U.S. market pulps k=1 to 6 (exports).
ξ_i^I	Import supply elasticity of foreign paper and paperboard products i=1 to 31.
ξ_k^I	Import supply elasticity of foreign pulp products k=1 to 6.
β_i, γ_{ji}	Supply function parameters for paper and paperboard products (i)by mill (j).
β_k, γ_{jk}	Supply function parameters for market pulps (k) by mill (j).
q_{ji}^M , q_{jik}^M	Production capacity for paper and paperboard products (i) and market pulps (k) manufactured at each mill (j).
q_{ji}^m , q_{jik}^m	Minimum economically feasible production level for paper and paperboard products (i) and market pulps (k) manufactured at each mill (j).
I_{ji}, I_{jk}	Cost indices of variable-proportion inputs into paper and paperboard (i) and pulp (k) production by mill (j).
α_{jik}^o , α_{jik}^p	Input ratios for pulps manufactured on-site (o) and purchased from the market (p). Indicates the amount of pulp k required to produce paper and paperboard product i at mill j.
c_{jk}	Regulatory control costs (per unit of output) for pulps (k) by mill (j).
A_i^d, A_i^x, A_k^x	Demand function parameters for paper and paperboard products (i) and exported market pulps (k). (Multiplicative constants for domestic (d) and foreign (x) demand.)
B_i^I, B_k^I	Import supply function parameters for those paper and paperboard products and market pulps produced abroad and shipped to U.S. (Multiplicative constants for paper and paperboard (i) and market pulp (k) supply.)

TABLE A-21 (cont.)

Variables	Description
Endogenous	
p_i	Price of paper and paperboard products.
r_k	Price of market pulps.
q_{ji}^S , q_i^I, Q_i^S	Domestic (mill-level) and foreign supply (q_{ji}^S , q_i^I), of paper and paperboard products and market-level supply (Q_i^S).
q_{jik}^S , q_k^I, Q_k^S	Domestic (mill-level) and foreign supply (q_{jik}^S , q_k^I) of market pulps and market-level supply (Q_k^S).
q_i^d, q_i^x, Q_i^D	Domestic and foreign demand (q_i^d, q_i^x) for paper and paperboard products and market-level demand (Q_i^D).
q_k^d, q_k^x, Q_k^D	Domestic and foreign demand (q_k^d, q_k^x) for market pulps and market-level demand (Q_k^D).

Equations

Market Supply of Paper and Paperboard Products:

$$Q_i^S = q_i^I + \sum_j q_{ji}^S$$

where

$$q_i^I = B_i^I \left[p_i\right]^{\xi_i^I}$$

and

$$\sum_j q_{ji}^S = \sum_j \left(\gamma ji + \frac{\beta_i}{2} \left[\frac{I_{ji}}{p_i}\right]^{\frac{1}{2}} \right) \textit{without regulation}$$

Variables	Description

or

$$\sum_j q_{ji}^S = \sum_j \left[\gamma ji + \frac{\beta_i}{2} \left[\frac{I_{ji}}{p_i - \sum_{k=1}^{n} \alpha_{jik}^{p} \Delta r_k + \sum_{k=1}^{n} \alpha_{jik}^{o} c_{jk}} \right]^{\frac{1}{2}} \right] \text{ with regulation} \quad .$$

Market Supply of Pulp Products:

$$Q_k^S = q_k^I + \sum_j q_{jk}^S$$

where

$$q_k^I = B_k^I \left[r_k \right]^{\xi_k^I}$$

and

$$\sum_j q_{jk}^S = \sum_j \left(\gamma jk + \frac{\beta_k}{2} \left[\frac{I_{jk}}{r_k} \right]^{\frac{1}{2}} \right) \text{ without regulation}$$

or

$$\sum_j q_{jk}^S = \sum_j \left(\gamma jk + \frac{\beta_k}{2} \left[\frac{I_{jk}}{r_k - c_{jk}} \right]^{\frac{1}{2}} \right) \text{ with regulation} \quad .$$

Market Demand of Paper and Paperboard Products:

$$Q_i^D = q_i^d + q_i^X$$

where

$$q_i^d = A_i^d \left[p_i \right]^{\eta_i^d} .$$

TABLE A-21 (cont.)

Variables	Description

and

$$q_i^x = A_i^x \left[p_i\right]^{\eta_i^x}$$

Market Demand for Pulp Products:

$$Q_k^D = q_k^d + q_k^x$$

where

$$q_k^d = \sum_j \sum_i \alpha_{jik}^p q_{ji}^s$$

and

$$q_k^x = A_k^x \left[r_k\right]^{\eta_k^x}$$

the market supply of paper and paperboard products (Q_i^S) is the sum of supply from all paper and paperboard producers, that is,

$$Q_i^S = q_i^I + \sum_j q_{ji}^S$$

where q_i^I is foreign supply of paper and paperboard products (i) and $\sum_j q_{jik}^s$ is the domestic supply of paper and paperboard products (i), which is the sum of paper and paperboard (i) production across all U.S. mills (j).

The market demand for pulp (Q_k^D) is the sum of demand from all market pulp consumers, that is,

$$Q_k^D = q_k^x + q_k^d$$

where q_k^x is foreign demand for market pulp (k) and q_k^d is the domestic demand for market pulp (k), which is the sum of the derived demand for market pulp (k) across all U.S. mills (j). In similar fashion, the market demand of paper and paperboard products (Q_i^D) is the sum of demand from all paper and paperboard consumers, that is,

$$Q_i^D = q_i^x + q_i^d$$

where q_i^x is foreign demand of paper and paperboard products (i) and q_i^d is the domestic demand of paper and paperboard products (i).

Each type of facility, integrated or nonintegrated, has a different decision to make. Integrated mills must determine optimal output given the market prices for all paper products they produce, which will determine the amount of internal pulp to produce. An excess supply of pulp will spillover into the market, while an excess demand will cause the facility to demand market pulp. For nonintegrated paper mills, the optimal level of output will be determined by the market prices for pulp inputs and final paper and paperboard outputs the optimal level of

output will determine the corresponding amount market pulp to purchase. For pulp mills, the optimal supply of market pulp will be determined by the price of market pulp.

Facility responses and market adjustments can be conceptualized as an interactive feedback process. Facilities face increased production costs due to compliance, which cause facility-specific production responses. The cumulative effect of these responses leads to a change in the market price that all producers (affected and unaffected) and consumers face, which leads to further responses by producers (affected and unaffected) as well as consumers and thus new market prices, and so on. The new post-regulatory equilibria is the result of a series of iterations between producer and consumer responses and market adjustments until a stable market price arises where total market supply equals total market demand, that is,

$$Q_i^S = Q_i^D, \textit{ for all paper and paperboard products } (i) \tag{42}$$

and

$$Q_k^S = q_k^D, \textit{ for all market pulps } (i) \tag{43}$$

This process is simulated given the producer and consumer response functions and market adjustment mechanisms to arrive at the post-compliance equilibria.

The process for determining equilibrium prices (and outputs) is modeled as a Walrasian auctioneer. The auctioneer calls out a price for each product and evaluates the reactions by all participants (producers and consumers, both foreign and domestic), comparing quantities supplied and demanded to determine the next price that will guide the market closer to equilibrium (i.e., market supply equal to market demand). We developed an algorithm to simulate the auctioneer process and find a new equilibrium price and quantity for all 37 pulp and paper product markets simultaneously. Decision rules were established to ensure that the process will converge to an equilibrium and to specify the conditions for equilibrium. The result of this approach is a vector of post-compliance product prices that equilibrates supply and demand for all product markets. To capture the derived demand nature of the market for market pulps, this auctioneer algorithm was applied simultaneously to both the markets for final paper and paperboard products and market pulps.

The algorithm for deriving the post-compliance equilibria in all markets can be generalized to five recursive steps:

1. Impose the control costs on the mills, thereby affecting their supply decisions.

2. Recalculate the market supply of each paper and paperboard product and each market pulp product. The new market supply of each product will determine the demand for pulp in a derived manner through the input ratios. Therefore, demand for market pulp is simultaneously determined with paper and paperboard supply.

3. Determine the new prices via the price revision rule for all product markets (i.e., 31 paper and paperboard products and 6 market pulp products).

4. Recalculate the supply functions for all mills with the new prices, resulting in a new market supply of paper, paperboard, and market pulp, in addition to derived (domestic) demand for market pulp. Evaluate domestic demand for paper and paperboard products, as well as import supply and export demand for paper, paperboard, and market pulp products given the new prices.

5. Return to Step 3, and continue to repeat until equilibrium conditions are satisfied in all markets (i.e., the ratio of supply to demand is arbitrarily close to one for each and every product).

A.4.8 Post-Regulatory Impact Estimates

The model results can be summarized as market-level and facility-level impacts due to the regulations.

A.4.8.1 Market-Level Results

Market-level impacts include the market-level adjustments in price and quantity for all affected products as well as the changes in international trade flows. In addition, the market adjustments in price and quantity were used to calculate the changes in the aggregate economic welfare using applied welfare economics principles. The following sections outline the results and the methods used to quantify these market-level impacts.

A.4.8.1.1 Price and quantity impacts. Market adjustments are a result of moving from the pre-compliance to post-compliance equilibrium. Given the regulatory control costs, the interaction of facility-level responses and price revision mechanism, modeled as a Walrasian auctioneer, along with the simultaneous coordination of the final product and input markets results in a new post-compliance equilibrium with new prices and quantities for all 37 product markets.

A.4.8.1.2 Foreign trade impacts. The impacts of the regulations on foreign trade in the pulp and paper industry were estimated by comparing baseline and post-compliance levels of exports and imports of affected products.

A.4.8.1.3 Economic welfare impacts. The value of environmental improvements that result from regulatory policy can be measured against the change in economic welfare the policy generates. Welfare impacts resulting from the regulatory controls on the pulp and paper industry will extend to the many consumers and producers of pulp and paper products. Consumers of pulp and paper products will experience welfare impacts due to the adjustments in price and output of the pulp and paper products caused by imposing the regulations. Producer welfare impacts result from the changes in product revenues associated with the additional costs of production and the corresponding market adjustments. The theoretical approach used in applied welfare economics to evaluate policies follows and indicates the approach used in this study to estimate changes in economic welfare.

The economic welfare implications of the post-compliance market price and output changes of pulp and paper products can be examined using two slightly different measures, each giving a somewhat different insight but the same implications: changes in the net benefits of consumers and producers based on the price changes, and changes in the total benefits and costs of pulp and paper products based on the quantity changes. For this analysis, we focused on the first measure—the changes in the net benefits of consumers and producers. Figures A-23 through A-25 depict the changes in economic welfare by first measuring the change in consumer

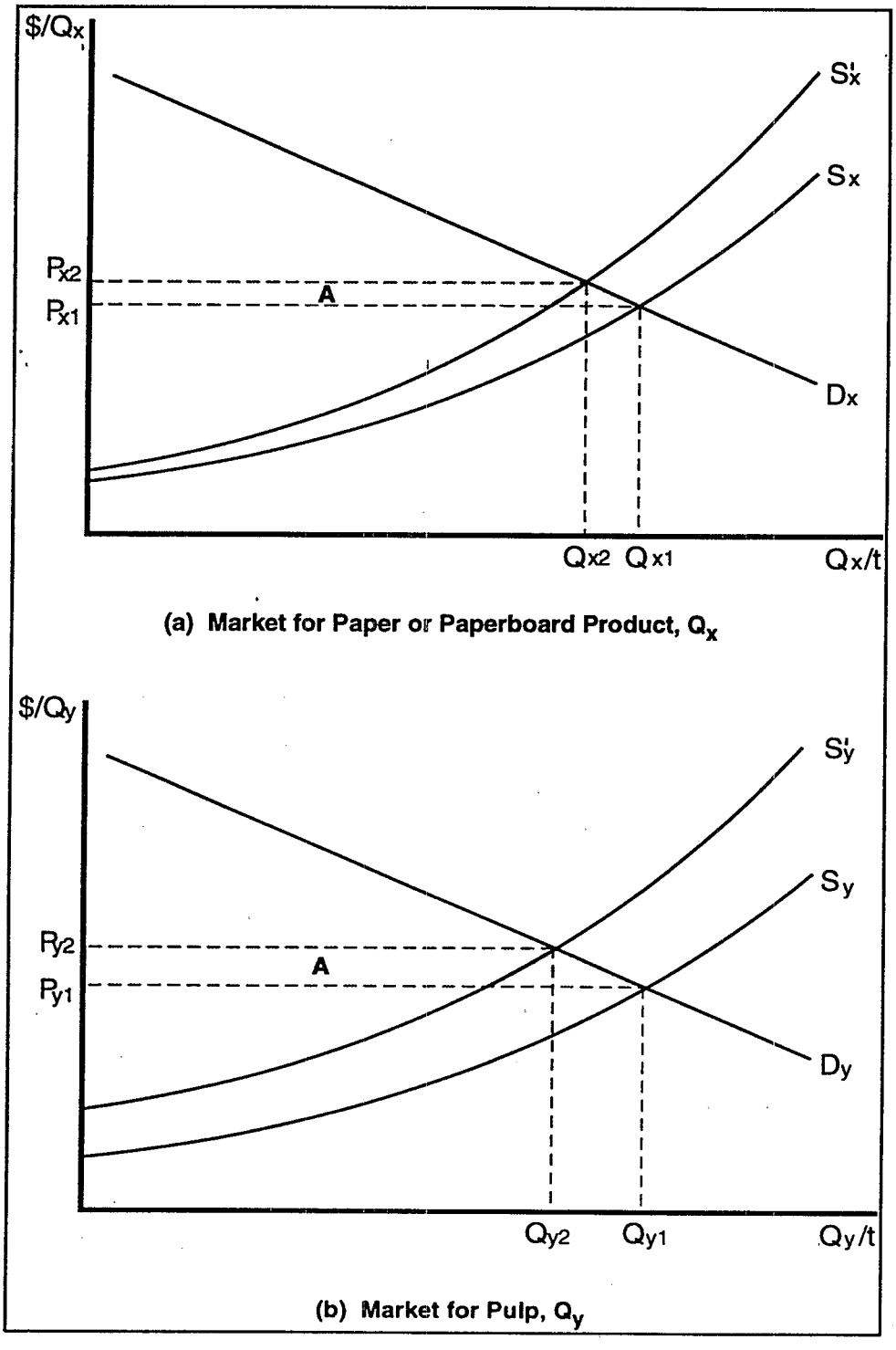


Figure A-23 Change in consumer surplus with regulation

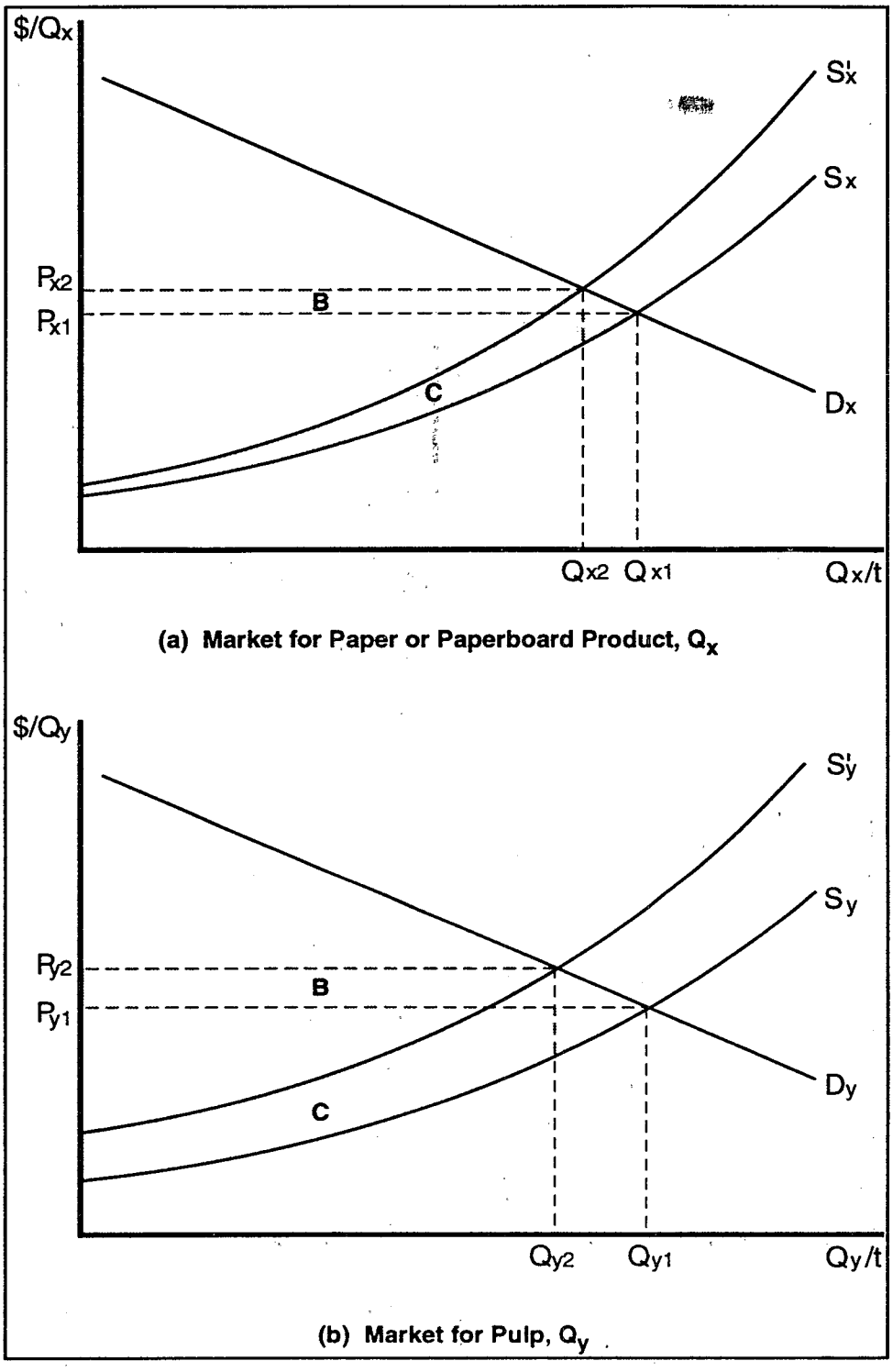


Figure A-24 Change in producer surplus with regulation

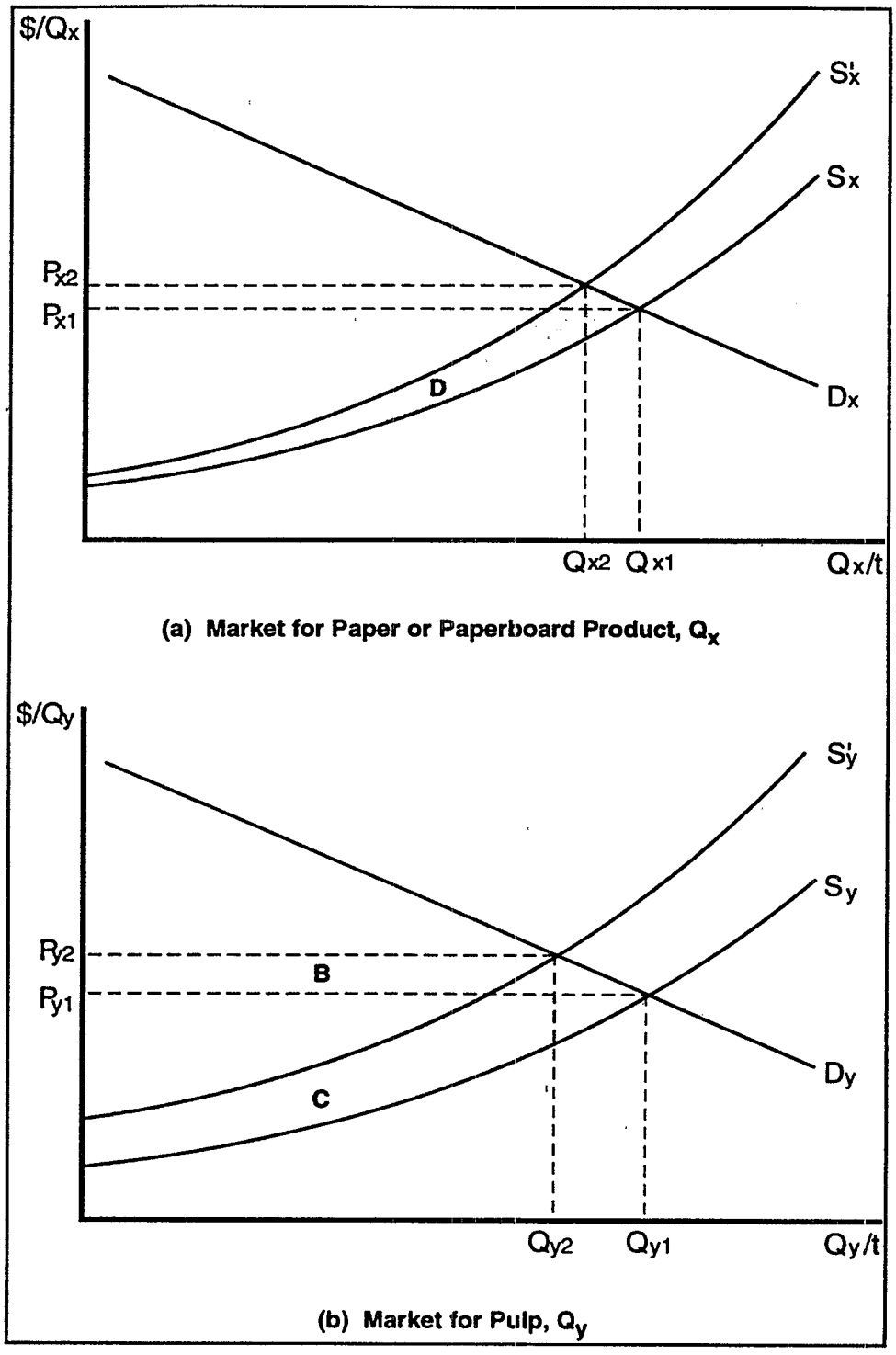


Figure A-25 Change in economic welfare with regulation

surplus and then the change in producer surplus. In essence, the demand and supply curves previously used as predictive devices are now being used as a valuation tool.

This method of estimating the post-regulatory change in economic welfare divides society into consumers and producers. In a market environment, consumers and producers of the good or service derive welfare from a market transaction. The difference between the maximum price consumers are willing to pay for a good and the price they actually pay is referred to as consumer surplus. Consumer surplus is measured as the area under the demand curve and above the price of the product. Similarly, the difference between the minimum price producers are willing to accept for a good and the price they actually receive is referred to as producer surplus. Producer surplus is measured as the area above the supply curve to the price of the product. These areas may be thought of as consumers' net benefits of consumption and producers' net benefits of production, respectively.

In Figure A-23, baseline equilibrium occurs at the intersection of the pulp and paper product demand curves, D_x and D_y, and supply curves, S_x and S_y. Paper price is P_{x1} with quantity Q_{x1}, while pulp price is P_{y1} with quantity Q_{y1}. The increased cost of production with the regulations will cause the market supply curve of both to shift upward to S_x' and S_y', respectively. The new equilibrium price of paper is P_{x2} and price of pulp is P_{y2}. Higher pulp and paper product prices mean less consumer welfare, all else being unchanged. In Figure A-23, for both products, area A represents the dollar value of the annual net loss in consumers' benefits with the increased price of pulp and paper products. The rectangular portion represents the loss in consumer surplus on the quantity still consumed, Q_{x2} for paper and Q_{y2} for pulp, respectively, while the triangular area represents the foregone surplus resulting from the reduced amount of pulp and paper product consumed, $Q_{x1} - Q_{x2}$ and $Q_{y1} - Q_{y2}$, respectively.

Because this analysis involves a derived demand market for pulp, which is not a final product market, the change in "consumer surplus" shown is actually the sum of the downstream markets' changes in producer surplus at paper mills and integrated paper producers as well as the change in consumer surplus for households (see Just, Heuth, and Schmidt[78]). Thus, to avoid double counting, we excluded the consumer surplus measures calculated from the pulp market

adjustments that are included in the producer surplus changes for paper producers. In addition to the changes in consumer welfare, producers' welfare also changes with the regulations.

With the increases in pulp and paper product prices, producers receive higher revenues on the quantity still purchased, Q_{x2} for paper and Q_{y2} for pulp. In Figure A-24, for both products, area B represents the increase in revenues due to this increase in prices. For each product, the difference in the areas under the two supply curves up to the original market price, area C, measures the loss in producers' surplus, which includes the loss associated with the quantity no longer produced. The net change in producers' welfare is calculated as area B – C.

The change in economic welfare attributable to the compliance costs of the regulations is the sum of consumer and producer surplus changes. The change is – (A) + (B – C) for paper products, but as mentioned earlier we included only the producer surplus change (B – C) for market pulp products. The consumer surplus change resulting from the markets for pulp is included in the producer's surplus change for paper and paperboard products. Figure A-25 shows the net (negative) change in economic welfare associated with the regulations as the sum of area D for paper products and area (B – C), the producer surplus change for pulp products. This value is the same as the one found by the alternative method of comparing the changes in the total benefits of consumption and the total costs of production. However, this analysis does not include the benefits that occur outside the pulp and paper products markets—the value of the reduced levels of air and water pollution with the regulations. Inclusion of this benefit may reduce the net cost of the regulations or even make them positive.

A.4.8.2 Facility-Level Results

Facility-level impacts include an evaluation of the post-regulatory compliance cost; product-line and facility closures; and changes in production, production costs, and EBIDT. In addition, we computed the change in employment attributable to the changes in output at each mill. These output changes are caused by product-line and facility closures as well as adjustments in production at mills that continue to operate under regulation. Workers' dislocation costs associated with industry-wide job losses are also calculated.

A.4.8.2.1 Post-policy compliance cost. For each regulatory alternative, the post-regulatory compliance cost at an affected facility has two components:

- Variable compliance cost (i.e., O&M expenditures)
- Fixed compliance cost (i.e., annualized capital expenditures)

The variable compliance cost at each facility depends on its post-compliance output rate, while the fixed compliance cost, as the name implies, is a constant lump-sum incurred at the facility. As shown in Figure A-26, the marginal cost curve for the single-product facility shifts upward from MC to MC' by the per-unit output variable compliance cost (c). The facility response to the upward shift and new market price ($p^{*'}$) is to reduce output from q^* to $q^{*'}$. The corresponding total variable compliance cost at the facility can be calculated as the product of the per-unit output variable compliance cost (c) and the new output rate ($q^{*'}$). This cost is represented by the area A in Figure A-26. This calculation can be extended to the multi-product facility where total variable costs can be summed across all product-lines that continue operating after post-regulatory market adjustments.

At the industry-level, the post-policy compliance cost is the sum of the variable and fixed compliance costs across all facilities and product-lines continuing to operate in the post-compliance equilibrium. Thus, the post-compliance cost is not necessarily equal to the estimated compliance costs before accounting for market adjustments. These cost estimates differ because facilities and product-lines close, and firms decide not to bear the costs of compliance (variable or fixed). Output rates change at affected facilities so that total variable compliance cost equals per-unit output variable compliance cost (c) times the post-compliance output rate ($q^{*'}$) as opposed to the pre-compliance output rate (q^*).

A.4.8.2.2 Production and closure impacts. The economic model accommodates both product-line and facility closures in moving from the pre-compliance to post-compliance equilibrium. Within a model iteration, recalculating market prices allows for the possibility that the minimum efficient level of production (q^m) becomes binding for a product line. In other

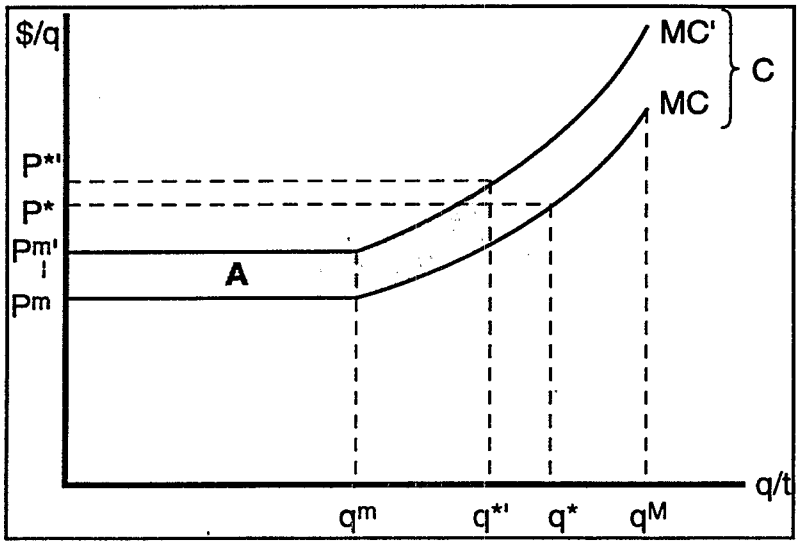


Figure A-26 Variable post-compliance costs

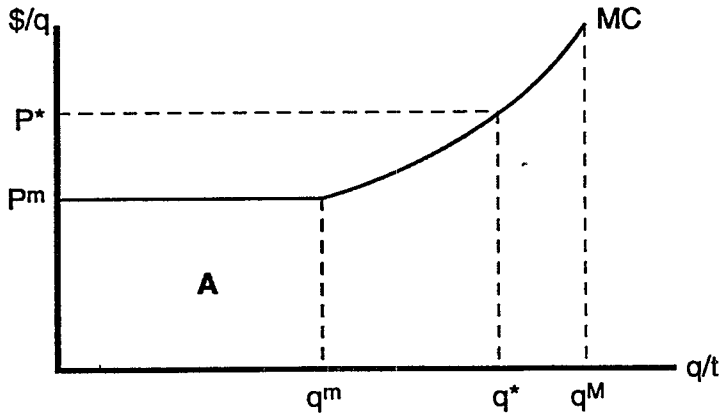
words the estimated production response to the new prices and costs may drive production levels below q^m. In such a case, the model "closes" that product line for that facility by setting production to zero, and market quantities are adjusted accordingly. The same is true when the entire facility closes because total revenues are less than total avoidable costs. In the case of a facility closure, the algorithm sets the production for each and every product line at the facility to zero.

A.4.8.2.3 Revenue, production cost, and profit impacts. The economic model generates information on the change in facility and market quantities and market prices. This information is used to compute the change in total revenue and total cost at the facility level. The change in facility production and market prices effects a change in product revenue at the facility, which is the difference between pre-compliance product revenue (R(q)) and post-compliance product revenue (R(q)'):

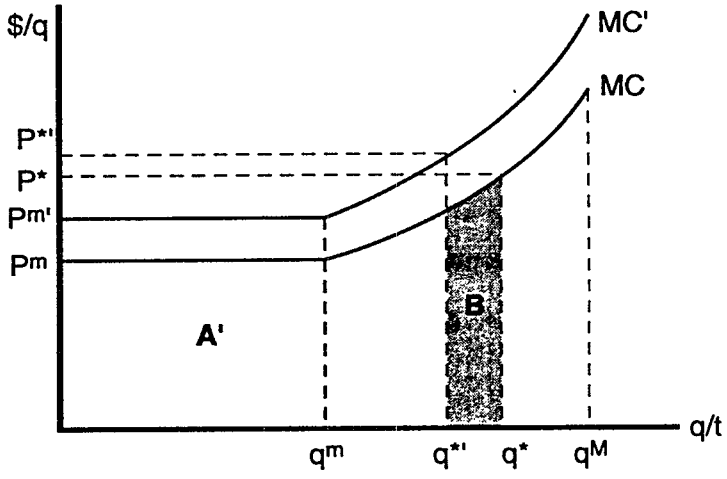
$$R(q) - R(q)' = \sum_i \left[p^*_i \times q^*_i \right] - \sum_i \left[p^{*\prime}_i \times q^{*\prime}_i \right] \qquad (44)$$

In addition, the change in facility production effects a change in production costs, which can be added to post-compliance costs to estimate the change in total costs for the facility.

As shown in Figure A-27 (a), the variable production costs at the single-product facility without regulation is the area under the marginal cost curve (MC) up to the current output rate, q^* (as represented by the area A). After imposing the variable control costs, as illustrated in Figure A-27 (b), the marginal cost curve shifts upward to MC' and market price increases to $p^{*\prime}$ resulting in a reduced output rate of $q^{*\prime}$. The post-compliance total variable production cost at the facility is represented by the area A' in Figure A-27 (b). The major components are the area under the original marginal cost curve (MC) up to the new output rate and the area between the original and new marginal cost curves up to the new output rate—the variable compliance cost. In addition, the facility no longer incurs the production costs associated with the forgone output ($q^* - q^{*\prime}$), represented by the area B in Figure A-27 (b). Thus, the total change in production cost at the facility can be calculated as the post-compliance variable costs of production minus



a) Total Variable Cost at Facility Without Regulation



b) Total Variable Cost at Facility With Regulation

Figure A-27 Production cost changes due to regulation

the pre-compliance variable costs of production, which will account for the increase in costs due to the regulation, and the decrease in costs due to the lower output rate.

The changes in total revenue and total cost were then used to measure the profitability impact of the regulations at the facility level and at the industry level.

A.4.8.2.4 Employment impacts. The regulatory alternative will displace workers from jobs by affecting production levels. The methodology employed to estimate the number of displaced workers depends on the methodology used to project output effects. In this case, changes in employment at mills that continue to operate after the regulation were estimated by multiplying a mill-specific ratio of production workers per output (E_j) by the projected change in mill output (Δq_j):

$$\Delta Emp_{industry} = E_j * \Delta q_j \quad . \tag{45}$$

If the mill ceases to operate, then the change in employment at the mill equals total employment, both production and nonproduction. Thus, the estimate of the change in employment for the entire industry was obtained by adding the sum of the employment changes across all mills that continue to operate and the sum of total employment across all mills that close (e_j):

$$\Delta Emp_{industry} = \sum_j [E_j * \Delta q_j] + \sum_j e_j \quad . \tag{46}$$

This estimate will aggregate the job losses at facilities with reduced or zero output and job gains at facilities with increased output. Therefore, employee displacement, or job losses, were estimated by summing the projected change in employment for those facilities that experience a decrease in output because of the regulations.

Worker displacement costs have traditionally not been measured in economic impact analyses of regulations. The assumption has usually been that workers costlessly move to new jobs of equal productivity and earnings, despite numerous studies that show costs borne by

displaced workers are significant (see Flaim[79], Hamermesh[80], Maxwell[81], and Anderson and Chandran[82]).

Building on the work by Adams[83] and Topel[84], Anderson and Chandran[85] constructed incremental willingness-to-pay measures for job dislocations in a hedonic wage framework. Their method is analogous to that used by economists to estimate the implicit value of a life using labor market data (see Moore and Viscusi[86]). The hedonic displacement cost estimate conceptually approximates the one-time willingness to pay to avoid an involuntary unemployment episode. Theoretically, it includes all worker-borne costs net of any off-setting pecuniary or nonpecuniary "benefits" of unemployment (e.g., unemployment compensation, leisure time enjoyment). The hedonic displacement cost estimate is a net present value valuation.

According to Bureau of Labor Statistics data, average annual earnings in the paper and allied products for 1989 was $26,929.[87] Using Topel's compensating differential estimate and the Anderson-Chandran methodology, we estimated that pulp and paper industry workers would demand an annual compensating differential of $673 ($26,929 * 0.025) to accept a one-point increase in the probability of displacement. We assumed they would be willing to pay an equivalent amount to avoid such an increase in the probability of displacement. The implied statistical cost of an involuntary layoff is thus $67,323 ($673 / 0.01). This value is multiplied by the total number of employee displacements, or job losses, to estimate the worker displacement cost of the regulation.

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Subappendix

TABLE AA-1

NATIONAL CENSUS PROCESS CODE DEFINITIONS[88]

Code	Process
A	Dissolving Sulfite Pulp
B	Papergrade Sulfite Pulp
C	Kraft Pulp
D	Dissolving Kraft Pulp
E	Semi-Chemical Pulp
F	Groundwood-Chemicai-Mechanical Pulp
G	Groundwood-Thermo-Mechanical Pulp
H	Groundwood-Stone Pulp
I	Groundwood-Chemi-Thermo-Mechanical Pulp
J	Groundwood-Refiner Pulp
K	Deink-Fine Papers
L	Deink-Newspapers
M	Deink-Tissue Papers
N	Tissue from Wastepaper
O	Wastepaper-Molded Products
P	Paperboard from Wastepaper
Q	Builders' Paper and Roofing Felt
R	Newspaper - No Deink
S	Paper from Wastepaper
T	Deink - Paperboard
U	Paperboard and Linerboard from Broke and Virgin Pulp
V	Rag and Cotton Pulp
W	Soda Pulp (Commonly included with sulfate/kraft)
X	High-Yield Acid Bisulfite
Y	Paper from Waste-paperboard
Z	Other Processes
SS	Synthetic or Semi-Synthetic Glass, Fiberglass, Rayon, Nylon Combinations

TABLE AA-2

PRODUCT CATEGORY CROSS-REFERENCES: U.S. PULP, PAPER, AND PAPERBOARD INDUSTRY

1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities		Current Industrial Report		Import/Export Product Category from API's Statistics of Paper, Paperboard, and Wood Pulp	
EPA Survey Code	Product Category	Product Code	Product Category	Exports	Imports
Pulp					
10	Special Alpha and dissolving woodpulp		Dissolving and special Alpha grades	Dissolving and special Alpha	Dissolving and special Alpha
11	Sulfate-bleached		Sulfate-bleached and semibleached, including soda	Sulfate-bleached (semi-bleached not included)	Sulfate-bleached (semi-bleached not included)
12	Sulfate-unbleached		Sulfate-unbleached	Sulfate-unbleached	Sulfate-unbleached
13	Sulfite-bleached		Sulfite-bleached	Sulfite-bleached	Sulfite-bleached
14	Sulfite-unbleached		Sulfite-unbleached	Sulfite-unbleached	Sulfite-unbleached
Paper					
20	Newsprint	2621100	Newsprint	Newsprint	Newsprint
21	Uncoated groundwood paper (uncoated papers containing more than 10% mechanical fiber)	26212	Uncoated groundwood paper (uncoated papers containing more than 10% mechanical fiber)	Printing and writing paper, uncoated groundwood	Printing and writing paper, uncoated groundwood
22	Clay coated printing and converted paper	26213	Clay coated printing and converted paper	Coated printing & converting paper	1978 on, printing and writing paper, Coated and impregnated paper

TABLE AA-2 (cont.)

1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities		Current Industrial Report		Import/Export Product Category from API's Statistics of Paper, Paperboard, and Wood Pulp	
EPA Survey Code	Product Category	Product Code	Product Category	Exports	Imports
23	Uncoated free sheet (containing not more than 10% mechanical fiber)	26214	Uncoated free sheet (containing not more than 10% mechanical fiber)	Uncoated book; 1978 on, uncoated free sheet	Printing and writing paper, uncoated book
24	Bleached bristols, excluding cotton fiber index and bogus	26215	Bleached bristols, excluding cotton fiber index and bogus	Bristols	Bristols
25	Cotton fiber writing paper and thin paper	26216	Cotton fiber writing paper and thin paper	Writing and related papers; 1978 on, printing & writing paper - thin & cotton fiber	Writing and related papers, 1978 on, writing papers, other fine paper, thin paper
26	Unbleached kraft packaging and industrial converting paper	26217	Unbleached kraft packaging and industrial converting paper	Unbleached kraft (exc. shipping sack)	Unbleached kraft packaging and industrial converting paper
27	Special industrial paper, except specialty packaging	2621900	Special industrial paper, except specialty packaging	Special industrial paper	Special Industrial Paper
28	Tissue	26210	Tissue	Tissue paper	Tissue paper

TABLE AA-2 (cont.)

1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities		Current Industrial Report		Import/Export Product Category from API's Statistics of Paper, Paperboard, and Wood Pulp	
EPA Survey Code	Product Category	Product Code	Product Category	Exports	Imports
30	Wrapping	2621812	Wrapping	30 & 32-37 Other packaging and industrial converting papers	30-37 Other packaging and industrial converting papers
31	Shipping sack, unbleached and bleached sulfite, semibleached and bleached kraft and mixtures of both	2621832	Shipping sack, unbleached and bleached sulfite, semibleached and bleached kraft and mixtures of both	Shipping sack, unbleached	
32	Other shipping sack, including rope and combination kraft and rope shipping sack paper	2621834	Other shipping sack paper		
33	Other bag and sack, unbleached and bleached sulfite, semibleached and bleached kraft and mixtures of both, grocers and sack paper	2621851	Other bag and sack, unbleached and bleached sulfite, semibleached and bleached kraft and mixtures of both, grocers and sack paper		

TABLE AA-2 (cont.)

1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities		Current Industrial Report		Import/Export Product Category from API's Statistics of Paper, Paperboard, and Wood Pulp	
EPA Survey Code	Product Category	Product Code	Product Category	Exports	Imports
34	Other bag and sack paper for conversion in liquor, millinery, notion, or other variety bags	2621859	Other bag and sack paper for conversion in liquor, millinery, notion, or other variety bags		
35	Waxing stock	2621864	Waxing stock		
36	Other, such as asphalting and creping stocks, coating and laminating, gummed, twisting and spinning stocks	2621868	Other, such as asphalting and creping stocks, coating and laminating, gummed, twisting and spinning stocks		
37	Specialty packaging	2621872	Specialty packaging		
38	Glassine, greaseproof and vegetable parchment	2621883	Glassine, greaseproof and vegetable parchment	Glassine, greaseproof and vegetable parchment	Glassine, greaseproof and vegetable parchment (added)
Paperboard					
40	Unbleached kraft packaging and industrial converting paperboard	26311	Unbleached kraft packaging and industrial converting paperboard	1978 on, other kraft paperboard-unbleached	40 and 42, Other paperboard

TABLE AA-2 (cont.)

1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities		Current Industrial Report		Import/Export Product Category from API's Statistics of Paper, Paperboard, and Wood Pulp	
EPA Survey Code	Product Category	Product Code	Product Category	Exports	Imports
41	Semichemical paperboard, including corrugated medium and other uses	2631300	Semichemical paperboard, including corrugated medium and other uses	Corrugating medium semichemical	1978 on, Semichemical corrugating
42	Recycled paperboard	26314	Recycled paperboard	Recycled furnish paperboard	
43	Wet machine board, including binder's board and shoe board	2631800	Wet machine board, including binder's board and shoe board	Wet machine board	Wet machine board
50	Construction paper	26612	Construction paper	Construction paper and board, building paper	Building paper
51	Hardboard	2499620	Hardboard	1978-83, Hard pressed board	1967-1983, Hard pressed board
52	Insulating board	2661110	Insulating board	Insulating and hard pressed board; 1978 on, insulating and other building board	Insulating board & Other building board
60[a]	Linerboard	2631210	Linerboard	Kraft linerboard	60-66 Test or container board

TABLE AA-2 (cont.)

1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities		Current Industrial Report		Import/Export Product Category from API's Statistics of Paper, Paperboard, and Wood Pulp	
EPA Survey Code	Product Category	Product Code	Product Category	Exports	Imports
61[a]	Folding carton type board	2631240	Folding carton type board	61-66 Bleached packaging paperboard; 1984 on, Folding boxboard	
62[a]	Milk carton board	2631261	Milk carton board	1984 on, milk carton	
63[a]	Heavyweight cup and round nested food container	2631262	Heavyweight cup and round nested food container	1984 on, 63 and 64, Plate, dish, tray and cup	
64[a]	Plate, dish, and tray stock	2631263	Plate, dish, and tray stock		
65[a]	Bleached paperboard for miscellaneous packaging	2631283	Bleached paperboard for miscellaneous packaging	1984 on, 65 and 66, Other bleached packaging paperboard	
66[a]	Other solid bleached board including bleached paperboard for moist, oily, and liquid foods	2631286	Other solid bleached board including bleached paperboard for moist, oily, and liquid foods		

TABLE AA-2 (cont.)

1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities		Current Industrial Report		Import/Export Product Category from API's Statistics of Paper, Paperboard, and Wood Pulp	
EPA Survey Code	Product Category	Product Code	Product Category	Exports	Imports
Molded Pulp					
70[b]	Molded pulp products including fruit and vegetable packs and egg cartons	2646 1987 on, 26794	Pressed and molded pulp goods; 1987 on, Molded pulp goods	2567140; Pressed or molded pulp goods including trays, dishes, cups, egg cartons; 1989 on, 4823700000, Molded or pressed articles of paper pulp	2567000; pulp articles exc paper and paperboard, NSPF; 1989 on, 4823700000, Molded or pressed articles of paper pulp

[a]For the *1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities* survey and *Current Industrial Report* product categories, these codes are for bleached packaging and industrial converting paperboard. For product 60 (linerboard), the unbleached portion was subtracted from the export and import data and added to product 40 (unbleached kraft packaging and industrial converting paper).

[b]Production data for product category 70, molded pulp, are from the *1982* and *1987 Census of Manufactures: Converted Paper and Paperboard Products, Except Containers and Boxes* (years 1981-1986)[89, 90] and the *1990 Annual Survey of Manufactures, Value of Product Shipments* (years 1987-1989).[91] Export data for product category 70, molded pulp, are from the U.S. Department of Commerce.[92]