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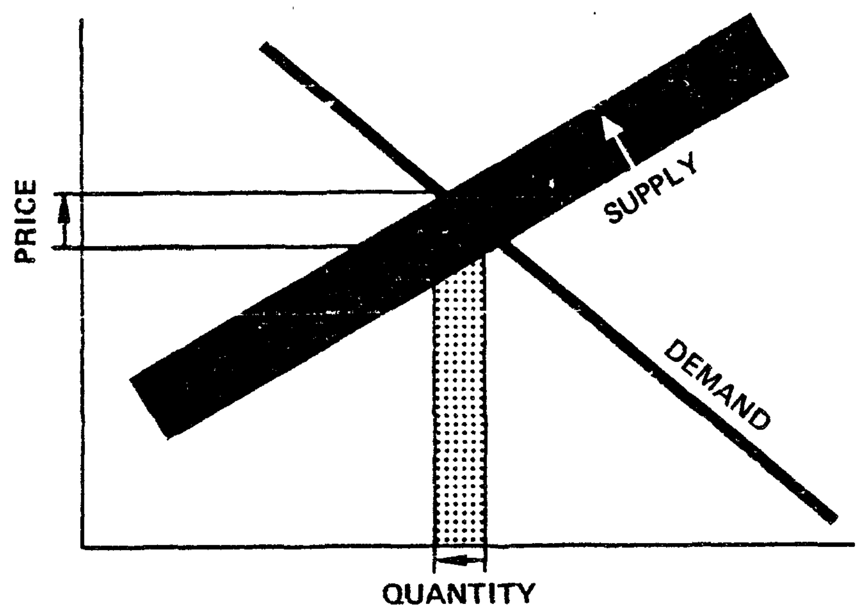
Economic Impact Analysis of Proposed Effluent Guidelines and Standards for Deink Subcategory of the Pulp, Paper, and Paperboard Industry



ECONOMIC IMPACT ANALYSIS OF PROPOSED EFFLUENT LIMITATIONS AND STANDARDS FOR THE DEINK SUBCATEGORY IN THE PULP, PAPER AND PAPERBOARD INDUSTRY

Prepared for

U.S. Environmental Protection Agency
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by

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PREFACE

This document is a contractor's study prepared for the Office of Water Regulations and Standards of the Environmental Protection Agency (EPA). The purpose of the study is to analyze the economic impact which could result from the application of effluent standards and limitations issued under Sections 3-1, 304, 306 and 307 of the Clean Water Act to the Pulp, paper, and paperboard industry.

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

The study has been prepared with the supervision and review of the Office of Water Regulations and Standards of EPA. This report was submitted in fulfillment of Contract No. 68-01-6162 by Meta Systems, Inc. The analysis was completed in October 1982.

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Section 1

Summary

Introduction

This report analyzes the economic impacts of proposed effluent guidelines limitations on the Deink Subcategory in the Pulp, Paper and Paperboard Industry for PCB control: Best Available Technology (BAT) and New Source Performance Standards (NSPS). No effluent guidelines limitations are proposed for Pretreatment Standards for Existing Sources (PSES) or Pretreatment Standards for New Sources (PSNS). Two sections of the subcategory are affected: Deink-Tissue and Deink-Fine. Mills in these subcategories produce output in the following product sectors: Bleached and Unbleached Kraft Papers, Uncoated Freesheet, Uncoated Groundwood, and Tissue. Since 86 percent of Deink-Fine production is Uncoated Fresheet and 95 percent of Deink-Tissue production is Tissue, only impacts for these two product sectors are estimated. New capacity subject to new source standards is expected to occur only in the Tissue product sector. The impacts analyzed are: total costs of compliance, the resulting increase in production costs, changes in prices and the quantity produced, capital availability, mill closures, impacts on the number of persons employed, indirect impacts, and impacts on small businesses.

Following this Summary, Section 2 gives a detailed discussion of the methodology used in the economic analysis. Section 3 presents descriptions and analysis of the structure of the industry, financial profiles of firms and mills, and the pricing structure of the Pulp, Paper and Paperboard Industry. This section is based on data from various sources, including a financial survey of the industry, Data Resources, Inc., the EPA Development Document,* the American Paper Institute, Standard and Poor's Corp., U.S. Department of Commerce, the Federal Trade Commission, and trade literature. Section 4 presents a description of the regulatory controls analyzed. The last two sections present the results of the economic analysis and the limits of the analysis. These are based primarily on data from the 308 Survey, Data Resources, Inc., and EPA.

Section 2: Methodology - Economic Impacts

This section presents the methodology, assumptions and data sources used in the economic assessment of the effect of proposed BAT and NSPS regulations for PCB control on the Pulp, Paper and Paperboard Industry. A methodology using demand/supply analysis was developed to determine the likely effect of NSPS regulations on price, output, and capacity in the industry given Base Case estimates of these variables and unit costs of compliance for new

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*U.S. Environmental Protection Agency, Effluent Guidelines Division, "Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards and Pretreatment Standards for the Pulp, Paper and Paperboard and the Builders' Paper and Board Mills Point Source Categories", Washington, DC, December 1980, EPA 440/1-80/025-6, and also the Final Development Document, October 1982.

source mills. Since some existing mills would incur costs to comply with BAT, a mill closure methodology was developed also to analyze these impacts. The results of the capital availability, employment and indirect impacts and social costs analyses flow directly from the results of the NSPS demand/supply and BAT plant-level analyses.

Costs of Compliance

Before examining impacts of the proposed regulations on price, output and capacity expansion, EPA estimated unit costs of compliance for mills in each subcategory, based on model mill sizes for each subcategory and an assumption of 330 operating days per year.

Results for three kinds of costs are presented: capital, operating and maintenance, and total annual costs. Total annual costs are the sum of operating and maintenance costs and capital costs multiplied by a capital recovery factor (CRF). The capital recovery factor indicates how many dollars per year a company must earn per dollar of invested capital to cover taxes, depreciation and the required return on capital. The value of the CRF used is .22. Real costs of compliance are assumed to remain unchanged between 1978 and 1985.

Demand/Supply Analysis

The core of the approach to estimating the impact of NSPS regulations on the industry is a microeconomic demand/supply analysis for each market (product) sector of the industry. (Analyses of proposed regulations for existing sources do not use demand/supply analysis.) The analysis produces both a Base Case (assuming no new regulations) forecast of price, output, and capacity expansion for each product sector and forecasts of the effects of the cost of various treatment options on those variables. The approach assumes that prices are determined by the costs of new mills. In particular, the increase in unit total annual costs at new mills due to compliance costs is assumed to determine the increase in price. The demand curve then determines the reduction in output needed to accommodate that price increase. The decrease in output is assumed to be absorbed entirely by an equivalent reduction in the amount of new source capacity expansion subject to the proposed regulations. In the post-control cases, variable costs are assumed to include total annual costs of pollution control. Unit compliance costs for each sector are an average of the compliance costs for each subcategory producing that product weighted by production shares. Market or product sectors rather than subcategories are used because the relevant set of competing products depends on product type, not manufacturing process. The organization of the industry into product sectors corresponds closely to product groups used by The American Paper Institute (API).

The long-run supply curve is assumed to be a horizontal line with marginal cost equal to the unit production costs (including annualized capital costs) of new capacity. This reflects the assumption of long-run equilibrium that output expands to meet any demand for it at a price equal to or greater than its full unit costs of production. This implies a growth rate of new capacity which is used to estimate total costs of compliance for new sources. Rather than attempting to estimate Base Case production costs for each product sector explicitly, it is assumed that the 1985 Base Case price estimates already reflect these costs, i.e., that the 1985 Base Case forecasts depict a long-run equilibrium situation. This assumption allows much simplification and is not crucial to the analysis because we are interested primarily in the incremental impacts of the regulation.

The demand for each product sector is modeled using demand equations estimated by Data Resources, Inc. and linked with DRI's macroeconomic forecasts over the period of the analysis. The growth rate of demand is the stimulus which leads to corresponding growth in capacity to meet demand at the constant long-run cost.

The interaction between supply and demand is modeled by solving the system of supply and demand equations for each product sector for equilibrium values of price and output for each year of the forecast period.

All reductions in output are assumed to be borne by new source capacity. Specifically, the rate of capacity expansion over the period 1985-90 is assumed to be reduced so that the annual loss of output in 1990 relative to the Base Case is equal to the cumulative reduction in new source capacity over the period. There is assumed to be only a single price increase over the period due to the per ton compliance costs of new capacity. These assumptions are consistent with the assumption that existing capacity and new capacity not subject to NSPS regulations produce at the same level over the forecast period as in the Base Case.

Base Case Forecast. Base Case estimates of price, output, capacity expansion, new source capacity and cash flow are made for each product sector for the period 1985-90. Given predicted relationships between product sectors and technical subcategories, rates of capacity expansion over the period are also estimated for product sectors. The Base Case assumes that treatment controls to meet promulgated BAT, PSES, NSPS, and PSNS regulations are already in place.

Total Costs of Compliance

Costs of compliance for BAT are computed by imputing average costs of compliance for each subcategory to individual mills (i,e., for monitoring costs) or by using mill-specific costs computed by EPA where available. These costs are then summed over all existing mills to determine total costs of compliance.

Total costs of compliance for NSPS are found by multiplying total new source capacity in each product sector or subcategory by the relevant value for unit costs of compliance.

Capital Availability

The capital availability analysis examines the ability of the industry to finance investments in new capacity both without and with pollution controls. The analysis compares the cash flow available in a given year for investment with the total capital costs of normal capacity expansion and the capital and variable costs of compliance with the proposed regulations. Unit capacity costs are used to estimate the total costs of capacity expansion over the period as an input to the capital availability analysis. This corresponds to a worst-case "capital squeeze" situation.

Closure Analysis

In the closure analysis, the estimated compliance costs for individual existing mills are compared with estimated mill sales to determine if the impact is significant. In addition, profit and loss statements are developed for mills which also have financial data available from the Economic 308 Survey to determine the effect of treatment costs on their profitability. These results are used to evaluate the results for the other mills using the simpler treatment costs to sales impact ratio.

Comparing the total annual costs of compliance with the annual sales value of the production of a mill gives a rough measure of the size of the economic impact. We assumed that a cost to sales ratio of less than one percent implies a negligible impact, while a ratio of greater than four percent may indicate a significant impact, i.e., the possibility of closure.

Employment and Indirect Impacts

Employment Impacts. Changes in output due to changes in capacity expansion also cause changes in employment relative to the Base Case. (At least some of this loss will be offset due to increased purchases and investment in other industries.) Rough estimates of these employment changes can be obtained by multiplying the change in the value of output by average sales per employee figures. The change in sales is obtained by multiplying the total change in output by the Base Case industry average price.

Indirect Effects on Earnings and Employment. Direct impacts from pollution control regulations such as output reductions can be expected to have indirect effects, arising from the reduction in demand for inputs and reductions in consumption because of both direct and indirect losses in earnings. Input/output analysis provides a straightforward framework for accounting for these indirect effects as long as the direct effects are small and a number of other important limitations are recognized. An earnings/sales multiplier is developed to relate changes in industry sales due to the proposed regulations to changes in value-added (earnings) in other sectors of the economy. An average earnings per worker ratio is applied to these changes to obtain impacts on indirect employment.

Small Business Analysis

The Regulatory Flexibility Act of 1981 requires agencies to conduct a small business analysis to determine whether a substantial number of small entities (in this case, paper mills) are expected to be significantly affected. If so, a formal Regulatory Flexibility Analysis is required. The definition of small entity used in this analysis is a mill with less than $10 million in annual sales. The method used is to classify all mills in the data sample either as large or small and then to compare the distribution of impacts on mills belonging to the two sets.

Section 3: Industry Structure, Financial Profile, Pricing

Industry Structure

The general structure of the industry was analyzed in terms of 26 product sectors. A single mill can have production in more than one product sector. Detailed descriptions of each of these product sectors is presented in Volume II of the 1980 Proposal Document.* A number of important product sector characteristics were found to be associated with the overall production level.

The product sectors characterized by medium volume paper producers are Solid Bleached Bristols, Uncoated Groundwood, and Bleached Kraft Paper. These mills tend to have somewhat newer capital stock and more widespread regional distribution than the smaller, specialty mills. Their productivity growth rates are moderate with some mills planning expansion.

The product sectors characterized by large volume paper producers are Uncoated Freesheet, Unbleached Kraft Paper, and Tissue. These firms tend to be publicly owned and multi-mill. The mills are generally new, with high productivity growth rates and large planned expansions.

Financial Profile

Using data compiled by Standard and Poor Corporation, the financial condition of various firms and the different subcategories was analyzed in terms of long-run, non-liquid asset ratios. Twelve firms which have high

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*U.S. EPA, Office of Water Regulations and Standards, "Economic Impact Analysis of Proposed Effluent Limitations Guidelines, New Source Performance Standards and Pretreatment Standards for the Pulp, Paper and Paperboard Mills Point Source (2 Vols.)," EPA 440/2-80-086, December 1980.

ratios of net income to total assets were compared with ten firms which have low ratios and seventeen small firms. While a few of the small firms are clearly in financial trouble, small firms are not necessarily weak firms. See the 1980 Proposal Document, Section 4, for a more detailed discussion, especially on capacity expansion.

Pricing

This section addresses the question of how cost increases due to NSPS treatment requirements are likely to affect prices in the Pulp, Paper and Paperboard Industry. First, the historical relationship between costs and prices is reviewed, both for the industry as a whole and for smaller segments. The results emphasize the effect of capacity utilization rates on the ability to cover cost increases. Next, the effects of demand growth and elasticity of supply and demand on likely price impacts are discussed. Data on predicted end-use market growth and demand and supply elasticities in each product sector are used to assess expected price behavior under the assumption of competitive markets.

Section 4: Effluent Control Guidelines

Best Available Treatment for Existing Sources (BAT)

BAT effluent limitations for direct dischargers are proposed for the control of PCB's for the Deink-Fine and Deink-Tissue subcategories. Two options are considered: the treatment level of best performing existing mills (BAT Option 1) and tertiary chemically assisted clarification (BAT Option 2). BAT Option 1 is the selected option.*

New Source Performance Standards (NSPS)

For NSPS, two levels of PCB controls are analyzed: the treatment level of best-performing mills plus in-plant controls (NSPS Option 1) and chemically assisted clarification (NSPS Option 2). NSPS Option 1 is the selected option.

Section 5: Economic Impact Assessment

Base Case Forecast

For the NSPS analysis, a Base Case forecast for 1985 is estimated for price, output, capacity expansion and cash flow, since that year is the

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* BAT Option 1 corresponds to the BAT Option B in the EPA Proposed Development Document. Similarly, BAT Option 2 corresponds to BAT Option C. (BAT Option A is BPT treatment).

first full year when compliance with the proposed regulations is required. These variables are then forecast through 1990 based on a constant real price and constant annual growth rates for each product sector. Estimates are made for the Uncoated Freesheet and Tissue Product Sectors. The forecasts are summarized in Table 1-1.

BAT Impacts

Fourteen mills in the Deink-Fine and Deink-Tissue subcategories would incur BAT compliance costs. Two options are considered: the treatment level of best performing mills (BAT Option 1) and chemically assisted clarification (BAT Option 2). Four mills can meet the proposed limits for BAT Option 1 with existing pollution control treatment but none can currently meet the limits for BAT Option 2. Cost-to-sales ratios are estimated for these mills to determine if any may close.

The results are shown in Table 1-2. No mills have cost-to-sales ratios greater than four percent under BAT Option 1 so significant impacts are not expected. Total costs of compliance are $29.40 million in capital costs and $9.93 million in total annual costs. Because all mills have estimated cost-to-sales ratios of less that four percent, no mill closures or unemployment are expected.

Under BAT Option 2, three mills have cost-to-sales ratios greater than four percent, indicating possible plant closures. Nine mills have ratios in the range of 2-4 percent. Total costs of compliance are $59.74 million in capital costs and $26.11 million in total annual costs. Unemployment associated with these closures is estimated at 402 employees.

Under either option, all 14 mills incur monitoring costs, for total annual costs of $250,000, which are included in the above totals.

NSPS Impacts

Two options for control of PCB's in the Deink-Tissue and Deink-Fine subcategories were considered. The first equals the NSPS promulgated limitations for conventional pollutants (NSPS Option 1) and requires no additional costs. The second is chemically-assisted clarification (NSPS Option 2), which would impose additional costs. The results of the NSPS analysis are summarized below.

Units Costs of Compliance, Demand Supply Impacts, Total Costs of Compliance. Total Base Case new source capacity subject to NSPS in the Tissue product sector is 41.2 million tons per year over the period 1985-90. The Uncoated Freesheet product sector is predicted to have no new source capacity subject to NSPS.

Table 1-1. Summary of Base Case Forecast

	Product Sector	
	Uncoated Freesheet	Tissue
Price ($/ton)	812	1,339
Output (1000 tons)		
1985	9,238	4,982
1990	10,734	5,264
Average Annual Growth Rate (%)	3.0	1.1
Cumulative Capacity Expansion, 1985-90 (1000 ton/year)		
Total	1,780	335
New Source	1,050	274
Cash Flow (Million $)	1,870	1,660

Source: EPA Estimates.

Note: All costs in January 1982 dollars.

Table 1-2. Summary of Analysis of PCB BAT Impacts

	Option 1		Option 2	
Number of Mills With Costs				
Monitoring	14		14	
PCB Control	10		14	
Total Costs of Compliance (Millions of 1982 $)*	Capital	Total Annual	Capital	Total Annual
Monitoring Costs	0.0	.25	0.0	.25
PCB Control	29.40	9.68	59.74	25.86
Total	29.40	9.93	59.74	26.11
Distribution of Mill Treatment Cost to Sales Ratio				
0-1%	7		0	
1-2%	3		2	
2-4%	4		9	
≥ 4%**	0		3	

*EPA originally estimated compliance costs in first quarter 1978 dollars (ENR Construction Cost Index = 2683). The value of this index in January 1982 is 3726. The conversion factor is 3726/2683 = 1.389.

** Indicates significant impact.

Source: EPA estimates.

The results of the NSPS impact analyses of unit costs of compliance, price and output impacts from the demand/supply analysis, and total costs of compliance are summarized in Table 1-3. No price or output impacts are expected under NSPS Option 1, the selected option. Under NSPS Option 2, predicted unit costs of compliance for Deink-Tissue are $101 per ton for capital costs and $42.6 per ton for total annual costs. Predicted production-weighted average unit capital costs for Tissue are $16.2 per ton and total annual costs are $6.8 per ton. The expected average price is $1,346 per ton, or 0.5 percent higher than the Base Case price. The total reduction in output predicted in 1990 is 1,160 tons per year, or .02 percent. This causes expected new source capacity expansion over the period 1985-90 to drop to 42.7 million tons. Total estimated capital costs are $4.42 million and total annual costs are $1.86 million.

Capital Availability

Results of the capital availability analysis are shown in Table 1-4. Total Base Case cash flow for Tissue and Uncoated Freesheet is $3.53 billion and the capital costs of Base Case capacity expansion are $474 million. In comparison, the highest 1985 one-year compliance costs (capital plus O&M costs) are $73.3 million for BAT Option 2 and NSPS Option 2. One-year compliance costs for the selected options are $32.8 million. Therefore capital availability is not judged to be a problem.

Employment and Indirect Impacts

The results of the employment and indirect analyses for all options are also shown in Table 1-4 for 1990. Industry employment reductions relative to the Base Case due to output reductions range from zero to 413 jobs, indirect earnings range from zero to $17.2 million, and indirect employment from zero to 814 jobs. The lower bounds correspond to the selected options.

Small Business Analysis

Aside from monitoring costs, only 14 existing mills have compliance costs under BAT. Based on the definition of small mills as those having annual product value of $10 million or less, one of these fourteen is classified as small. This mill is not expected to close or bear serious impacts under BAT Option 1, the selected option.

Section 6: Limits of the Analysis

Limits of the analysis are discussed for five major parts: Base Case forecast; unit costs of compliance; the demand/supply methodology; total costs of compliance; and other analyses. Sensitivity analyses are performed to determine the most important parameters which affect the impact estimates.

Table 1-3. NSPS Impact Summary Table
Averages and Totals for Tissue Product Sector
(1982 dollars)

	NSPS Option 1	NSPS Option 2
Incremental Unit Costs of Compliance (Deink-Tissue)*		
($/ton)		
Capital	0.0	101
Total Annual	0.0	42.6
Unit Costs of Compliance (Tissue Product Sector)		
($/ton)		
Capital	0.0	16.2
Total Annual	0.0	6.8
Demand/Supply Impacts		
Price ($/ton)	1339	1346
Percent Change	0.0	0.5
1990 Production Loss (1000 t/y)	0.0	1.16
Percent Change	0.0	-0.2
Reduction in New Source Capacity (1985-90) (1000 t/y)	0.0	1.16
Percent Change	0.0	-0.4
Total Costs of Compliance		
(Millions of 1982 $)		
Capital	0.0	4.42
Total Annual	0.0	1.86

Source: EPA estimates.

* NSPS Option 1 for PCB control has the same technology basis as promulgated NSPS standards for conventional pollutants. Therefore, there is no incremental cost for this option.

Note: No impacts are projected for the Uncoated Freesheet product sector under either NSPS option.

Table 1-4. Summary of Capital Availability, Employment, and Indirect Impact Analyses (1982 dollars)

	BAT		NSPS		
	Option 1	Option 2	Option 1	Option 2	Total*
Capital Availablilty Analysis (1985) (Millions of 1982 $)					
One-Year Compliance Costs**	32.8	72.5	0.0	0.8	32.8-73.3
Capacity Expansion Costs					474
Total Demand for Funds					506.8-547.3
Cash Flow					3,530
Employment and Indirect Impacts (1990)					
Employment (no. jobs lost)	0	402	0	11	0-413
Indirect Earnings (Mill. 1982 $)	0.0	16.6	0.0	0.6	0-17.2
Indirect Employment (no. jobs lost)	0	792	0	22	0-814

*Ranges show minimum and maximum cost combinations of BAT and NSPS options.

**Defined as capital costs plus O&M costs.

Total costs of compliance are most affected by the share of new capacity subject to NSPS and the growth rates of the individual product sectors. The effect of different estimates of the capital recovery factor on unit costs and price increases is relatively small.

Section 2

The Economic Assessment Methodology

Introduction

This section presents the methodology, assumptions and data sources used in the economic assessment of BAT and NSPS proposed effluent limitations for PCB's on the Pulp, Paper and Paperboard Industry. Figure 2-1 shows the major elements and information flows of the analysis. A methodology using demand/supply analysis was developed to determine the likely effect of NSPS regulations on price and output in the industry given Base Case estimates of price and output and unit costs of compliance for new source mills. Since some existing direct discharger mills are expected to incur compliance costs, a mill closure methodology was developed to analyze the impacts of BAT costs. The results of the capital availability and employment and indirect impacts analyses flow directly from these results.

Much of the data and methodology used here are derived from that developed in the 1980 Proposal Document.* Because the analysis here covers much less ground, reference will sometimes be made to that document, rather than reproducing the methodology in full.

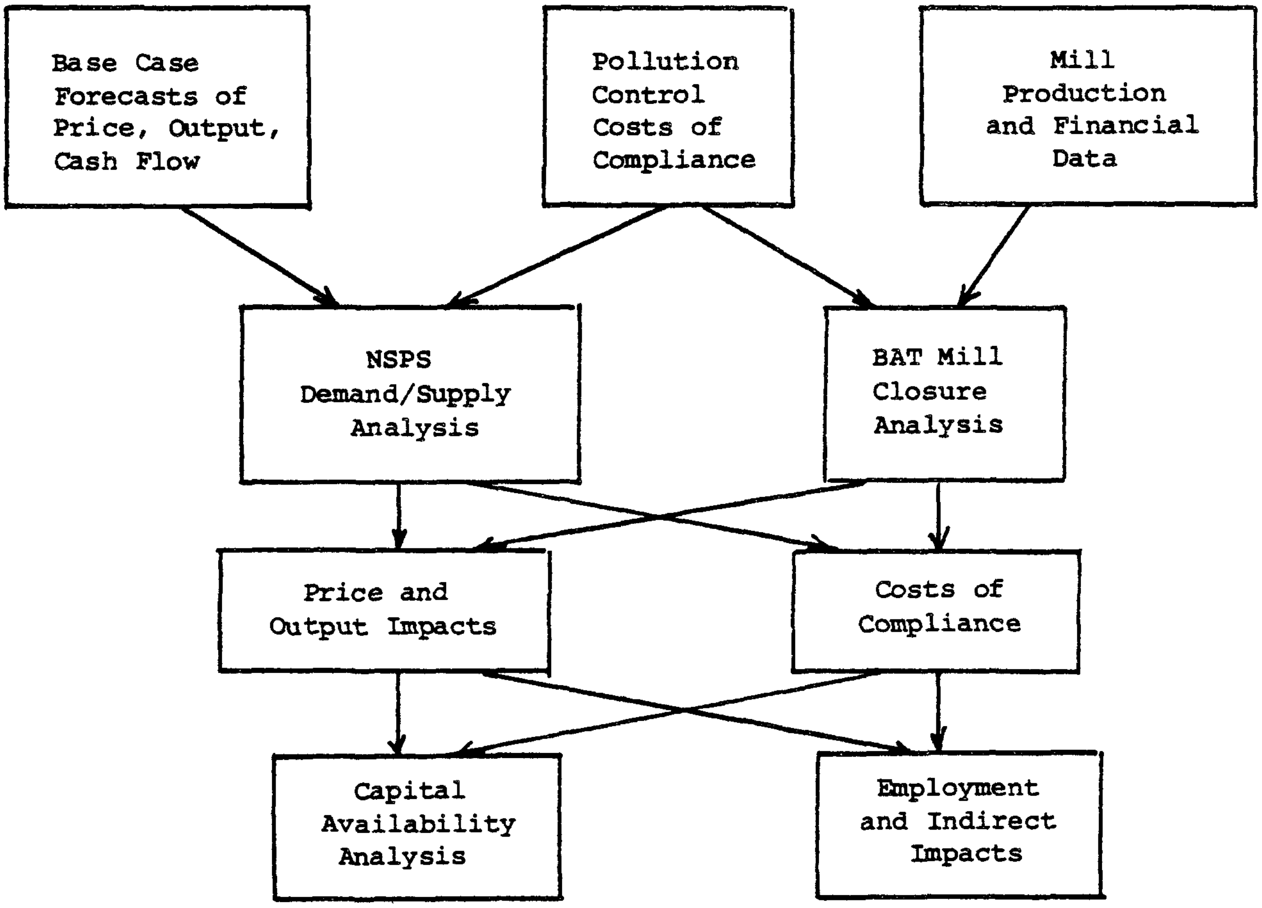
Not all elements of the analysis are performed for each of the regulations being analyzed in this study; this section describes the procedures used for each regulation. These elements and regulations are summarized in Table 2-1.

Table 2-1. Relationship of Analyses and Regulations

Analysis	BAT	NSPS
Demand/Supply (including capacity reduction)		X
Total Costs of Compliance	X	X
Capital Availability	X	X
Closure	X	
Employment	X	X
Indirect	X	X
Small Business	X	

*U.S. Environmental Protection Agency, Office of Water Regulations and Standards, "Economic Impact Analysis of Proposed Effluent Limitations Guidelines, New Source Performance Standards and Pretreatment Standards for the Pulp, Paper and Paperboard Mills Point Source Category (2 vols.)." EPA 440/2-80-086, December 1980.

Figure 2-1. Major Elements of the Analysis



Essentially, only mill-level analyses are performed for BAT, since only a small number of mills have costs other than monitoring costs, and only a few mill have significant impacts which may lead to output changes. On the other hand, the effects of NSPS on price and output are more pervasive and warrant a demand/supply analysis for the affected product sectors. The capital availability analysis and employment and indirect impacts are calculated for both regulations.

Costs of Compliance

Before examining impacts of the proposed regulations on price, output and capacity expansion, EPA estimated unit costs of compliance for mills in each subcategory. These unit costs were developed from costs provided in the EPA Development Document based on standard mill sizes for each subcategory and a standard assumption of 330 operating days per year. For example, suppose costs of compliance for a 500 ton/day mill are $1 million/year. Then average costs per ton are $1 million/year divided by (500 ton/day x 330 days/year) which equals 6.06 $/ton.

Results for three kinds of costs are presented: capital, operating and maintenance, and total annual costs. Total annual costs are the sum of operating and maintenance costs and capital costs multiplied by a capital recovery factor (CRF). The capital recovery factor indicates how many dollars per year a company must earn per dollar of invested capital to cover taxes, depreciation and the required return on capital. The methodology used to develop the CRF is described in Appendix A. The value of the CRF used is .22. Real costs of compliance are assumed to remain unchanged between 1978 and 1985.

Demand/Supply Analysis

Overview

The core of the approach to estimating the impact of NSPS regulations on the industry is a microeconomic demand/supply analysis for each market (product) sector of the industry. The BAT analysis does not use a demand/supply analysis. The NSPS analysis produces both a Base Case (assuming no new regulations) forecast of price, output, and capacity expansion for each product sector and forecasts of the effects of the cost of various treatment options on those variables. The approach assumes that prices are determined by the costs of new mills. In particular, the increase in unit total annual costs at new mills due to compliance costs is assumed to determine the increase in price. The demand curve then determines the reduction in output needed to accommodate that price increase. The decrease in output is assumed to be absorbed entirely by an equivalent reduction in the amount of new source capacity expansion. In the post-control cases, variable costs are assumed to include total annual costs of pollution control. Unit compliance costs for each sector are an average of the compliance costs for each subcategory producing that product weighted by production shares. Market or product sectors rather than subcategories are used because the relevant set of competing products depends on product type, not manufacturing process. The organization of the industry into product sectors corresponds closely to product groups used by The American Paper Institute (API).

The long-run supply curve is assumed to be a horizontal line with marginal cost equal to the unit production costs (including annualized capital costs) of new capacity. This reflects the assumption of long-run equilibrium that output expands to meet any demand for it at a price equal to or greater than its full unit costs of production. This implies a growth rate of new capacity which is used to estimate total costs of compliance for new sources. Rather than attempting to estimate Base Case production costs for each product sector explicitly, it is assumed that the 1985 Base Case price estimates already reflect these costs, i.e., that the 1985 Base Case forecasts depict a long-run equilibrium situation. This assumption allows much simplification and is not crucial to the analysis because we are interested primarily in the incremental impacts of the regulation.

The demand for each product sector is modeled using demand equations estimated by Data Resources, Inc. and linked with DRI's macroeconomic forecasts over the period of the analysis. The growth rate of demand is the stimulus which leads to corresponding growth in capacity to meet demand at the constant long-run cost.

The interaction between supply and demand is modeled by solving the system of supply and demand equations for each product sector for equilibrium values of price and output for each year of the forecast period.

Supply Curves

The supply curve shows the supply response of the industry to a given price. The analysis of the impacts of new source costs focuses on the long-run response of the industry without being concerned about shorter run adjustments. The key assumption is that investment in new capacity adjusts so that marginal new capacity earns a competitive return on its capital costs. This implies that long-run price is equal to the unit costs of marginal new capacity, including annualized capital costs, both before and after the imposition of treatment requirements. It follows that, in the long-run, incremental costs of compliance are fully passed through in the form of higher prices so that new capacity continues to earn a competitive return. Therefore, both pre- and post-impact supply curves are represented as horizontal lines with marginal cost equal to the full units costs of new capacity.

The supply curve methodology has two major tasks for each product sector:

- o estimate capacity expansion, both overall and new source;
- o estimate unit costs of compliance.

No attempt is made to estimate unit production costs of new capacity explicitly. Instead, it is assumed that the Base Case price forecasts for each product sector for 1985 reflect these full production costs (O&M costs plus annualized capital costs).* This assumption is not crucial for the analysis, since we are mainly interested in the incremental effect of the regulation.

Capacity Expansion. Given the assumption of long-run equilibrium and constant real price and unit cost, capacity grows at the same rate as demand. This growth rate is applied to the 1984 level of capacity in each product sector to determine the required increment to capacity for each year of the period 1985-90. Capacity expansion in year t for product sector j is denoted as $DELCAP_{jt}$. Only capacity increases due to "greenfield" mills or major alterations of existing plants are assumed to be subject to NSPS requirements. Thus, it is necessary to forecast what fraction of new capacity would be classified as a "new source." This is done using information on installation of new machines from the American Paper Institute's (API) capacity forecasts and planned capacity increases in existing plants from the Economic 308 Survey. The estimated share of new capacity in each product sector classified as "new source" is shown in Table 2-2. The estimates presented here have a great deal of uncertainty. Therefore, sensitivity analyses using alternative estimates are given in Section 6. New source capacity for product sector j is

$$NSDELCAP_{jt} = (i-v_j) \cdot DELCAP_{jt} \qquad (2\text{-}1)$$

where v_j is the share of non new source capacity.

Compliance Costs. The compliance costs added to the supply curves are total annual costs per ton. Total annual costs are defined as O&M and energy costs plus annualized capital costs (capital costs multiplied by the capital recovery factor, .22). Unit costs are found by dividing model mill costs by annual production (daily mill capacity x 330 days per year).

Because costs of compliance are defined on the basis of subcategories rather than product sectors, it is necessary to relate capacity expansion in each product sector with specific subcategories. Because announced capacity expansion plans are usually described in terms of product sectors rather than subcategories, a number of assumptions must be made to obtain these estimates. The approach taken is to assume that expansion comes

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*These price estimates were derived from the more complex demand/supply methodology used in the 1980 Proposal Document. See Appendix C.

primarily from integrated mill subcategories, and that it follows the current mix of integrated subcategories in each product sector.*

The resulting estimates are given in Table 2-2, which shows the share of new source capacity expansion in the Tissue product sector contributed by each subcategory. Only Tissue is forecast to have new source capacity from the Deink (Tissue) subcategory and no product sector is forecast to have new source capacity from the Deink (Fine) subcategory. A preliminary analysis indicated that the BCT Bleached Kraft subcategory would also contribute new source capacity to Tissue. However, the product sector capacity expansion estimates together with the new source and subcategory share coefficients in Table 2-2 implied annual additions to capacity for this subcategory which were small (less than 20 percent) relative to the size of a new mill. Therefore, it was deemed unlikely that new source mills in this subcategory would be built. The share coefficients of this subcategory were dropped from Table 2-2 and the shares of the remaining subcategories adjusted accordingly.**

Table 2-2. Relation of Subcategories to Product Sector Capacity Expansion: Tissue

Annual Growth Rate of Output = 1.1 Percent

Subcategory	Fraction of Total Product Sector New Source Capacity Expansion met by each Subcategory
Non-Integrated Tissue Papers	0.50
Papergrade Sulfite	0.35
Deink (Tissue)	0.15

Source: EPA estimates.

*This distribution is described in detail in the 1980 Proposal Document, pp. 3-24 to 3-28.

**The remaining shares were adjusted upwards by equal percentage amounts so that they summed to unity for each product sector.

Unit costs for each product sector are weighted averages of the costs for each subcategory. Let:

$UTAC_i$ = unit treatment cost for subcategory i (i = 1,..., n)

a_{ij} = share of subcategory i in new source capacity expansion of product sector j

Then the unit cost for product sector j is

$$UTAC_j = \sum_{i=1}^{n} a_{ij} \; UTAC_i \qquad (2\text{-}2)$$

The share coefficients are also used to determine capacity expansion in each subcategory, which is the sum of its shares of capacity expansion in each product sector. The total increment to capacity for subcategory i is:

$$DELCAP_{it} = \sum_{j=1}^{m} a_{ij} \; DELCAP_{jt} \qquad (2\text{-}3)$$

and the increment of new source capacity is

$$NSDELCAP_{it} = \sum_{j=1}^{m} a_{ij} \; NSDELCAP_{jt} \qquad (2\text{-}4)$$

Demand Curves

A separate demand curve is estimated for each product sector. The demand curves used in the NSPS methodology are simplified versions of those used in the 1980 Proposal Document. The methodology used to develop the original demand curves is described in Appendix C. The simplified demand curves take the following form:

$$Q_t = (c + \sum_{i=0}^{4} d_i \; P_{t-i}) \; (1+s)^{t-T} \qquad (2\text{-}5)$$

where:

Q_t = quantity demanded (thousand tons/year) in year t
P_t = price (cents/lb.) in year t
s = average annual growth rate of demand
T = last year before NSPS takes effect (1984)

Although much simplified, these curves preserve the essential behavioral features of the original demand curves: price elasticity of demand and growth of end-use demand. The values of c and d_i are obtained by inserting the 1984 values for all other variables in the right-hand side of the original demand equation besides the real price terms, setting all the price terms equal to the 1984 level (to be consistent with long-run equilibrium) and solving. The 1984 demand curves are given in Appendix D. The structure of the equation implies that if capacity also grows at rate s, long-run equilibrium is maintained, with price remaining at the real 1984 level and output growing at rate s. This is consistent with the assumptions originally used to develop the capacity expansion forecasts, and provides a convenient baseline against which to measure the impact of treatment costs for new capacity on price and output.

Solution of the Model

The supply and demand curves for each sector are combined to form a product sector model which can be solved to predict the equilibrium paths of price and output over time. The system is closed by assuming the relationship

$$P_t = MC_t \qquad (2\text{-}6)$$

i.e., the competitive assumption of price being equal to long-run marginal cost. The model is started by inputting the initial five values of present and lagged price.

Figure 2-2 shows the determination of Base Case price and output. The intersection of the demand curve DD and the supply curve SS yields price P and output Q. Figure 2-3 shows the impact of adding treatment costs S'S to the supply curve, causing it to shift upward to line S'S'. The price increase is P'P (equal to S'S) and the change in output is Q'Q.

It is assumed that the reduction in output in 1990 due to the price increase causes an equal drop in cumulative new source capacity expansion over the forecast period 1985-90. This implies that all existing capacity, except for normal retirement, stays open, which is plausible, since price increases while the costs of almost all existing mills do not. (The amount of Tissue capacity lost because of closures due to BAT PCB control costs is small.) Given this, the marginal ton of new source capacity just earns a competitive return while covering the added costs of compliance; any greater capacity expansion would depress price below the required level.

Denoting $NSCAP^*_{i,90}$ as the cumulative Base Case amount of new source capacity in 1990, the post-impact amount of new source capacity is:

$$NSCAP_{i,90} = NSCAP^*_{i,90} - Q'Q_{90} \qquad (2\text{-}7)$$

Assuming that new source capacity still grows of rate s over the forecast period, this implies that the 1985 post-impact amount of new source capacity:

$$NSDELCAP_{i,85} = NSCAP_{i,90} \left(\frac{s}{(1+s)^6 - 1} \right) \qquad (2\text{-}8)$$

Figure 2-2. Base Case Demand/Supply

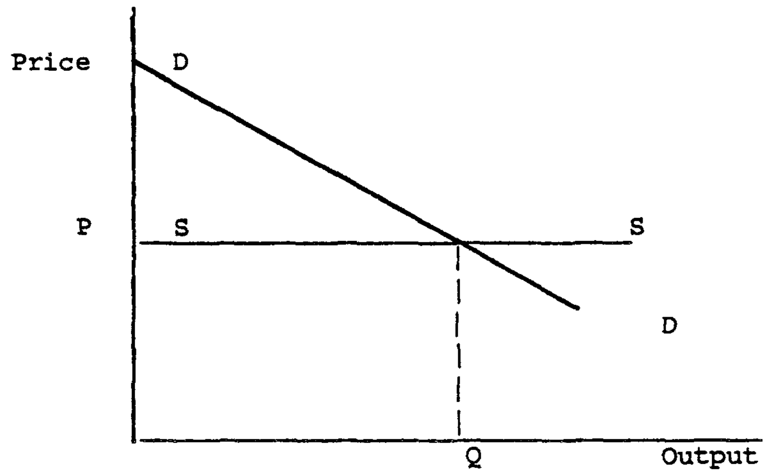
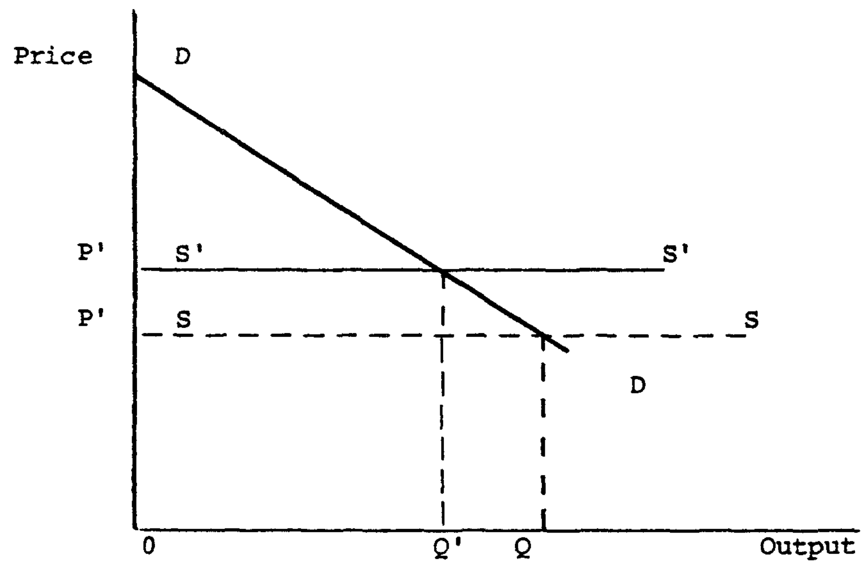


Figure 2-3. Impact of Treatment Costs



Total Costs of Compliance

Costs of compliance for existing sources are computed by imputing average costs of compliance for each subcategory to individual mills (e.g., for monitoring costs) or by using mill-specific costs computed by EPA. These costs are then summed over all existing mills to determine total costs of compliance.

Total costs of compliance for new sources are found by multiplying total new source capacity (product sector or subcategory) by the relevant value for unit costs of compliance. For example, total annual costs of compliance for subcategory i are:

$$TTAC_i = UTAC_i \times NSDELCAP_i \quad (2\text{-}9)$$

Total capital costs are determined in the same way.

Capital Availability

The capital availability analysis examines the ability of the industry to finance investments in new capacity and capital costs of compliance for existing and new capacity. The analysis compares the cash flow available in a given year for investment with the total capital costs of capacity expansion and the capital and variable costs of compliance with the BAT and NSPS effluent limitations.

Cash flow for a given product sector is defined as:

$$CASH = (1-t) \times (R-C-RV-B) \quad (2\text{-}10)$$

where:

- t = corporate income tax rate;
- R = total revenue;
- C = variable costs;
- RV = reinvestment (assumed equal to depreciation);
- B = interest payments.

It is difficult to obtain estimates of total reinvestment and interest payments for a given product sector. The method used here is to take the 1978 values of these variables for all mills from the Economic 308 Survey, and then to add the imputed amounts for new capacity based on the estimates of new capacity costs and the cost of capital used in this study.

Costs of capacity expansion are obtained by multiplying unit capital costs by the increment to capacity for each product sector in a given year. Unit capital costs are estimated from responses to the Economic 308 Survey. In algebraic terms,

$$TXCAP_t = UXCAP \times DELCAP_t \quad (2\text{-}11)$$

where $TXCAP_t$ is total expansion cost, UXCAP the capital cost per ton of new capacity, and $DELCAP_t$ the total increment to capacity in year t.

Costs of compliance to be met out of cash flow are capital and operating costs of compliance for the year's new source capacity expansion and for existing capacity. Capital costs for existing sources are only incurred in the first year, while capital costs of new capacity increase each year along with the rate of capacity expansion. Once capacity is in place, its annual O&M costs continue indefinitely. Therefore, total compliance costs in the year t = 1985 are:

$$CCOST_t = DELCAP_t\ (1-v)UCAP + (CAP_t - CAP_T)(1-v)OM + XSTCAP + XSTOM \quad (2\text{-}12)$$

where:

$CCOST_t$	=	Compliance costs met out of cash flow in year t
T	=	Last year before NSPS is effective
UCAP	=	Unit capital costs of compliance
OM	=	Unit O&M costs of compliance
CAP_t	=	Total capacity in year t
XSTCAP	=	Capital costs of compliance for existing sources
XSTOM	=	O&M costs of compliance for existing sources

Mill Level Impact and Closure Analysis

EPA has estimated compliance costs for individual existing mills, which are compared with estimated mill sales to determine if the impact is significant. In addition, profit and loss statements are developed for mills which also have financial data available from the Economic 308 Survey to determine the effect of treatment costs on their profitability. These results are used to evaluate the results for the other mills using the simpler treatment costs to sales impact ratio.

Comparing the total annual costs of compliance with the annual sales value of the production of a mill gives a rough measure of the size of the economic impact. We assumed that a cost to sales ratio of less than one percent implies a negligible impact, while a ratio of greater than four percent indicates a significant impact, i.e., the possibility of closure.

Mill sales are estimated as the product of annual production and the average 1985 price (in 1978 dollars) of the products assumed to be produced at the mill. Daily production figures from the Technical 308 Survey are multiplied by an assumed 330 days per year to yield annual production. Product prices are taken from the Base Case estimates. In the absence of additional information, Deink-Tissue mills are assumed to produce only Tissue (964 $/ton), and Deink-Fine mills are assumed to produce only Uncoated Freesheet (585 $/ton).

Financial data from the Economic 308 Survey are available for some mills that submitted surveys directly to EPA. This allows a more detailed analysis of the effects of costs of compliance on mill profitability, and provides a means to check the results of the cruder analysis based on the cost to sales ratio. A profit and loss statement is computed for each mill, showing revenues, variable and fixed costs, margin (revenues less variable costs), after tax earnings, and cash flow. The margin indicates whether the mill is covering its variable costs of production; if not it may close. After tax earnings and cash flow indicate whether the mill is covering its fixed costs and earning the required rate of return. The effect of treatment costs on these measures is examined.

Although the methodology is very simple, some inconsistencies exist because the data come from different sources. The source of the Base Case financial estimates is, as mentioned above, the Economic 308 Survey, while incremental treatment costs are estimated based on the Technical 308 Survey. Estimates of production vary between the two sources, and have to be adjusted to make meaningful comparisons. The basic strategy adopted is to put all costs on a per ton basis.

Employment and Indirect Effects

Employment Impacts

Changes in output also cause changes in employment relative to the Base Case. (At least some of this loss is offset due to increased purchases and investment in other industries.) Rough estimates of these employment changes can be obtained by multiplying the change in the value of output (sales) by average sales per employee figures. The change in sales is obtained by multiplying the change in output by the Base Case average price for each product sector. Average sales per employee are obtained for general pulp, paper and paperboard categories, based on 1977 U.S. Census of Manufactures data on total employment and sales:

	Value of Shipments (millions $)	Total Employment (1,000)	Sales / Employee ($1,000/employee)
Pulp and paper	14,679	143.9	102
Paperboard	7,114	68.3	104

These figures are adjusted to 1978 dollars by multiplying the ratios by the percent change in the GNP deflator from 1977 to 1978, 7.3 percent. No adjustment is made for real productivity changes between 1977 and 1985.

In mathematical terms, for a given product sector:

$$dEMP = dSALES/LPROD \tag{2-13}$$

where:

EMP = Employment in product sector
LPROD = Average sales/employee
SALES = PQ

and the prefix "d" denotes a change due to the proposed regulations.

Employment impacts are measured both for overall changes in output due to price changes and for predicted individual mill closures. As mentioned above, both numbers are likely to overstate the net impacts on employment, because output can be expected to increase in other mills or in other industries to take up some of the slack.

These employment coefficients have a number of weaknesses. Sales per employee may vary significantly for different kinds of products. There is a balancing effect, however. Large mills tend to have low employee per ton ratios, but also low value per ton products, and vice versa for small mills. Therefore, the ratio of sales to employees may vary less. New capacity tends to be more capital intensive than existing capacity, so using averages based on existing mills will underestimate the sales/employment ratio, and hence overestimate employment impacts.

Indirect Effects on Earnings and Employment

Direct impacts from pollution control regulations such as output reductions can be expected to have indirect effects, arising from reduction in demand for inputs and reductions in consumption because of both direct and indirect losses in earnings. Input/output analysis provides a straightforward framework for accounting for these indirect effects as long as the direct effects are small and a number of other important limitations are recognized.*

The measure of net impact used by the Bureau of Economic Analysis (BEA) and adopted here is earnings, defined as the sum of wage and salary income, other labor income, and payments to proprietors. It does not

*See U.S. Water Resources Council, Guideline 5: Regional Multipliers (Industry Specific Gross Output Multipliers for BEA Economic Areas) prepared by Regional Economic Analysis Division, Bureau of Economic Analysis, U.S. Department of Commerce, Washington, D.C., January 1977.

include returns to capital.* The impact on earnings can be calculated by multiplying the demand change in each sector by the ratio of earnings to gross output (sales) in that sector and then summing earnings changes over sectors.

This procedure has been used by BEA to calculate a ratio of change in total earnings to changes in final demand for the "paper and related products" industry, i.e.,

$$\frac{\text{d Total Earnings}}{\text{d Total Demand}} = .88 \tag{2-14}$$

This number includes direct earnings changes. Deducting average industry value added per dollar final sales of .48 yields the indirect earnings multiplier:

$$\frac{\text{d Indirect Earnings}}{\text{d Total Demand}} = .40 \tag{2-15}$$

This must be taken with some caution, because it represents a national average. However, it was not feasible to use state-specific gross output multipliers to obtain similar earnings/final demand ratios for each state. First, doing so would underestimate impacts, since state multipliers only capture indirect impacts in that state. Therefore, summing over state impacts would not yield the national impact because out-of-state impacts would not be captured. Second, the only existing complete set of state multipliers is very outdated. More recent work on a few states indicates that those multipliers are off by as much as 30 percent.**

The total indirect earnings impact of a change in output is just:

$$\text{d INDEARN} = .40 \times \text{dSALES} \tag{2-16}$$

where

INDEARN = indirect earnings.

Indirect employment impacts can be calculated from regional employment/earnings ratios for the indirect impacts. The formula is:

$$\text{dINDEMP} = \text{dINDEARN} \times \text{INDLPROD} \tag{2-17}$$

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*This is a more reasonable assumption for regional impact analysis since owners of capital are likely to be outside the region. Use of this measure would underestimate impacts at the national level. The extent of this error is unclear since it depends on the effect of changes in wealth on consumption. These effects are likely to be less than those of earnings on consumption.

**Private communication, Joseph Cartwright, BEA.

where INDLPROD is a national average value for the employment/earnings ratio.

This approach does have a number of limitations. Output in other sectors may expand because of substitution. Second, the use of a single national earnings/final demand ratio ignores regional differences in costs and input mixes. Finally, the effects of changes in wealth on consumption have been ignored, thereby underestimating impacts somewhat.

Small Business Analysis

The regulatory Flexibility Act of 1981 requires agencies to conduct a small business analysis to determine whether a substantial number of small entities (in this case, paper mills) will be significantly affected. If so, a formal Regulatory Flexibility Analysis is required. The method used is to classify all mills in the data sample as either large or small and then to compare the distribution of impacts on mills belonging to the two sets. The impacts include the number of mills with compliance costs, the distribution of the costs-to-sales ratio and the number of closures.

The Small Business Administration (SBA) provides a general definition of a small business as a concern

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

To fulfill the need for additional specificity, the SBA has published specific guidelines for identifying small businesses in various business activities including manufacturing, based on the number of employees. The most relevant set of guidelines for the small business analysis is given in the Code of Federal Regulations, Title 13, Section 121.2-10 (definition of small business for SBA loans). For companies in SIC group 2621 (paper mills, except for building paper mills) the SBA defines a small firm as one with fewer than 750 employees.

For the small business analysis, we believe that a cutoff figure of 750 employees is too high. Based on 1977 U.S. Census of Manufactures data, the average number of employees per mill for paper mills is 349.** Given the skewed distribution of mill sizes, with most mills smaller than the average size, the SBA definition would include well over half the number of mills in the industry. The analysis is primarily concerned with

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*Small Business Act, Section 3.

**U.S. Department of Commerce, 1977 Census of Manufactures: Paper Mills Except Building Paper: Preliminary Report, November 1977, p. 2.

small firms with limited resources or those which would face barriers to entry due to regulation. Such criteria are not likely to apply to such a large number of mills. Because the pulp and paper mills tend to be capital intensive, we believe that the employee criterion is inappropriate. Because production is a better indication of size, we have elected to use annual revenues as the basis of our small business definition.

In light of these considerations, we have defined small businesses to be mills having less than $10 million in annual sales. Based on data from the U.S. Census of Manufactures and the Economic 308 Survey, this definition covers about 20 percent of all mills in the Pulp, Paper and Paperboard Industry.

Section 3

Industry Structure, Financial Profile, Pricing

Industry Structure

This section provides a description of the Pulp, Paper and Paperboard Industry.* Attention is given to productive and financial characteristics relevant to the economic analysis.

The general structure of the industry was analyzed in terms of 26 product sectors. A single mill can have production in more than one product sector. Detailed descriptions of each of these product sectors is presented in Volume II of the 1980 Proposal Document.

A number of important product sector characteristics were found to be associated with the overall production level. Medium volume paper producers are Solid Bleached Bristols, Uncoated Groundwood, and Bleached Kraft Paper. The median mill size ranges from about 420 to 550 tons per day. These mills tend to have somewhat newer capital stock and more widespread regional distribution than the smaller specialty mills. Their productivity growth rates are moderate with some mills planning expansion.

Large volume paper producers are Uncoated Freesheet, Unbleached Kraft Paper, and Tissue. The median mill size ranges from 140 to 890 tons per day. These firms tend to be publicly owned and multi-mill. The mills are generally new, with high productivity growth rates and large planned expansions.

Product sectors vary in terms of degree of integration from pulp to papermaking. For purposes of this economic analysis, mills are classified into three categories: integrated, nonintegrated and secondary fiber. In general, the degree of integration is related to the value of the end product. Mills producing low-price-per-unit products are usually integrated, while mills making specialized, high value products frequently are nonintegrated. Integrated mills are usually located in rural areas, while nonintegrated and secondary fiber mills tend to be located in urban areas.

This analysis divides the United States into five regions. While the Northeast has more mills than any other region, the Southeast has more capacity. Also, more investment has been taking place in the Southeast than in any other region.

The United States clearly dominates world production and consumption of pulp, paper and paperboard products. However, over the past several years, U.S. production as a percent of world production has been declining slowly. Given the size of our industry, our relatively low-cost timber

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*U.S. Environmental Protection Agency, Office of Water Regulations and Standards, "Economic Impact Analysis of Proposed Effluent Limitations Guidelines, New Source Performance Standards and Pretreatment Standards for the Pulp, Paper and Paperboard Mills Point Source Category (2 vols.)". EPA 440/2-80-086, December 1980.

supply, and current expansions, the U.S. can be expected to maintain its major role in world production levels.

Research and development has never been a major activity for this industry. On average, it allocates about 0.7 percent of its sales revenues to this area. Research funds are divided between process development, including pollution control, and product development. The most commercially attractive innovations in the future are likely to be those which reduce fiber requirements, effluent loads or energy requirements. However, new technologies related to product development, such as fluff pulp, air layering, and supercalendaring have recently led to new products.

Financial Profile

The Pulp, Paper, and Paperboard Industry entered 1980 expecting a major downturn along with the rest of the U.S. economy. Data Resources, Inc. predicts a drop of 3.5 percent in total U.S. paper and board production in 1980, but expects the future to be very good. The general financial performance of paper and allied industries during the last several years has been better than that during the late 1960's and early 1970's.

One of the distinguishing characteristics of this industry is the high level of capital investment required. A majority of the capacity expansion has occurred at existing facilities as opposed to greenfield mills which tend to be more expensive. Much of this expansion has been financed internally.

Using data compiled by Standard and Poor Corporation, the financial condition of various firms and the different subcategories were analyzed in terms of long-run, non-liquid asset ratios. Twelve firms which have high ratios of net income to total assets were compared with ten firms which have low ratios and seventeen small firms. The high ratio firms tend to be less dependent on paper sales than the low ratio firms, and are more likely to be producers of paper as opposed to board. The high and low ratio groups have nearly the same ranking in terms of total sales. While a few of the small firms are clearly in financial trouble, small firms are not necessarily weak firms.

Subcategories were compared in terms of three ratios: working capital to total assets, investment in the past five years to fixed assets, and general, sales and administrative expenditures to cost of goods sold. Working capital as a percent of total assets tends to be highest for small and/or secondary fiber mills and nonintegrated mills. Generally, sales and administrative expenditures as a percent of cost of goods sold also tend to be high for mills producing highly differentiated products and for secondary fiber and nonintegrated mills, although this relationship is less strong. Investment over the last five years as a percent of fixed assets tends to be higher for integrated mills, with both large-mill and small-mill subcategories experiencing heavy investment.

Pricing

This section addresses the question of how the pricing behavior of the Pulp, Paper and Paperboard Industry might affect NSPS capacity expansion. A review of the history of price and cost shows that a key factor in industry pricing is the capacity utilization rate for the industry. When capacity utilization is 92 percent or greater, the industry is usually able to raise prices faster than costs increase.

Demand conditions have an important effect on the ability of the industry to pass cost increases through to customers. In general, consumption is strongly related to the overall level of business activity of the economy. Among the exceptions to this are Unbleached Kraft, Uncoated Groundwood and Solid Bleached Board.

The structure of the pulp and paper industry combines both competitive and oligopolistic characteristics. In general, the industry can be described as a commodity industry with minimal product differentiation. The Dissolving Pulp, Molded Pulp, Uncoated Groundwood and Tissue sectors are fairly highly concentrated. Most of the Board sectors have a low concentration and consist of a large number of firms.

Detailed Description of Product Sectors

The following pages give detailed descriptions of the Uncoated Freesheet and Tissue Product sectors.* As mentioned earlier, they contain almost all production of the Deink-Fine and Deink-Tissue subcategories, respectively.

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*They are taken from the 1980 Proposal Document, v. II.

UNCOATED FREESHEET PAPER

Product Sector

Definition of Product Sector

Uncoated freesheet paper in this report is defined as bleached uncoated printing and writing papers containing not more than 25 percent groundwood pulp in their furnish, such as offset, tablet, envelope, business (bond, ledger, mimeo, duplicator), form bond, cover and text, and book paper.

Firms in Product Sector

There are 53 U.S. firms that produce uncoated freesheet. The major producers are:

Champion International
International Paper Co.
Boise Cascade Corp.
Hammermill Paper Co.
Nekoosa Papers, Inc.
Union Camp Corp.
Mead Corp.
Weyerhaeuser Co.

Source: Meta Systems estimates based on Lockwood's, DRI estimates, and E.C. Jordan estimates.

Concentration

In 1978, the top five firms' capacity share was 40.1 percent, and the top eight firms' capacity share was 53.5 percent. This is thus an unconcentrated product sector. (Meta Systems estimates based on Lockwood's, DRI estimates, and E.C. Jordan estimates).

Total Capacity and Utilization Rate

U.S. capacity to produce uncoated freesheet is 20,452* tons per day, or 10.12 percent of total U.S. paper, paperboard, and market pulp production capacity (308 Survey). The 1979 capacity utilization rate for U.S. firms producing uncoated printing and writing papers was 92.3 percent (Pulp and Paper, March 1979 estimate).

Vertical Integration

About 80 percent of the firms in this product sector are backward

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*Six mills in this product sector did not report capacity data and were not included in this total.

integrated to raw materials (DRI estimate). Paper is often sold in rolls to end users for final conversion. Smaller orders, sold as cut paper, tend to be converted at the paper mill site. Fifty-eight mills, or 56 percent of the mills in this product sector, include converting operations (308 Survey).

Horizontal Integration

The 15 largest firms are horizontally integrated to other economic production sectors, as indicated by the following earnings percentages:

Firm	Percent Earnings in Paper and Paperboard Sector	Publicly or Privately Owned
Champion International	47%	Public
International Paper Co.	79%	Public
Boise Cascade Corp.	53%	Public
Hammermill Paper Co.	93%	Public
Nekoosa Papers, Inc.	96%	Public
Union Camp Corp.	89%	Public
Mead Corp.	44%	Public
Weyerhaeuser Co.	43%	Public
Allied Paper, Inc.	--	--
Potlatch Corp.	64%	Public
Georgia-Pacific Corp.	20%	Public
Westvaco Corp.	90%	Public
Finch, Pyrun & Co., Inc.	--	--
Scott Paper Co.	92%	Public
Crown Zellerbach Corp.	55%	Public

Source: Paper Trade Journal, June 30, 1979, pp. 44-47.

Economic and Technological Trends

Demand for uncoated freesheet papers has increased rapidly in the past 20 years. The underlying causes are as diverse as the markets which use uncoated freesheet. Among these causes are:

- increases in demand for business forms, created largely by computers;
- office automation and concomitant demand for copy, electric typewriter and duplicator papers, etc.;
- increases in offset printing use and development of commercial printing as a major market; and

- very low nominal price increases which offer an incentive to use these papers (the average price for uncoated book papers was actually lower, in nominal terms, in 1972 than in 1960).

This very competitive sector underwent significant capacity expansions in the 1960s. High operating rates, needed to offset large capital investment costs, and low variable cost increases combined in the 1960s and early 1970s to keep prices low. However, suppliers, hurt by excessive inventories in 1975, are now less prone to expand capacity, suggesting a future of infrequent large increments of capacity increase (following periods of very high capacity utilization).

Business demand for several types of uncoated freesheet -- business forms, computer stock, off-set paper for commercial printing and other converting, business papers, and book papers -- remains strong, as do future growth prospects. Cover and text papers probably will not grow due to consumer acceptance of lower priced, lower quality grades over this very high quality paper. Demand for Kraft envelopes will probably also remain roughly stable. (ADL, 1977; Kline Guide; DRI, Pulp and Paper Review, August 1979; discussions with DRI Pulp and Paper Service staff).

Mills

Number of Mills

The 53 firms in this product sector control 103 mills which produce uncoated freesheet. These are listed below by production subcategory:

Number of Mills	Percent of Mills in This Product Sector	Production Subcategory Name
17	17%	Fine Bleached Kraft & Soda
*	*	Semi-Chemical
7	7%	Papergrade Sulfite
*	*	Groundwood--Coarse, Molded Newsprint
*	*	Groundwood--Fine Papers
20	19%	Misc. Integrated Mills
5	5%	Deink (Fine Papers)
5	5%	Misc. Secondary Fiber Mills
34	33%	Nonintegrated Fine Papers
*	*	Nonintegrated Lightweight
*	*	Nonintegrated Filter & Non-woven
*	*	Nonintegrated Paperboard
8	8%	Misc. Nonintegrated Mills
103	100%	

Source: 308 Survey.

Size

The average mill capacity is 401 tons per day, with a standard deviation of 423; the median capacity is 271 tons per day (308 Survey).

Location

Uncoated freesheet producing mills are located generally in the northeast and north central regions of the United States, with a breakdown as follows:

Region	Number of Mills
Northeast	38 (37%)
Southeast	13 (13%)
North Central	40 (39%)
Northwest	* (*%)
West and Southwest	* (*%)
	103

Source: 308 Survey.

Indirect Dischargers

Thirty-four mills, or 33 percent of the mills in the uncoated freesheet product sector, are indirect dischargers. The percents of mills in each region which are indirect dischargers are as follows:

Region	% of Mills
Northeast	39
Southeast	*
North Central	35
Northwest	*
West and Southwest	*

Source: 308 Survey.

Planned Capacity Expansion

Planned daily capacity expansion in the uncoated freesheet product sector is expected to be 1,247 short tons per day. This represents a reduction of capacity in two mills and an expansion of capacity in 17 mills. This expansion will be an increase of 6.1 percent in capacity to produce uncoated freesheet by all mills. A capital investment of $190,579,000 is planned for this expansion. These data apply to projects which were under construction in 1978 or budgeted and approved for expenditure. (308 Survey)

Assuming 352 operating days per year as listed in the American Paper Institute (API) capacity survey, the planned daily capacity expansion reported in response to the 308 Survey equals 439,000 tons annually. Capacity expansion as reported in the API Survey from 1978 to 1982 is 1,004,000 tons annually (API Survey). The 308 Survey reported capacity expansion for the uncoated freesheet paper product sector is thus lower than capacity expansion reported by API.

Age and Productivity

The age structure in the uncoated freesheet product sector is mixed. Mills producing uncoated book, excluding offset, and cover and text papers are generally old, while those producing offset papers and chemical wood pulp papers are typically young. Only a few mills, but a fairly high number of new machines, have been recently added in the sector. Productivity growth in this product sector has been very high, especially in the 1960s, and the degree of technological obsolescence is high only in those grades with an old age structure. (Discussions with DRI Pulp and Paper Service staff, August 2, 1979). Capital investment during the past five years by mills producing in this product sector totals $2,766,964,000. Investment per unit capacity equals $54,000, which is moderate compared to the industry as a whole. (308 Survey). (Note: High capital investment does not necessarily correlate with low-cost production.)

Employment

Meta Systems estimates that the uncoated freesheet product sector employed roughly 36,600 people in 1978. This represented approximately 14.6 percent of total pulp, paper, and paperboard mill employment. (Meta Systems estimates based on E.C. Jordan data.)

TISSUE

Product Sector

Definition of Product Sector

Tissue in this report includes sanitary grades (i.e., toilet, facial, napkin, toweling, sanitary napkin, diaper, wiper, and special sanitary papers) for brand name sale (or produced for store brands) in supermarkets, drugstores, etc., and sanitary grades for industrial use and waxing, wrapping, wadding, and miscellaneous grades.

Firms in Product Sector

There are 42 U.S. firms that produce tissue. The major producers are:

Scott Paper Co.
The Proctor & Gamble Co.
Kimberly-Clark Corp.
American Can Co.
Crown Zellerbach Corp.
Fort Howard Paper Co.
Georgia-Pacific Corp.
Brown Co.

Source: Meta Systems estimates based on Lockwood's, DRI estimates, and E.C. Jordan estimates.

Concentration

In 1978, the top five firms' capacity share was 65.5 percent and the top eight firms' capacity share was 80.1 percent. This is thus a concentrated product sector (Meta Systems estimates based on Lockwood's, DRI estimates, and E.C. Jordan estimates).

Total Capacity and Utilization Rate

U.S. capacity to produce tissue is 12,792 tons per day, or 6.33 percent of total U.S. paper, paperboard, and market pulp production capacity (308 Survey). In 1979, U.S. firms' capacity utilization rate was 88.3 percent (Pulp and Paper, April 1979 estimate). (This may be low due to effects of several West Coast mill strikes in 1978 and 1979.)

Vertical Integration

Most of the firms in this sector are vertically integrated (ADL, 1977 and DRI estimates). Vertically integrated here means integrated from raw materials (wood, wastepaper, etc.) to converted product. Fifty-eight mills or 64 percent of the mills in this product sector include converting operations (308 Survey).

Horizontal Integration

The 15 largest firms are horizontally integrated to other economic production sectors as indicated by the following earnings percentages:

Firm	Percent Earnings in Paper and Paperboard Sector	Publicly or Privately Owned
Scott Paper Co.	92%	Public
The Proctor & Gamble Co.	15%	Public
Kimberly-Clark Corp.	92%	Public
American Can Co.	9%	Public
Crown Zellerbach Corp.	55%	Public
Fort Howard Paper Co.	100%	Public
Georgia-Pacific Corp.	20%	Public
Brown Co.	78%	Public
Hudson Pulp & Paper Corp.	90%	Public
Diamond International Corp.	54%	Public
Erving Paper Mills	64%	Public
Marcal Paper Mills, Inc.	--	--
Potlatch Corp.	64%	Public
Nitec Paper Corp.	--	Private
Statler Tissue Co.	--	Private

Source: Paper Trade Journal, June 30, 1979, pp. 44-47.

Economic and Technological Trends

In the 1950s and 1960s, consumer tissue displaced reusable fabrics in the napkin and towel product categories. By roughly 1968 this displacement was completed. Future demand for tissue products will relate closely to factors such as consumer disposable income and household growth (since tissue displacement of reusable fabrics has subsided). Consumer tissue is, and is expected to continue to be, more recession-proof and less subject to cyclical swings in consumption levels than the pulp and paper industry, or the economy as a whole. Many consumer tissue producers rely heavily on non-price incentives to market their products, in contrast to the majority of paper and paperboard products producers whose sales of commodities are almost entirely based upon price considerations.

The only economical substitute for consumer tissue is a return to reusable cloth fabrics. A new process to produce fluffier tissue using less pulp has very recently been developed (discussions with DRI Pulp and Paper Service staff; ADL, 1977; Kline Guide).

Industrial tissue products may contain a large amount of recycled material in addition to, or as a substitute for, virgin wood pulp. Much of it is therefore produced in non-integrated secondary fiber mills. Industrial tissue demand closely follows employment patterns and consumption is based almost solely on price (rather than on non-price characteristics as in the consumer tissue sector). Demand for industrial tissue is less recession-proof than demand for consumer tissue, and fluctuates as employment and GNP fluctuate. It is likely that future industrial tissue production will shift toward large vertically integrated producers and away from the urban based smaller non-integrated producers. Though the integrated producers use more virgin fiber in their furnish, which is more costly than waste fiber, the economies of scale associated with large operations, the present relatively low cost of company-owned wood, and the ability to offer consumers higher quality products will create difficulties for the marginal, non-integrated producers. In addition, it is possible that increases in industrial tissue prices may cause some consumers to economize on consumption (discussions with DRI Pulp and Paper Service staff; DRI, Pulp and Paper Review, August 1979, pp. 67-68; ADL, 1977; Kline Guide).

Mills

Number of Mills

The 42 firms in this product sector control 89 mills which produce tissue paper. These are listed below by production subcategory:

Number of Mills	Percent of Mills in This Product Sector	Production Subcategory Name
*	*%	Market Bleached Kraft
*	*%	BCT Bleached Kraft
*	*%	Fine Bleached Kraft and Soda
*	*%	Semi-Chemical
6	7%	Papergrade Sulfite
*	*%	Unbleached Kraft (Bag)
10	11%	Misc. Integrated Mills
12	13%	Deink (Tissue)
17	19%	Tissue from Wastepaper
*	*%	Paperboard from Wastepaper
5	6%	Misc. Secondary Fiber Mills
*	*%	Nonintegrated Fine Papers
25	28%	Nonintegrated Tissue Papers

Number of Mills	Percent of Mills in This Product Sector	Production Subcategory Name
*	*%	Nonintegrated Lightweight
*	*%	Misc. Nonintegrated Mills
89	100%	

Source: 308 Survey.

Size

The average mill capacity is 285 tons per day, with a standard deviation of 353, and the median capacity is 137 tons per day (308 Survey).

Location

Tissue producing mills are located mainly in the northeast and north central sections of the United States, with a regional breakdown as follows:

Region	Number of Mills
Northeast	38 (43%)
Southeast	12 (13%)
North Central	22 (23%)
Northwest	8 (9%)
West and Southwest	9 (10%)
	89

Source: 308 Survey.

Indirect Dischargers

Twenty-seven or 30 percent of the mills in the tissue product sector are indirect dischargers. The percents of mills in each region which are indirect dischargers are as follows:

Region	% of Mills
Northeast	32
Southeast	*
North Central	27
Northwest	0
West and Southwest	78

Source: 308 Survey.

Planned Capacity Expansion

Planned daily capacity expansion in the tissue product sector is expected to be 1,141 short tons per day. This represents an expansion of capacity in 13 mills. This expansion will be an increase of 8.9 percent in the capacity to produce tissue by all mills. A capital investment of $377,552,000 is planned for this expansion. These data apply to projects which were under construction in 1978 or budgeted and approved for expenditure. (308 Survey)

Assuming 352 operating days per year as listed in the American Paper Institute (API) capacity survey, the planned daily capacity expansion reported in response to the 308 Survey equals 402,000 tons annually. Capacity expansion as reported in the API Survey from 1978 to 1982 is 751,000 tons annually (API Survey). The 308 Survey reported capacity expansion for the tissue product sector is thus lower than capacity expansion reported by API.

Age and Productivity

The age structure of consumer tissue mills is fairly young; there have recently been many new mills and machines added. The age structure of the tissue mills is old but becoming younger as large integrated companies move in; there have been several new mills and several new machines added in the 1970s. Productivity growth in this product sector is high (3 to 4 percent per year). Consumer tissue mills' technologies are modern, since this is a prime basis of competition among producers. The degree of technological obsolescence in industrial tissue mills is high; however, many old, inefficient mills are being replaced (discussions with DRI Pulp and Paper Service staff, August 2, 1979). Capital investment during the past five years by mills producing in this product sector totals $1,270,515,000. Investment per unit capacity equals $43,000, which is moderately low compared to the industry as a whole. (308 Survey) (Note: High capital investment does not necessarily correlate with low-cost production.)

Employment

Meta Systems estimates that the tissue product sector employed roughly 37,400 people in 1978. This represented approximately 15.0 percent of total pulp, paper, and paperboard mill employment. (Meta Systems estimates based on E.C. Jordan data.)

Section 4

Effluent Control Guidelines

Introduction

This section describes the basis for the various control options considered in the analysis of BAT and NSPS effluent guidelines for PCB control.

Option Descriptions

Best Available Technology Economically Achievable (BAT) Effluent Limitation

PCB control limitations are proposed for the Deink-Fine and Deink-Tissue subcatories. Two control technologies are considered. The first is the level met by best performing mills at BPT. The second is based on chemically assisted clarification in addition to Option 1, using an alum dosage of 150 mg/l. There are also monitoring costs. See Final Development Document.

New Source Performance Standards (NSPS)

PCB control limitations for NSPS are proposed for the Deink-Fine and Deink-Tissue subcategories. The first NSPS technology is that of best performing mills plus in-process controls, which equals the treatment level required by promulgated NSPS for conventional pollutants. The second NSPS technology for PCB control is chemically assisted clarification in addition to Option 1 using an alum dosage of 150 mg/l. There are also monitoring costs.

Section 5

Economic Impact Analysis

Introduction

This section presents the results of the economic analysis of the proposed regulations described in Section 4. Results for the following parts of the analysis are included:

- o Base Case Forecast: Price, output, cash flow and capacity expansion for 1985; average growth rates of output, capacity and cash flow for the period 1985-90;
- o BAT Impacts: Costs of compliance;
- o NSPS Impacts: Costs of compliance, impacts on price, output, new source capacity expansion;
- o Capital Availability: Effect of compliance costs on ability of industry to finance new investment out of current cash flow;
- o Employment and Indirect Impacts: Effects of output changes on employment, non-industry earnings, and non-industry employment;
- o Closure Impacts: Effects of closure on employment and non-industry earnings and employment; and
- o Small Business Analysis.

Because the proposed regulations affect only two subcategories, Deink (Fine paper) and Deink (Tissue) and the production of two products, Tissue and Uncoated Freesheet, falling in these two subcategories, the presentation is restricted to these subcategories and products.*

Base Case Forecast

This section presents a summary of the Base Case to provide a reference point for the results of the impact analysis given in the following sections. The Base Case describes the industry both in terms of product sectors and subcategories. Table 5-1 presents the Base Case forecasts of price, output, cash flow and capacity expansion in 1985, as well as the average growth rate of output, cash flow and capacity over the period 1985-90 and cumulative capacity expansion 1985-90. Given the assumption of long-run equilibrium which underlies the analysis, and

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*Based on the Economic 308 Survey, 95 percent of Deink-Tissue production is Tissue, and 86 percent of Deink-Fine production is Uncoated Freesheet. The other product sectors are therefore excluded from analysis.

Table 5-1. Summary of Base Case Forecast
1985-90: Product Sectors

Sector	Price (1978/$/t)	Base Case Capacity Expansion 1985 (1000 ton/y)	Output, 1985 (1000 ton)	Exponential Growth Rate of Output	Output, 1990 (1000 ton)	Cumulative Capacity Expansion (1985-90) (1000 ton/y)	Cash Flow 1985, (Mill. $ 1978)	Fraction of Capacity Classified as New Source
Uncoated Freesheet	585.0	277.0	9238	3.0%	10734	1774	1347	0.58
Tissue	964.2	52.6	4982	1.1%	5264	335	1198	0.82

Source: EPA estimates.

assuming that real costs do not change, prices in real terms remain constant over the forecast period.

The Base Case is defined as follows:

1. BAT Treatment is in place to remove and monitor pentachlorophenol, trichlorophenol and zinc.

2. NSPS Treatment is in place to remove and monitor conventional pollutants, pentachlorophenol, trichlorophenol, and zinc. This level of treatment is equivalent to NSPS Option 2, as described in the 1982 Promulgation Document.*

Capacity increases due to "greenfield" mills or major alterations of existing plants were assumed to be subject to NSPS requirements. Thus it was necessary to forecast what fraction of new capacity would be classified as a "new source."** This was done using information on installation of new machines from the American Paper Institute's (API) capacity forecasts and planned capacity increases in existing plants from the 308 Survey. The estimated share of new capacity in each product sector classified as "new source" is shown in Table 5-1. This implies cumulative new source capacity expansion over the period 1985-90 of 1.050 million tons per year and 274,500 tons per year for Uncoated Freesheet and Tissue, respectively. The estimates presented here have a great deal of uncertainty. Therefore, sensitivity analyses are given in Section 6.

Because costs of compliance are defined on the basis of subcategories rather than product sectors, and because the analysis focuses on new capacity, it is necessary to relate capacity expansion in each product sector with specific subcategories. The methodology for doing this was

Table 5-2. Summary of Base Case Forecast 1985-1990: Subcategories

Subcategory	Cumulative New Source Capacity Expansion (1985-90) (1000 ton/y)
Deink (Fine)	0.0
Deink (Tissue)	43.9

* U.S. EPA., Office of Water Regulations and Standards, "Economic Impact Analysis of Effluent Limitations and Standards for the Pulp, Paper and Paperboard Industry," October 1982, EPA 440/2-82-015.

** Capacity expansion at existing sources are often not considered new sources for the purposes of NSPS. EPA estimated the amount of new capacity which would fall under this classification.

described in Section 2. Table 5-2 shows the resulting 1985 value of new source capacity expansion.

BAT Impacts

Two approaches have been adopted in analyzing the impact of these PCB costs. First, for all mills in the two subcategories for which EPA computed treatment costs, these costs are compared with estimated mill sales. Second, profit and loss statements were developed for three mills which also had financial data available from the Economic 308 Survey to determine the effect of treatment cost on mill profitability. The results of the second approach were used as a guide to evaluating the validity of the results of the simpler first approach.

Each mill faces two types of costs. Costs for monitoring PCB's are independent of the size of the mill and are shown in Table 5-3. Total costs of monitoring for the fourteen mills in Deink (Fine) and Deink (Tissue) subcategories are $182,000 per year, as shown in Table 5-5.

Each of the fourteen mills also incurs PCB control costs. Model mill costs are shown in Table 5-4. Two options are considered: BAT Option 1 is defined as the level of best performing mills; BAT Option 2 is chemically assisted clarification. Four mills currently can meet the proposed limits for BAT Option 1 with existing pollution abatement treatment but none can meet the limits for chemically assisted clarification.

As shown in Table 5-5, total control costs for BAT Option 1 are 21.2 million dollars in capital costs and 7.0 million dollars in total annual costs. For BAT Option 2, there are 43.0 million dollars in capital costs and 18.6 million dollars in total annual costs. Including monitoring costs, total annual costs are 7.2 million dollars for BAT Option 1 and 18.8 million dollars for BAT Option 2.

Our first approach was to calculate a cost-to-sales ratio for each mill. Sales was estimated as the product of annual production and the 1985 price*. Annual production was calculated assuming 330 production days per year and by using daily production estimates available from the Technical 308 Survey. Deink-Tissue mills are assumed to produce only Tissue, and Deink-Fine mills to produce only Uncoated Freesheet. Treatment costs, expressed in 1978 dollars, were estimated by EPA for each mill.

The results of this cost-to-sales ratio analysis are summarized in Table 5-5. Defining a significant impact as one where this ratio is greater than four percent, no mills are significantly affected by Option 1, while three mills are significantly affected by Option 2. Under BAT Option 1, 10 of 14 mills have a ratio of less than two percent, while under BAT Option 2, 12 of 14 mills have a ratio greater than two percent.

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*1985 average price expressed in 1978 dollars.

Table 5-3. PCB Monitoring Costs at Direct Discharging Mills (BAT and NSPS)

Subcategory	Cost-to-Mill (1000 $/yr)	Total Cost per Unit Capacity $/ton/yr
Deink (Fine)	13	0.08
Deink (Tissue)	13	0.39

Source: EPA estimates.

Note: Costs were chosen so as to be high estimates of the likely costs. In every case, the upper limit of a range of costs are used. When a subcategory had model mills of different sizes, the smallest one was used in calculating unit cost.

Table 5-4. PCB BAT Control Costs for Direct Discharger Mills (1978-$1000) (Assuming All Mills are at BPT Final Effluent Levels and Operate Activated Sludge Systems)

Model Mill Size (t/d)	BAT Option 1*		BAT Option 2**	
	Capital	Total Annual	Capital	Total Annual
Deink-Fine Papers				
180	1422	848	3387	2522
400	2328	1424	5342	4265
800	3669	2294	7971	6836
Deink-Tissue Papers				
25	480	269	1134	740
50	685	389	1648	1112
180	1422	830	3387	2479

*Best performing mills option.

**Chemically assisted clarification.

Source: EPA estimates.

Table 5-5. Results of BAT Analysis

	BAT Option 1		BAT Option 2	
o Number of Mills w/Costs				
PCB Monitoring	14		14	
PCB Control	10		14	
	Capital	Total Annual	Capital	Total Annual
o Total Costs of Compliance (Millions of 1978 $)				
PCB Monitoring	0.00	0.182	0.00	0.182
PCB Control	21.17	6.97	43.02	18.62
Total	21.17	7.15	43.02	18.80
o Distribution of Mill Treatment Cost-to-Sales Ratio				
0-1%	7		0	
1-2%	3		2	
2-4%	4		9	
> 4%+	0		3	

Source: EPA estimates.

+Indicates significant impact.

As a measure of the validity of the approach described above, we performed a mill profitability analysis on three mills for which we also had financial data from the Economic 308 Survey. Revenues, profits and cash flow were calculated both with and without costs of compliance. Under BAT Option 1, all mills would maintain positive profits, which is consistent with the result based on cost-to-sales ratios that impacts are not large. Under BAT Option 2, impacts for two are large, causing their profits to turn negative. Only one of these had a cost-to-sales ratio greater than four percent. The difference in estimated impact for the one mill arose from the value placed upon its tissue product, which was less than one-half of the average market value used in the ratio analysis. Because total sales were estimated as the product of production and unit sales value, we overestimated total sales, and underestimated the ratio of cost-to-sales. Despite the different estimated impacts for this mill, in general the results of impact calculation using the two different approaches agree favorably. The conclusion is that the simpler cost method using the ratio of cost-to-sales as a measure of impact is reasonable.

NSPS Impacts

Costs of Compliance

Table 5-6 shows costs of PCB control for model mills. Total annual costs are calculated as the sum of total capital cost times the capital recovery factor of 0.22 and variable costs. Unit costs, as shown in Table 5-6, are calculated assuming 330 production days per year. No added costs of compliance are associated with NSPS Option 1, which is equal to the promulgated NSPS for conventional pollutants. Costs for NSPS Option 2 are based on tertiary chemical clarification. For the Deink (Fine) subcategory unit total annual cost of compliance is 15.1 dollars per ton. For the Deink (Tissue) subcategory, unit total annual cost is 30.7 dollars per ton. These unit costs are used in calculating the price change in the demand/supply analysis.

Demand/Supply Analysis, Total Cost of Compliance

This section presents the results of the demand/supply analysis together with total costs of compliance for NSPS regulations. Because there is no expected capacity expansion in the Deink (Fine)* subcategory, the discussion is limited to Deink (Tissue) subcategory and its related product sector, Tissue. Table 5-7 shows unit cost of compliance, price, production and new source capacity changes from the Base Case. We have assumed that all reduction in output is borne by new source capacity. The average compliance cost per ton of capacity for the tissue sector is based on the mix of subcategories contributing to new source capacity shown in Table 2-2 and the unit costs shown in Table 5-6. Table 5-8 shows 1990 new

Table 5-6. NSPS Costs of Compliance for Model Mills

Subcategory	Size of Model Mill (t/d)	Capital Cost (1000$)	Annual Costs (1000$/yr) O&M	Energy	Total Annual	Unit Cost ($/t) Capital	Total Annual
Option 1:							
Deink (Fine)	500	0	0	0	0	0.0	0.0
Deink (Tissue)	100	0	0	0	0	0.0	0.0
Option 2:							
Deink (Fine)	500	5,604	1,194	73	2,499	33.9	15.1
Deink (Tissue)	100	2,402	464	22	1,013	72.8	30.7

Source: EPA estimates.

All costs in 1978 dollars.

source capacity based on product sector shares and unit and total costs of compliance for the two Deink subcategories.

Table 5-7 shows that there are no impacts on price, output and capacity due to NSPS Option 1. In NSPS Option 2, as price is expected to rise 0.5 percent, output is expected to fall 0.02 percent in response to the added costs of PCB control in the Tissue sector. Cumulative new source capacity in 1985-90 is estimated to drop .42 percent or 1,160 tons per year to 273,350 tons per year in the Tissue product sector. Comparing Table 5-8 with Table 5-2, new source capacity in the Deink (Tissue) subcategory is estimated to decline 2.8 percent due to NSPS controls.

Capital Availability Analysis

This subsection presents the results of the capital availability analysis for the two product sectors which will be affected by the proposed regulations. Table 5-9 shows the demands on cash flow due to capital costs of expansion (based on total Base Case capacity expansion in 1985 and unit capital costs of capacity expansion) and one-year compliance costs** due to BAT Options 1 and 2 and NSPS Options 1 and 2, and total Base Case cash flow.

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*See Table 5-2.

** For BAT, one year compliance cost is total capital cost plus total annual operating costs. For NSPS, one year compliance cost is the product of new source capacity in 1985 and unit capital cost plus unit annual operating cost. (See Table 5-7 for unit costs.)

Table 5-7. Total Costs of Compliance, Price and Output Impacts Due to NSPS: Product Sectors

Product Sector	Unit Costs ($/ton) Capital	Unit Costs ($/ton) Total Annual	Price ($/ton)	Percent Change	Reduction in Output 1990 (1000 t)	Percent Change	Cumulative New Source Capacity Expansion (1985-90) (1000t/y)	Percent Change	Total Costs of Compliance (Million $) Capital	Total Costs of Compliance (Million $) Total Annual
Option 1:										
Uncoated Freesheet	0.0	0.0	585.0	0.0	0.0	0.0	1050	0.0	0.0	0.0
Tissue	0.0	0.0	964.2	0.0	0.0	0.0	274.5	0.0	0.0	0.0
Option 2:										
Uncoated Freesheet	0.0	0.0	585.0	0.0	0.0	0.0	1050	0.0	0.0	0.0
Tissue	11.6	4.9	969.1	0.5	1.16	-0.02	273.35	-0.42	3.18	1.34

Source: EPA estimates.

All costs in 1978 dollars.

Table 5-8. NSPS Costs of Compliance by Subcategory

Subcategory	Cumulative New Source Capacity Expansion (1985-90) (1000t/y)	Unit Costs ($/ton) Capital	Unit Costs ($/ton) Total Annual	Total Costs of Compliance 1985-90 (Million $ 1978) Capital	Total Costs of Compliance 1985-90 (Million $ 1978) Total Annual
Option 1:					
Deink (Fine)	0.0	0.0	0.0	0.0	0.0
Deink (Tissue)	43.9	0.0	0.0	0.0	0.0
Option 2:					
Deink (Fine)	0.0	33.9	15.1	0.0	0.0
Deink (Tissue)	42.7*	72.8	30.7	3.18	1.34

*Calculated as the product of NSPS capacity (See Table 5-7), and the fraction of new source Tissue capacity which is within the Deink (Tissue) subcategory (0.16).

Source: EPA estimates.

Table 5-9 presents the cash flow estimate together with the two major demands on cash flow: funds for capacity expansion and for compliance costs. In a worst case capital squeeze situation, the industry would have to meet both needs out of its own cash flow. The results can be taken to represent a worst case, since the effect of price increases on revenues and hence cash flow is not taken into account. (Demand for most product sectors is inelastic, so an increase in price raises revenues.)

It is evident from Table 5-9 that one year compliance costs are a small fraction of total cash flow. For Uncoated Freesheet, total one year compliance costs, using BAT Option 2 and NSPS Option 2, are 0.8 percent of cash flow; for Tissue the figure is higher, 4 percent, but still insignificant. If BAT Option 1 is selected the percentages are still smaller. The difference between NSPS Option 1 and 2 does not affect the results either. Therefore, costs of compliance do not appear to be a major problem for these sectors of the industry even under the most pessimistic assumptions about cash flow and compliance costs.

Table 5-9. Capital Availability Analysis
Demands on Cash Flow and Total Cash Flow, 1985

Product	Capacity Expansion (1000 t/y	Unit Capacity Costs of Expansion ($/t)	Millions of 1978 $ Total Capital Costs of Expansion	One-Year Compliance Costs* BAT Option 1	BAT Option 2	NSPS Option 1	NSPS** Option 2	Total Cash Flow
Uncoated Freesheet	277	930	258.0	7.1	11.7	0.00	0.00	1356.6
Tissue	52.6	1402	73.8	16.6	40.7	0.00	0.60	1197.7

All costs in 1978 dollars.

Source: EPA estimates.

*Defined as capital costs plus one year's O&M costs.

**Based on 1985 new source capacity expansion of Deink-Fine capacity of 54,900 t/y (.82)(.15)(1-.028) = 6,600 t/y.

Employment and Indirect Impacts

Impacts Due to Output Changes

The results of the direct employment, indirect earnings and indirect employment impact analyses are derived from the sales value of lost output, which is approximated by the product of 1990 lost output and the average Base Case price for the Tissue sector, 964 dollars per ton.

The following ratios were used to estimate these impacts:

1. direct employment--$103,000/per employee;
2. indirect earnings to sales ratio--0.40;and
3. indirect earnings per employee--$20,000.

No impacts result from NSPS Option 1. For NSPS Option 2, lost output in 1990 is 1,160 tons, which has a sales value of 1.12 million dollars. Direct employment loss is therefore, 11 jobs. Indirect earnings losses are estimated to be 0.45 million dollars which would involve an indirect employment loss of 22 jobs.

Impacts Due to Closure

Using a definition of possible closure of a cost-to-sales ratio greater than four percent, no closures are expected to result from BAT Option 1 and three closures will result under BAT Option 2 (see Table 5-5). Revenues for these three plants were calculated as the product of annual production and the average sales value. Total revenue lost due to closure of these three mills is estimated to be 41.3 million dollars. Using the ratios cited in the "Employment and Indirect Impacts" section, this loss in revenue implies a direct loss of 402 jobs. The indirect earnings loss is 16.6 million dollars. The indirect employment loss is 792 jobs.

Small Business Analysis

Small mills are defined for this analysis as those having annual product value of $10 million or less. Using this criterion, only one out of the fourteen Deink-Fine and Deink-Tissue mills which incur BAT costs for PCB control is classified as a small mill. Because the cost-to-sales ratio is greater than four percent under BAT Option 2, it is predicted to close under that option. Three of the remaining thirteen mills are also projected to close under Option 2. It is unclear whether this option has a greater impact on small mills as only one mill is classified as small.

For BAT Option 1, the selected option, no significant impacts are expected for the one mill classified as small.

Section 6

Limits of the Analysis

This section discusses the major limitations of the assumptions, methodology and results of the analysis. It also presents the results of a number of sensitivity analyses which test the robustness of the results of Section 5. It is organized into parts which parallel those of the methodology and results sections (2 and 5, respectively), i.e., Base Case projections including demand equations and construction of supply curves; costs of compliance; demand/supply analysis; total costs of compliance; mill-level impacts and closure; capital availability; and employment and indirect impacts.

Base Case Projections

Demand Forecast

The demand forecast has two major components, growth of end-use demand and price elasticity of demand. The DRI macroeconomic forecast drives the end-use demand sector growth which determines the product sector growth rates used in the analysis. The growth rate does not affect the Base Case price level, since the analysis assumes that demand and supply grow at the same rate regardless of what the rate is. The growth rate does affect the speed at which new source capacity grows, and hence also the rate of growth of costs of compliance.

The estimate of price elasticity does not affect the constant long-run price or the rate of growth of output as long as the market remains in equilibrium. It does affect the response of demand to a cost change, and hence the extent of the effect of NSPS costs on the loss of output in a given sector. The elasticity estimates are subject to both random and model specification errors. The effects of the price elasticity estimates fall mainly on the capacity expansion forecasts, because these correspond to the loss in output resulting from the price increase.

Supply Curves

The supply curves used in the analysis are quite simple, reflecting assumed constant long-run unit costs of capacity expansion equal to the 1985 Base Case price for each product sector. The assumption about the level of costs is not crucial since we are concerned mainly with the incremental cost of the proposed regulations. Use of the long-run supply curve does ignore short-run adjustments, but these are less important given the focus on new source costs. The assumption of constant real costs over the forecast period is more reasonable than it seemed a few years ago, due to the leveling off of fuel prices.

Costs of Compliance

Pollution control costs were developed by EPA. Costs were developed from "model" mills and hence will only approximate actual costs borne by individual mills. However, they should provide reasonable estimates of overall compliance costs in a given subcategory or product sector.

In calculating total annual costs, a single cost of capital was used for all mills. However, total annual costs are not overly sensitive to variations in the cost of capital. For example, capital costs for most subcategories tend to be about nine times operating and maintenance plus energy costs. Using a CRF of .22 implies capital costs are about three times total annual cost. Therefore, using a value for the CRF 10 percent higher or lower causes total annual costs to be seven percent higher or lower.

Like variable production costs, variable pollution control costs are not escalated from real 1978 levels. Therefore total annual pollution costs are underestimated. Price impacts would be underestimated by a similar magnitude, but the impacts in percentage terms will be less affected. Also, real cost increases may be much less than previously predicted, due to the leveling off of fuel prices. Pollution control costs of new mills may be overestimated if they are able to reduce costs by making changes in design or production processes prior to construction. However, it is quite reasonable to make the conservative assumption of excluding them.

Demand/Supply Analysis

The demand/supply model can be characterized as one of competitive long-run equilibrium. In a long-run equilibrium growth path, price is determined by long-run average total cost. This adjustment is assumed to take place instantly on the supply side, although demand takes a few years to adjust completely. One issue is whether the industry behaves in a long-run competitive manner by fully passing through the treatment cost increase. The problem of how to describe imperfectly competitive markets has vexed economic theory for a long time. It is not possible to predict the outcome of price and output in an oligopolistic market. No single "noncompetitive" model could be used to forecast impacts of treatment requirements on price and output. Assuming long-run full cost pass-through is probably a reasonable approximation.

In this analysis a capital recovery factor of 0.22 was used to estimate total annual costs of NSPS. In order to examine the sensitivity of the analysis to this assumption, two sets of alternate costs for Option 2 were generated, using values of 0.27 and 0.17 for the CRF. These costs were then used as inputs to the model to solve for price and output changes for each of the product sectors. These different scenarios were each compared to the 1985 base case. Table 6-1 summarizes the results of this sensitivity analysis.

Table 6-1. Price and Output Changes in the Tissue Product Sector from the Base Case With Different Values for the Capital Recovery Factor: NSPS Option 2

	Capital Recovery Factor		
	0.22	0.27	0.17
Price Change			
$/ton	5.00	6.80	3.00
percent	0.52	0.71	0.31
Change in Output (1990)			
1000 tons	-1.16	-1.60	-0.72
percent	-0.02	-0.03	-0.01

Using a CRF of 0.22, total Tissue output is estimated to decline by 0.02 percent in 1990 relative to the Base Case, and average price is estimated to rise by 5.00 dollars per ton product, or 0.52 percent. Using a CRF of 0.27, total output will decline by 0.03 percent if price rise 6.80 dollars per ton, or 0.71 percent. If a CRF of 0.17 is applied, total output is predicted to decline by 0.01 percent if prices rise an average of 3.00 dollars per ton, or 0.31 percent. Because these impacts are consistently small, the analysis is not particularly sensitive to the estimate of the capital recovery factor.

Total Costs of Compliance

Estimates of total costs of compliance due to NSPS depend on the estimates of capacity expansion, the share of new capacity classified as direct discharging, the share of new capacity classified as "new source," and the mix of subcategories assumed. On the other hand, eventually most new capacity will be subject to NSPS. Therefore use of a constant share of NSPS capacity over time is probably inadequate.

Table 6-2 shows the effect of two other assumptions concerning new source capacity. In the first case, it is assumed that there is no decline in new source capacity expansion due to NSPS costs. In the second case, it is assumed that the share of new source capacity among all capacity expansion is 41 percent for Tissue, one-half the original value. Total costs of compliance are the product of new source capacity and unit costs of compliance. The first alternate assumption has almost no effect on estimated total costs of compliance. This is due to the fact that little new source capacity was lost in the original scenario because there was only a very small change in output, 0.02 percent. Results using the second alternative assumption are quite different from the original scenario. If the new source fraction of total capacity expansion is cut in half, estimated total

Table 6-2: Effect of Alternate Assumptions About the Share of New Source Capacity Expansion on Costs of Compliance: Tissue Product Sector NSPS Option 2 (1978 Dollars)*

Scenario	Cumulative New Source Capacity Expansion (1985-90) (1000 ton/yr)	Costs of Compliance (Millions 1978$) Capital	Total Annual
1. Result Using Base Assumption (New Source Fraction of Capacity Expansion = .82)	273.35	3.18	1.34
2. No Decline in New Source Capacity Expansion	274.51	3.20	1.35
3. New Source Fraction of Capacity Expansion = .41	134.89	1.57	0.66

*Cost calculated using unit costs from Table 5-7.

capital costs and total annual costs are reduced by 50 percent as well. Therefore the value of the new source fraction does have a significant effect on this portion of the analysis.

Mill-Level Impacts and Closure Analysis

Mills with significant impacts were identified using the criterion of a cost-to-sales ratio of greater than four percent. This criterion does not take mill-specific financial conditions into account, and is not based on more general average levels of profitability in the industry. The results of the financial analysis of the three mills with Economic 308 Survey data available were consistent with the four percent criterion in all cases for Option 1, and in two out of three cases for Option 2. If the cutoff criterion were two percent rather than four percent, four mills would have significant impacts under BAT Option 1, and nine mills would have significant impacts under BAT Option 2, a much more severe impact. See Table 5-5. However, those results would not be consistent with the financial analysis for the three mills.

Capital Availability

The comparison of cash flow and capital requirements depends on the sector-specific estimates of cash flow, the forecast of capacity expansion in each subcategory, including the mix of existing and new sources, costs of compliance, and the capital costs of new capacity. The cash flow estimates are based on revenues and costs taken from the demand/supply analysis. Revenues are the product of total output and price. Variable costs are the integral under the supply curve. However, in sectors with a variety of different grades, the price used may not have been the sector-wide average price, so revenues may be under- or over-estimated. Unfortunately, other information on cash flow broken down by product sector is not available. Revenue estimates would also be affected by using a different macroeconomic forecast for the base case. However, it is unlikely that these changes would significantly affect the overall financial evaluation of the industry, although the evaluations for individual sectors might change, since compliance costs are such a small fraction of total cash flow.

There is considerable uncertainty about the base costs of new capacity. Since costs of capacity expansion in a single year are larger than total costs of compliance in any of the treatment options, these estimates have an important effect on the overall financial picture of the industry, although they do not affect the estimate of the incremental effect of NSPS regulations.

Employment and Indirect Impacts

Employment. The employment to sales ratios derived are quite crude. They probably overestimate employment impacts because they are based on existing rather than new mills.

Indirect Earnings and Employment Effects. The estimates of indirect earnings and employment impacts rest on a very simple input/output framework. The approach tends to overestimate impacts because it does not take into account that the reduction in earnings and jobs in particular product sectors will be at least partially offset by increased growth due to higher investment elsewhere.

Appendix A

Capital Recovery Factor

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

The formula for CRF used in previous analyses was:

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

where:

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

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

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

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

where:

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

Other variables as above.

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

Average Cost of Capital

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

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

where:

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

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

Cost of Debt. Since firms often have more than one debt issue, it is necessary to calculate an average cost within a company as well as across companies. The following information on the debts of 27 pulp and paper companies was obtained from Standard and Poor's Bond Guide (January 1980).**

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

First, the total market value of each bond issue is calculated as the bond price multiplied by the amount of debt outstanding. Second, the average cost of debt is calculated as a weighted average of the various values for yield to maturity, where the weights equal the ratio of the market value of each bond issue to the total value of debt. The average before-tax cost of debt for these companies is 11.03 percent.

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

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

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

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

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

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

This information was collected for both preferred and common stocks. An estimate of the expected growth rate was obtained using data on production levels for the years 1979-1980 from the DRI model. The annual compound rate of growth for total paper and paperboard production was calculated to be 3.5 percent. Since this is an estimate of production, not sales or income, an inflation factor must be added in. Based on the DRI inflation projections for 1980-1990, an annual compound rate of inflation of 7.5 percent was calculated. Thus, the expected growth rate of dividends (g in the above formula) is 3.5 + 7.5 = 11.0 percent. (This assumes that real prices remain unchanged.)

Separate costs of capital were calculated for common stock and preferred stock. The yield to maturity on the common stock of 53 forest product companies is 5.2 percent, which yields a cost of equity of:

5.2 + 11.0 = 16.3

This is more accurately described as the cost of retained earnings. The cost of new issues of common stock is higher than the cost of retained earnings because of the flotation costs involved in selling new common stock. Since new issues are a very small proportion of a firm's capital, they are not included in our calculation of the overall weighted cost of capital.

Preferred stock is a hybrid between debt and common stock. Like debt, it carries a commitment on the part of the corporation to make periodic fixed payments. Thus, the cost of capital is equal to:

$$r = \frac{e}{P} \qquad \text{(A-5)}$$

without an estimate of the expected growth rate of dividends.

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

Depreciation

Depreciation is normally defined as the fraction of revenues set aside each year to cover the loss in value of the capital stock. Due to recent changes in the federal tax code, the economic life of a capital item is now considerably longer than the depreciation life for tax purposes. Based on earlier work the lifetime of capital stock for this industry is assumed to be about 10 years.* The depreciation rate for most personal property now is straight-line over five years (20 percent). These values are used in the revised calculation of the capital recovery factor.

Tax Rate

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

Sensitivity Analysis

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

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

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

Table A-1

Alternative Derivations of the Capital Recovery Factor

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

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

The weighted cost of capital is estimated based on the current costs as reflected in the current prices and yields of a sample of corporate stocks and bonds for that industry. In January of 1980, the weighted cost of capital for the pulp and paper industry was estimated to be about 12 percent. There are two major assumptions in using this method. First that current prices and yields accurately reflect future costs of capital. However, interest rates have increased significantly since the summer of 1979. Second, that the current portfolio mix will remain constant over the next several years. Given changes in tax codes, and changes in the availability of certain sources of capital such as industrial revenue bonds, this is unlikely. Therefore the cost of capital is expected to be higher than 12 percent. Given the mix of financing sources available, the weighted cost of capital for the period covered by this study is assumed to be close to 15 percent.

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

Appendix B

The 308 Survey

The economic analysis of various pollution control options is based in large part on information collected through a questionnaire issued by EPA under authority of section 308 of the Clean Water Act (the 308 Survey). This questionnaire was sent to approximately 700 mills in the pulp, paper and paperboard industry. A total of 633 responses to the 308 questionnaire, representing 648 mills, were included in the analysis. A follow-up on the non-responding mills showed that in most cases these mills were closed at the time of the survey, or were not producers of pulp, paper or paperboard.

Purpose of the Survey

The survey was designed to provide information on mill characteristics, production costs, investment in new capital, and market structure. Of primary concern was information on production costs. At the time of the survey there was only one public source which contained consistent and detailed manufacturing cost information organized in a way directly useful to an impact study.* These costs were for representative new facilities typical of good technical practice in 1974, however, and a host of assumptions would have to be made to translate them into a form which would allow us to construct marginal cost curves for industry product sectors. To develop new manufacturing cost functions and to verify or modify the assumptions made to translate the cost functions into cost curves for the sectors, information for individual mills was needed on the relationship between costs and capacity, capacity utilization, production processes and products, and age of capital.

To determine impacts it is essential to consider questions of demand. The DRI Forest Products model provided the capability to estimate demand on a product-by-product basis. However, we wanted to be able to test the assumptions of this model against information obtained from individual firms concerning the markets for their products. In addition, the demand analysis projects capacity expansion on the basis of announced plans for expansion and specified investment behavior. To assess the forecasts we needed information on individual mills' plans for expansion.

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*Economic Impacts of Pulp and Paper Industry Compliance with Environmental Regulations, Report for Office of Planning and Evaluation, U.S. Environmental Protection Agency, Arthur D. Little, Inc., May 1977.

Questionnaire

The questionnaire contained 24 questions, and was organized into five parts:

- Identification: Name and address of mill and (if different) name and address of parent company; name, address and telephone of individual responsible for completing the questionnaire.
- Capacity: Mill capacity in various grades of pulp, paper, and/or paperboard.
- Economic Information: Assets and capital investment, revenue, expenses, quantities sold and transferred, and annual production and inventory change information for two fiscal years.
- Annual Operating Costs and Capital and Operating Costs arising from Federal Regulations: Fiber, chemicals, labor and energy costs in the most recent fiscal year; and estimates of capital and operating costs for air and water pollution control and OSHA compliance.
- Future Plans: Planned capital expenditures on air and water pollution control and capacity expansion by product or process; plans to curtail operations; and if applicable, user charges of POTW's.

Confidentiality

Two procedures were employed to protect the confidentiality of the data. Those mills which sent their responses directly to EPA were protected by the procedures specified in Article XXI, Parts A to F of contract No. 68-01-4675. These included EPA removing the Identification Section from each questionnaire and assigning a code number with region and subcategory identifiers to each questionnaire before they were forwarded to Meta Systems for processing.

Those mills which did not respond directly to EPA sent their completed questionnaire to a third party (Arthur Andersen & Co.) whom they had hired to hold the data and protect its confidentiality. Both sets of data (mills responding directly to EPA and mills responding to Arthur Andersen & Co.) were stored on Arthur Andersen's computer, and Arthur Andersen personnel monitored the use of the data to prevent the exposure of 308 Survey data on an individual mill.

Limitations of Survey

As noted above, the response rate to this 308 Survey was excellent, and for the most part the quality of the data appears quite good. However, there are a few problems with the questionnaire and/or the responses. In the case of the question dealing with annual operating costs, it is unclear what the mills included in "other costs." It was assumed that these costs included the operating costs necessitated by current pollution control regulations, although this may not always be the case.

A couple of problems arose with responses by indirect dischargers. Due to the wording of the question, the flow level and user charge information is ambiguous. Also, final determination of whether a mill was an indirect or direct discharger was left to the technical contractor.

In some cases, a mill's reported production and capacity levels were inconsistent. Various stages of the analysis required one or the other level. Since it was not possible to determine which was correct, the production and capacity data were used as they appeared on the mill's response.

Appendix C

Demand/Supply Methodology

Overview

The core of the approach to estimating the impact of BCPCT and BATEA regulations on the industry is a microeconomic demand/supply analysis for each market (product) sector of the industry. The analysis produces a base case forecast of price, output, "contribution to capital" (revenues less variable costs) and capacity utilization for each product sector in the absence of new regulations. It also forecasts the effects of the costs of various treatment requirements on those variables. The approach assumes that individual product markets are competitive and that prices depend on the variable costs of the marginal (high cost) mills in the various sectors. Market or product sectors rather than subcategories are utilized because the relevant set of competing products depends on product type, not manufacturing process. The organization of the industry into product sectors corresponds closely to product groups used by API.

For each sector, supply curves are constructed from manufacturing cost and production data collected in the 308 Survey and pollution control cost estimates provided by the technical contractor. The supply curves explicitly relate mill subcategories, the basis for defining treatment costs, with product sectors, where the interaction of demand and supply takes place. Supply curves are generated for a base case with no additional pollution control requirements and for each of several control options. The supply curves for different years are adjusted to account for forecasts of capacity expansion through 1985.

The demand for each product sector is modeled using demand equations estimated by Data Resources, Inc. and linked with DRI's macroeconomic forecasts over the period of the analysis, 1979-85. This provides a demand forecast to match the capacity expansion forecasts on the supply side.

The interaction between supply and demand is modeled by solving the system of supply and demand equations for each product sector for equilibrium values of price, output, "contribution to capital" and capacity utilization for each year of the forecast period.

Figure C-1 shows the information flows and stages of analysis which form the demand/supply analysis.

Figure C-2 presents a more analytical picture of the relationship of the various elements of the analysis, and suggests some important implications of the methodology adopted. Quantity produced is measured along the horizontal axis and price and unit cost along the vertical axis. The base case assumes no new treatment requirements. Given demand curve DD and supply curve SS, market equilibrium implies price = P and output = Q. The excess of revenues over variable costs ("contribution to capital") is given by area CEP.

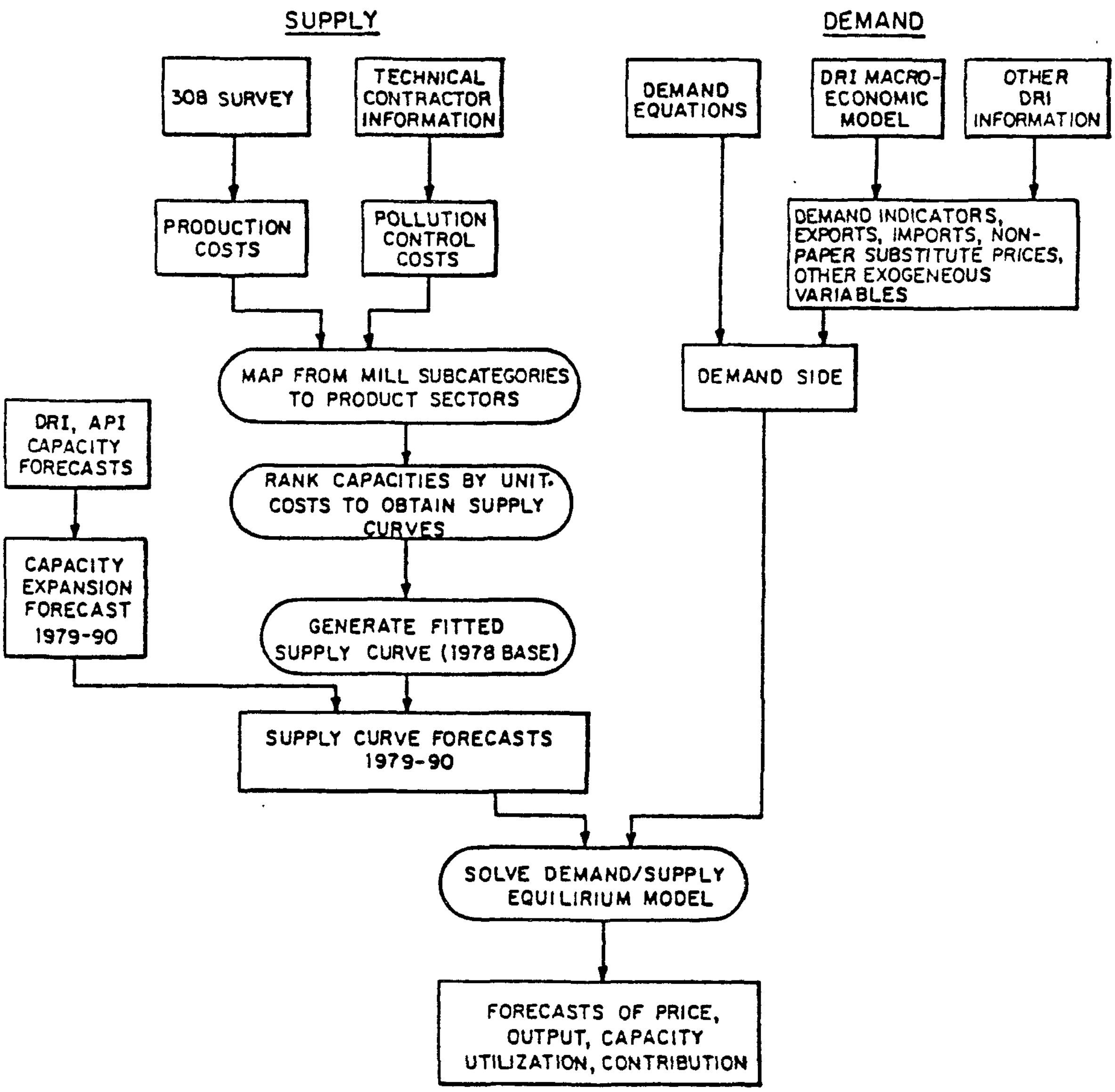
Let S'S' represent the industry supply curve with treatment costs. This yields a new equilibrium with price = P', quantity = Q' and contribution to capital = C'E'P'. A number of elementary but important observations flow from this analysis. First, as long as demand and supply are somewhat elastic, price will rise and output will fall. If supply is not perfectly elastic (i.e., if SS and S'S' are not horizontal) the price increase will be less than the cost increase for the original marginal producer (i.e., PP'<FE). Contribution to capital will either increase or decrease depending on the elasticity of supply and demand and the relative treatment costs of marginal and inframarginal producers. Also the imposition of controls will alter the relative profitability of mills in the industry depending on the size of the gap between SS and S'S' at various levels of output.

The resulting price and cost changes are inputs to the individual mill closure analysis and subsequent employment and community impact analyses. Price and contribution to capital also are used in the capital availability analysis. All of these factors highlight the advantage of being able to determine the effect of treatment costs on the entire supply curve, not just at the margin. Changes in cost and price are also inputs to the balance of trade analysis.

<u>Development of Supply Curves</u>

The demand/supply methodology assumes an essentially competitive short-run market structure where price is determined by marginal variable cost. In this case the product sector supply curve is the marginal cost curve obtained by horizontally summing the marginal cost curves of individual mills. By definition, the marginal cost curve shows the incremental cost of an increase in output. In general, marginal cost and average cost for an individual mill will vary with output, as shown in Figure C-3. However, if marginal variable costs of a mill are constant over a fairly wide range of capacity utilization, they will be roughly equal to average variable costs. Therefore, data for average variable costs from the 308 Survey are taken as an approximation of that mill's marginal variable costs. Figure C-4 shows the supply curve implied by this approximation.

FIGURE C-1. Demand/Supply Analysis



NOTE: RECTANGULAR BOXES DENOTE INFORMATION FLOWS.
OVAL BOXES DENOTE UNITS OF ANALYSIS.

FIGURE C-2. Shift in Supply Curve Due to Treatment Costs

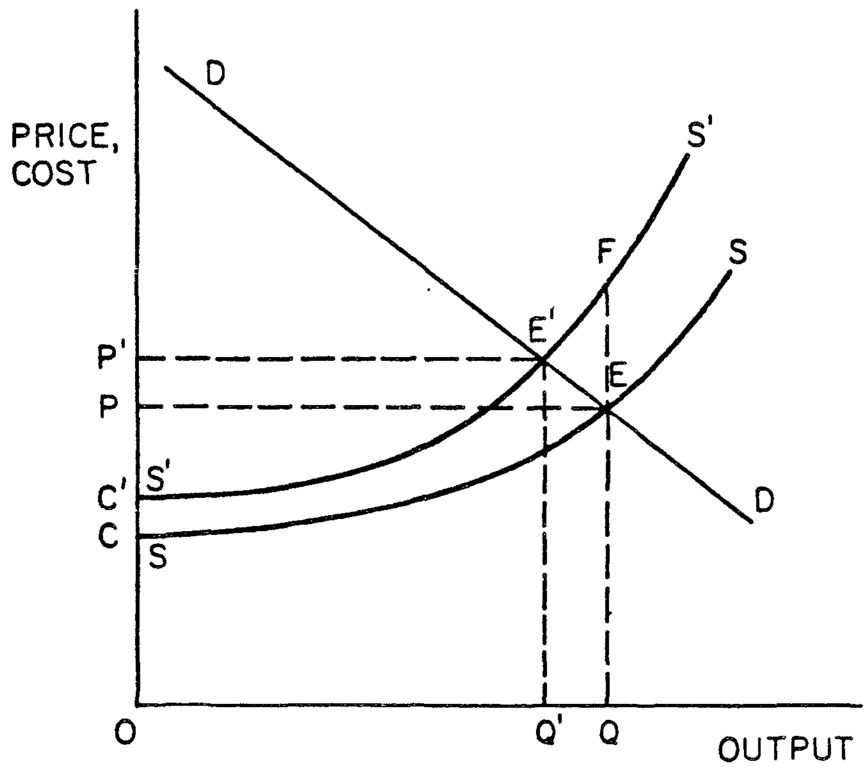


FIGURE C-3. Example of Marginal Cost and Average Cost Curves

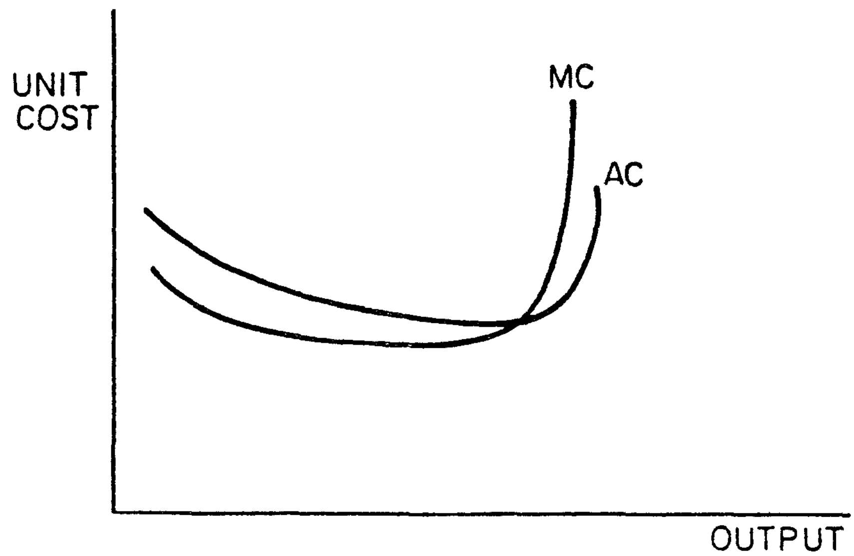
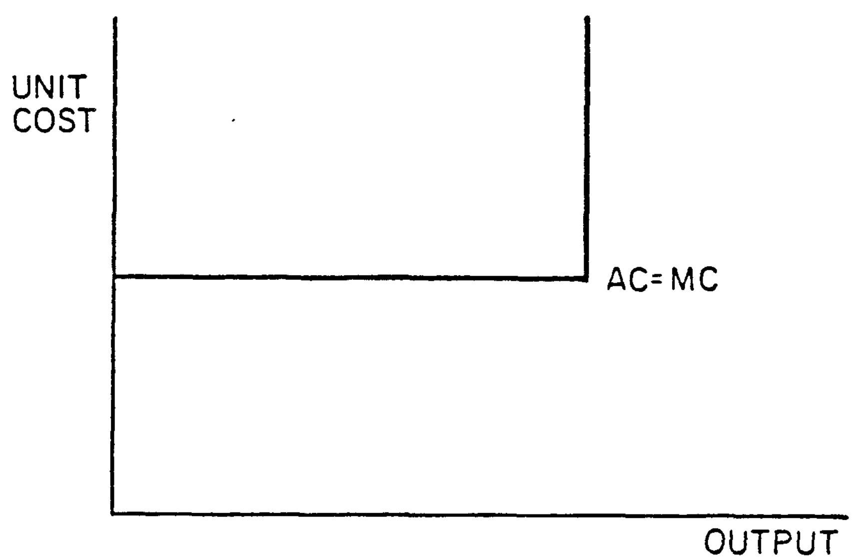


FIGURE C-4. Example Where Marginal Cost Equals Average Cost



An estimate of the supply curve for the entire sector can be obtained by ranking all mills manufacturing a given product in terms of unit cost, and then pairing the unit cost of a given mill with the cumulative production of all mills with unit costs less than or equal to that mill's. This is the procedure followed in this study. Although the curve so obtained strictly equals the industry supply curve only under the assumptions of perfect competition and constant marginal cost for each mill, we believe that it represents a good approximation even if these assumptions are relaxed somewhat. The following example illustrates the curve construction procedure.

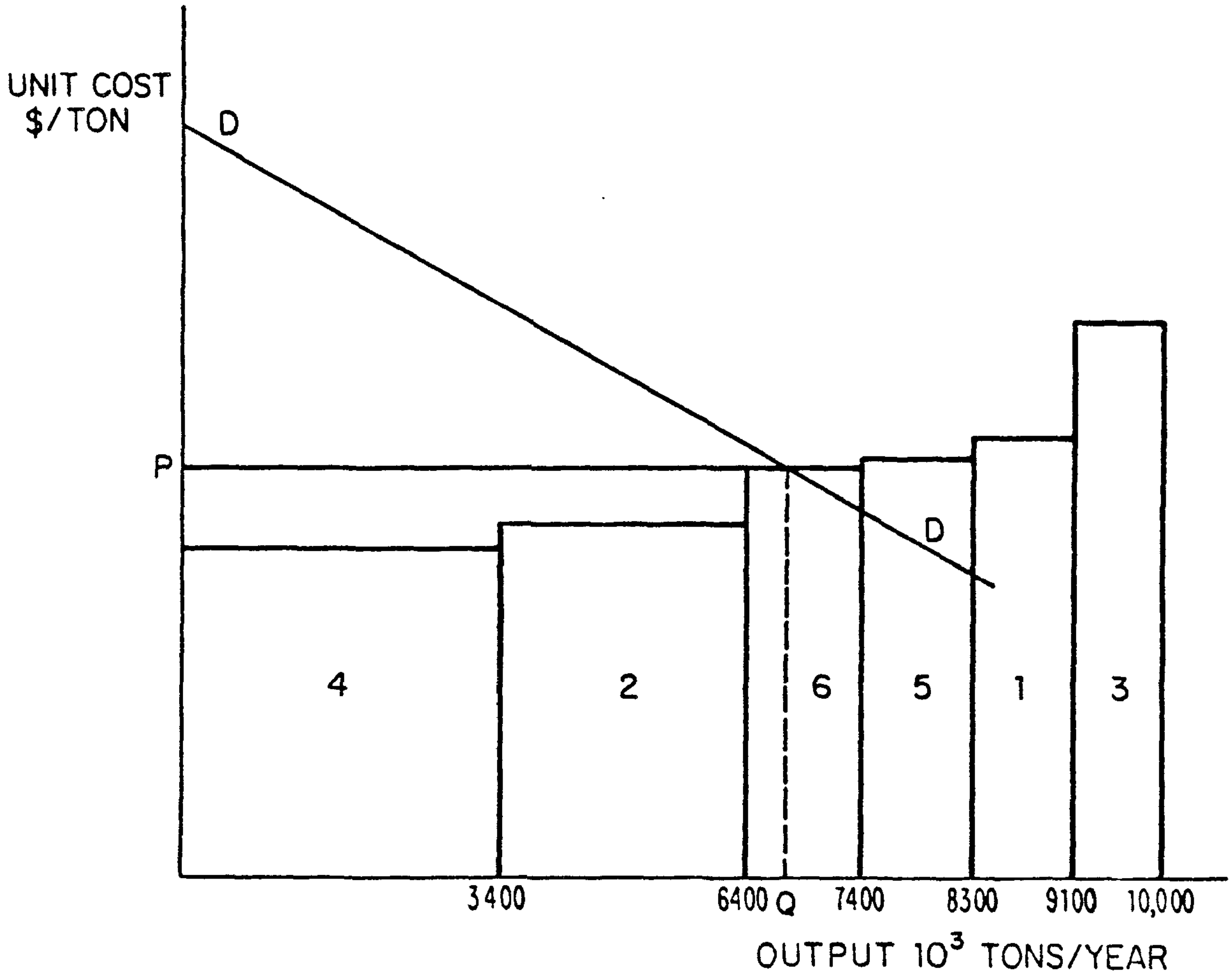
Example. Suppose the individual mill data for a given product sector are as follows:

Mill	Production cost, $/ton	Output, 1000s tons/year
1	210	800
2	180	3000
3	260	900
4	175	3400
5	205	900
6	200	1000
		(total = 10,000)

Mill #4, being the lowest-cost producer, forms the first step on the curve with unit cost = 175, production = 3400. Mill #2 is the next lowest cost producer; its incremental output adds 3000 to the accumulated production, with a unit cost of 180. The rest of the curve is constructed similarly, until all production is accounted for, with the highest cost producer being the point (260;10,000). This process results in a step function like that shown in Figure C-5. The length of each step is the production of that one mill, and the height of the step is that mill's unit cost.

In practice, the approach proceeds roughly as outlined above; with a supply curve constructed for each product sector. First, all of the mills that produce a given product, say Newsprint, are selected from the 308 Survey data base. Next, unit variable manufacturing cost is determined by summing the questionnaire responses for the individual cost components for that product: wood and pulp, chemicals, labor, energy, and other, and then dividing by the mill's output of that product. This is the basic step of the transformation of costs from subcategory to product sector.

FIGURE C-5. An Example of a Constructed Supply Curve



The structure of the supply curve has some implausible implications. Suppose the intersection of the demand curve (DD) and the supply curve yields price P and quantity Q as in Figure C-5. The figure implies that all mills with unit costs below that of mill 6 operate at full capacity, while mill 6 absorbs all the slack, and mills with higher costs do not operate at all, which is not realistic.* Nevertheless, the use of average costs gives a picture of the cost structure within a given product sector. Since high cost mills have the greatest variability of output, this should give a reasonable approximation of the shape of the supply curve.

Another limitation of the procedure is that it assumes that demand and supply in the entire product sector is cleared by a single price. In many markets, especially papers, there is a significant variation in quality and characteristics among subgrades, and prices will vary correspondingly. Therefore, producers that appear to have high costs may produce higher quality products with higher prices. Using a single price could distort the relative profitability of different mills. There is less harm on the demand side because prices of similar grades can be expected to move together.

Standardizing Costs. All costs are adjusted to first quarter 1978 dollars to agree with the pollution control costs provided by the technical contractor. To do this, all cost data from 308 responses must be inflated/deflated to correspond to this fixed base. The ends of the accounting base years in the 308 responses vary from January 1976 to December 1978. To adjust these costs, approximate deflators of two sorts were developed. The first type are deflators directly applicable to specific products, as obtained from DRI time series for average operating costs for these products. For products where no such direct deflators were available, estimates of cost changes for each input were developed, covering wood, pulp, and secondary fiber, labor, chemicals, and energy. Separate regional cost factors were also developed for each input. In both cases, the time period selected for adjustment was based on the midpoint of the year-long accounting period as reported by the mill.

No further adjustments were made to Survey costs to account for real (constant price) input cost increases between 1978 and 1983-85, the period of the analysis. Although forecasts of costs of the various input categories are available, it was felt that using these forecasts directly would overstate the cost increases because of process changes mills would make in response to higher costs. Nevertheless, it is expected that real production costs will increase 5 to 15 percent over this period.**

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*In the analysis, reported production was used as a proxy for capacity to construct the supply curves, since production costs were only available for that amount. This tends to understate capacity somewhat. However, this is compensated for in the calibration of the supply curves described below.

**DRI Pulp and Paper Review, June, 1980, passim.

Functional Form of the Supply Curve. Both for reasons of confidentiality and because of the cumbersome form of the step functions derived by the above procedure, the calculated values of unit costs and cumulative production are used to estimate econometrically a smooth supply function which approximates the step function. The fitted curve is the one used in the demand/supply analysis. It has the general form:

$$c = f(q)$$

where

c = unit cost
q = cumulative production

A variety of functional forms were investigated for each product sector and the choice of which to use in the demand/supply analysis depended on such criteria as reduction in sum of squares, significance of coefficients, and standard errors of estimate.

Calibration of Supply Curve to Base Case. Because the survey data on production are taken from several different years and coverage was not complete, the supply curve generated by the above procedure does not correspond to actual supply conditions in any particular year. Specifically, the cumulative production obtained from the curve corresponding to the price of a product in 1978 is not necessarily equal to reported output of that product in 1978. (In most cases, cumulative production at the 1978 price is within ten percent of actual 1978 production, but usually lower. In a few cases it is higher.)

In order to calibrate the demand/supply model for each sector, the estimated supply curve is shifted right or left so that it is consistent with the 1979 price (in 1978 dollars) and level of output.* Strictly speaking, this procedure assumes that the "unobserved" capacity has variable costs equal to the y-intercept of the fitted supply curve. In practice, as long as the unobserved capacity has variable costs less than those of the marginal high-cost mill, the calibration will not affect the shape of the supply curve in the region of its intersection with the demand curve. Therefore, it will not affect the forecast of price and output in the demand/supply analysis.

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*1979 is the most recent year for which annual information is available. Therefore, there is no need to start with 1978 levels and "forecast" 1979 levels. This approach is identical to that used to model capacity expansion in subsequent years.

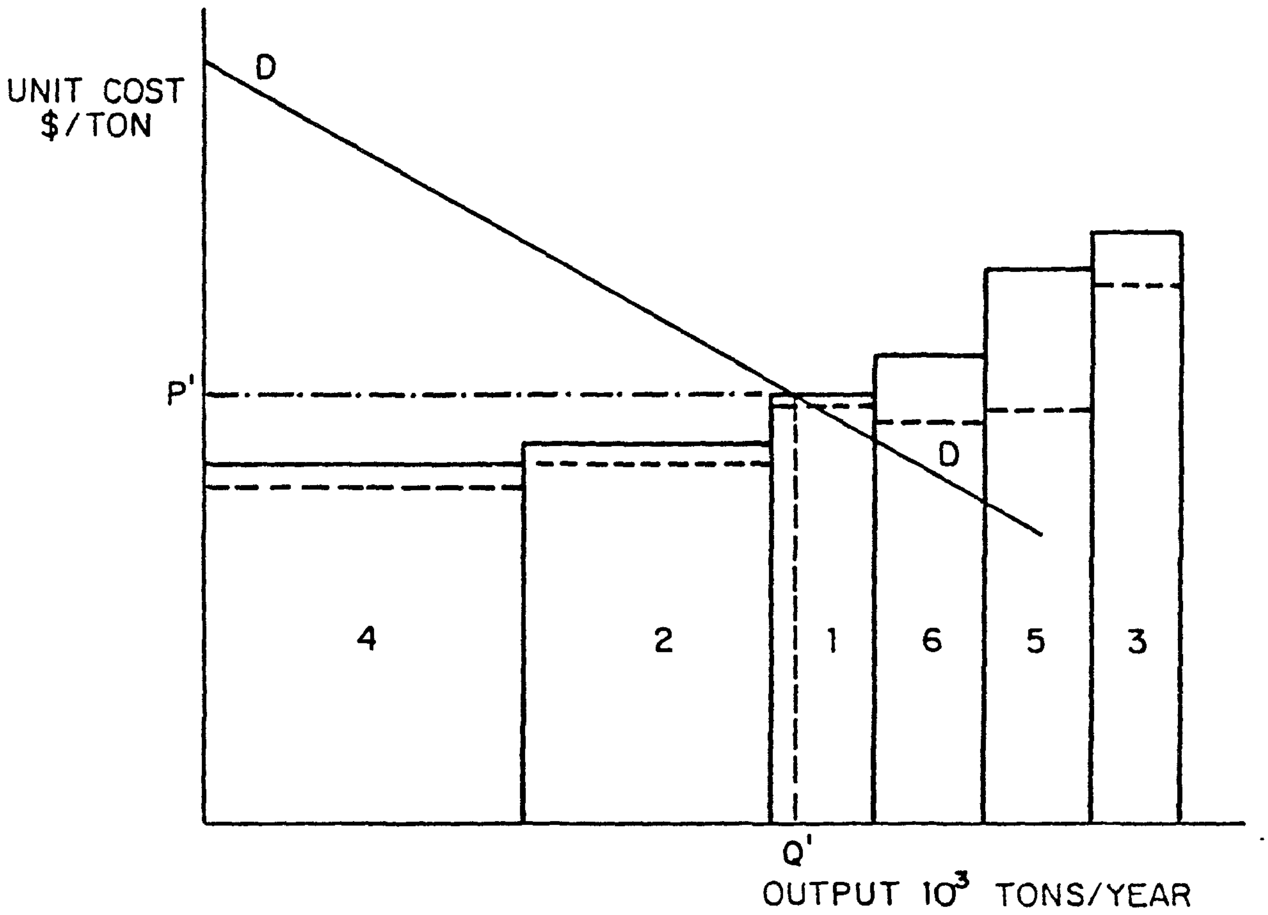
Inclusion of Pollution Control Costs. Pollution costs for several levels of control were determined by the technical contractor for individual mills and for the basic divisions of subcategory. Generally, one level of production process controls and two levels incorporating end-of-pipe treatment were considered. Costs were calculated for capital, operation and maintenance (O&M) and energy on an annual basis. Where appropriate, regional factors modifying these costs were developed.

The treatment costs added to the supply curve are total annualized unit costs which include capital charges (investment costs multiplied by the CRF), as well as variable costs. This is because the decision to install pollution control equipment and remain operating is a long-run decision. We assume that firms can correctly predict future trends so that only those which expect to recover at least the total costs of their pollution control system will stay open. This approach ensures that the marginal producer remaining open will recover total treatment costs.

The procedure for estimating the supply function including pollution control costs is to divide the costs of a specified level of pollution control for each mill, by the mill's capacity to obtain a treatment cost per ton. This unit cost is then added to the unit variable manufacturing cost of that mill. This implies that a mill's treatment costs are allocated across its various products on an equal per ton basis. The mills are reranked by unit cost and the supply curve is reestimated using these new cost figures. The new curve will shift upwards, reflecting the increased costs of additional pollution control. Note that if a mill had inframarginal unit costs before treatment, but has unit costs greater than the marginal mill after treatment, its position in the supply curve will shift to the right of the marginal mill. For example, Figure C-6 shows the supply curve from Figure C-5 after pollution costs have been added. In this case, the cost rankings of mills #1, #5, and #6 have switched.

The Adjustment of the Supply Functions to Account for Capacity Expansion. The supply functions were generated using the data on production, capacity, and costs available at the time of the 308 Survey. However, because we forecast supply through 1985, and because the supply curve will change shape with additions of new capacity and retirement of old capacity, these supply curves must be adjusted to account for capacity expansion.

FIGURE C-6. Supply Curve Resulting from the Reranking of Mills with Treatment Costs



NOTE: HORIZONTAL DASHED LINE (---) SHOWS PRE-CONTROL UNIT VARIABLE COST

HORIZONTAL SOLID LINE (—) SHOWS UNIT VARIABLE COST PLUS TOTAL ANNUAL POLLUTION CONTROL COST

There are several sources of information on current and future capacity. The capacity figures published by the American Paper Institute (API) are generally considered to be the most reliable of those publicly available. The responses to the 308 Survey also provide information on current capacity and expansion to which the mills are committed. Most of this expansion is to be on stream by 1981. Current API figures include probable expansion through 1982. The 308 Survey and API are in reasonably close agreement on capacity, both current and planned, to 1981.

DRI forecasts future capacity through 1985. They base their current capacity on API data, and use API estimates for expansion through 1982. After 1982 their forecast of capacity is based primarily on creating the capacity needed to meet the demand forecast by the DRI model. An additional source of information on future expansion is the historical trend for each product sector. The projection must take into account the cycles in investment which appear to be common for several product sectors. Through 1982 we use the API estimates of capacity. Estimating expansion beyond 1982 is more difficult because firms do not have definite plans that far in advance. The construction of a complete investment model is particularly difficult in an industry like pulp and paper, where expansions involve large sums of money and occur infrequently. Rather than treating investment as an endogenous variable, we have chosen to estimate future capacity based on API and DRI forecasts.

Two checks are imposed on these estimates of capacity expansion to ensure that they are reasonable. The first is capacity utilization. To a certain extent, output can be increased by making greater use of current capacity. According to API estimates, in 1977 there were 27,381,000 tons of paper produced, with a capacity of 29,859,000 tons. Thus, the overall capacity utilization rate was approximately 91.7 percent. Included in the measure of capacity is an allowance for normal maintenance, grade changes, and other downtime. Therefore, it is possible to have a capacity utilization rate of more than 100 percent, but only for a short period. On the other hand, if the capacity utilization factor declines sharply, there is reason to conclude that the capacity estimate is too high. This criterion was used to evaluate the results of the demand/supply analyses using initial capacity expansion estimates. In some cases, the capacity forecasts were revised if the changes in capacity utilization implied by the demand/supply forecasts varied significantly and/or were inconsistent with other information about the likely prospects for that product factor.

A second check is the profitability of investments in new capacity. The present discounted value of the excess of price over variable cost per ton after tax can be taken as the value of the investment. If this value exceeds the unit costs of new capacity from the 308 Survey, then the capacity expansion forecast is profitable. The methodology is discussed more fully in the section on capital availability analysis.

To actually model the effect of capacity expansion on the fitted supply curves, it is assumed that new capacity has unit variable costs equal to the minimum of that for existing capacity. Therefore, the addition of new capacity can be represented simply as a rightward shift of the existing cost curve, with unit costs of new capacity equal to the y-intercept of the original cost curve. This adjustment is exactly analogous to that used to calibrate the supply curve to the 1979 base period.

Consider the example in Figure C-7. Figure C-7a represents a product sector supply function as it might appear in 1979. If five units of additional capacity were projected for 1980, the supply curve would be shifted as shown in Figure C-7b; i.e., the new capacity would come in as low variable cost production onthe left end of the supply function. If additional capacity was expected to come on-stream in the following year, it would be introduced in exactly the same fashion.

It should be noted that this assumption about variable costs of new capacity could be relaxed without affecting the results of the demand/supply analysis. As long as variable costs are less than the variable costs of the marginal existing mill, the intersection of the demand and supply curves is unaffected. Therefore, price and output changes due to treatment costs will not be affected either. However, relaxing this assumption does affect the amount of "contribution to capital" available for capacity expansion. Therefore, the capital availability analysis must be examined for sensitivity to this factor.

Supply functions are prepared in this manner for individual product sectors with and without pollution controls for each year from 1978 to 1985.

Total Cost of Compliance. The capacity expansion forecasts are also used to predict total costs of compliance to the Proposed Regulation for capacity in place by 1983. Costs of compliance for mills in place in 1978 are taken directly from the sums of treatment costs estimated for mills in the 308 Survey. The expansion forecasts can be used directly to calculate costs of compliance by product sector for mills in place by 1978. To compute costs by subcategory, expansion forecasts

FIGURE C-7. Modeling Capacity Expansion Using the Product Sector Supply Curves

FIGURE C-7a. Supply Curve in 1979

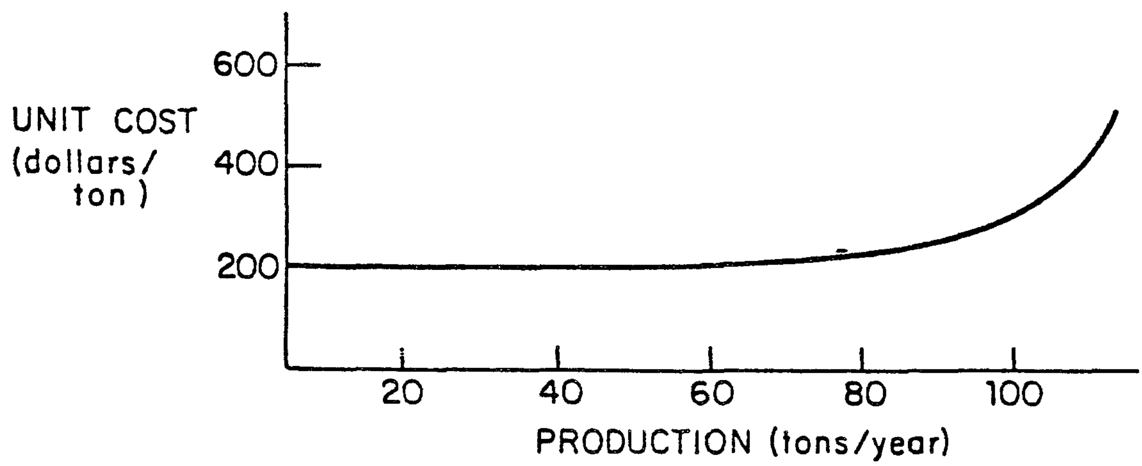
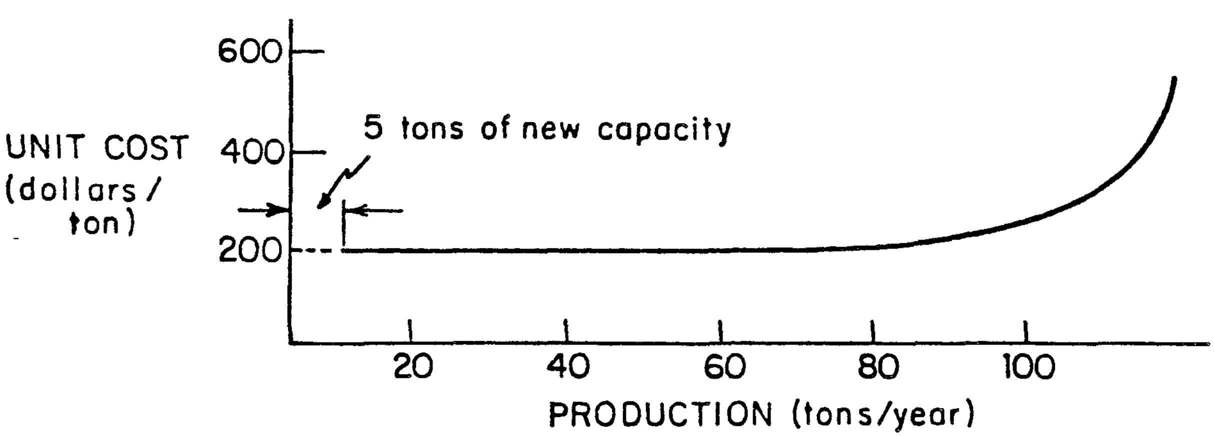


FIGURE C-7b. Supply Curve in 1980 with Five Units of New Capacity



for each subcategory must be developed based on the product sector forecasts. First, an expected mix of subcategories corresponding to expansion in each sector was estimated. It was assumed that expansion after 1978 in each sector would contain the same fractions of integrated subcategories as found in the 308 Survey. Only a small increase in nonintegrated capacity is predicted.*

Starting in 1982, capacity increases due to "greenfield" mills or major alterations of existing plants are assumed, subject to NSPS standards. Thus it is necessary to predict what fraction of new capacity would be classified as a new source. This was done using information on installation of new machines in API's capacity forecasts and planned capacity increases in existing plants from the 308 Survey.

Demand Side Analysis

This section outlines the methodology used to model demand for pulp and paper products. It includes a discussion of general factors affecting demand in the industry, the structure of the equations making up the model, the results of the econometric estimation, and the macroeconomic forecast which drives the demand side of the demand/supply model.

Factors Affecting Demand. Demand for specific products within the industry exhibits considerable variety, since each product has its own unique characteristics. The economic and technological trends affecting demand for the twenty-seven product sectors that have been defined for the industry are summarized in the product profiles in Draft Volume II. Some product sectors have been severely affected by the penetration of substitute materials into their traditional markets. Examples of this trend are the substitution of polyethylene bags for Bleached Kraft bags, of plastic film for Glassine and Greaseproof paper, of plastic containers for Molded Pulp products, and of plastic bottles for Solid Bleached Milk cartons. Other product sectors have not succumbed to penetration. For example, most Unbleached Kraft papers have superior packaging properties and consequently have maintained market shares.

Technological change in end use markets has affected some products. Demand for Solid Bleached Bristols is down since there is increased use of computer magnetic tape rather than cards. Uncoated Freesheet use, on the other hand, has grown due to the burgeoning need for business forms and paper for computers and copying machines.

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*This is because most new expansion does occur in integrated mills and because doing so automatically accounts for the increase in market pulp capacity that must, for consistency, accompany increase in nonintegrated capacity.

Technological changes in product production have improved demand in some sectors such as Newsprint, Uncoated Groundwood Paper, and very recently, Tissue, by improving product characteristics and therefore consumer acceptance.

The demand for each product is linked to the level of activity of particular sectors of the economy. For example, Special Industrial Papers demand follows overall industrial production, and Coated Printing Papers demand is related to the level of advertising in the U.S. Some products are also affected by national policy. The future use of the various recycled paperboards, for instance, will be influenced by national recycling policies.

Demand Model. Because most pulp and paper products are internationally traded, an analysis of demand must take into account both domestic and foreign demand and supply for a given product. The basic identity is:

$$\text{Apparent Consumption} = \text{Shipments} + \text{Imports} - \text{Exports} \qquad \text{(C-1)}$$

Shipments, i.e., domestic production, are the supply side of our model. Forecasting equations for imports and exports have been developed by DRI. In most cases, DRI's forecasts of exports and imports are taken as exogenous to the demand/supply models used in the present analysis, since their magnitudes are relatively small. (Dissolving Pulp is the exception.)

In the next step of the analysis, apparent consumption is analyzed into two components, actual consumption and inventory changes. In equation form:

$$\text{Apparent Consumption} = \text{Consumption} + \text{Inventory Change} \qquad \text{(C-2)}$$

This reflects the fact that consumers of paper and board products buy them to add to their inventories, as well as consuming them immediately for their given "end-use". Because inventory demand tends to be very volatile, it is preferable to separate it out and focus on the underlying end-use demand, i.e., actual consumption. Actual consumption is more stable and reflective of long-term effects of demand such as substitution and technological change. Not doing so would tend to overestimate the price elasticity of demand.

Lastly, in DRI's estimation approach, actual consumption is analyzed as the product of an "end-use factor" (EUF) and a "demand indicator" (IND). In equation form:

$$\text{Consumption} = \text{EUF} \times \text{IND} \qquad \text{(C-3)}$$

One can think of the demand indicator as an index which measures the effect on demand (consumption) of the size of the end-use consumption market while holding price and other factors constant. In the case of consumer Tissue, for example, an obvious candidate for a demand indicator would be the number of households in the U.S. Everything else equal, one would expect a doubling in the number of households to double the demand for consumer Tissues. In economic terms, the demand indicator represents shifts in the demand curve. In other cases, the demand indicator might be the index of production of the end-use industry. The choice of a demand indicator for a particular product sector depends on which macroeconomic variable best correlates with the size of the end-use sector.

Several product sectors are represented by more than one demand indicator because components of their demand are experiencing different market trends. Each demand indicator is weighted by the share of that component of total demand. For instance, demand for Coated Printing Paper has three major components. Demand for the smallest -- coated one-side paper -- is declining because of substitution by plastics. However, demand for the two types of coated two-side paper is growing, resulting in an overall increase in demand for the sector.

Conversely, the end-use factor can be thought of as the demand of an average unit of the end-use sector. In the case of tissues this would be a single average household. In some other sector it would be a unit of production of the end-use industry. Therefore, the end-use factor captures all other factors affecting demand (price, substitute price, technological change) except the size of the end-use sector. It is the demand curve "normalized" to a unit of the end-use sector. Multiplying the end-use factor (demand per end-use unit) by the demand indicator (number of end-use units) gives us back the total demand of the end-use sector, which, in equilibrium, equals actual consumption.

End-Use Factor Equations. DRI's approach is to estimate econometrically the end-use factor equation. Given time series for consumption and the chosen demand indicator, equation C-3 yields a time series of the end-use factor. This end-use factor is then regressed against the appropriate own and substitute price series and other independent variables to obtain the coefficient estimates for the equation.

A typical end-use factor equation has the following form:

$$EUF_t = C + L(PQ_t/PD_t) + L(PQ_t/PS_t) + L(X_t) \qquad (C-4)$$

where

- EUF = end-use factor
- C = constant term
- PQ = price of paper grade
- PD = GNP deflator or other price index
- PS = price of substitute good
- X = other independent variables, e.g., time or proxy for technological change
- L = lag operator (e.g., $L(X_t) \equiv \sum_{i=o}^{n} a_i x_{t-i}$)
- t = time subscript

The constant term captures the "exogenous" component of demand. The second term in equation C-4 measures the effects of changes in the real price of the paper grade, the third term measures the effect of relative changes in own and substitute prices, and the fourth term captures the effects of othe exogenous variables on demand. Lags on most price terms range from four to eight quarters.

In most cases, the end-use factor equations are estimated with quarterly data. In these cases quality is always a function of lagged relative price (not current price). This form makes them awkward to use in the demand/supply analysis bacause the elasticity of demand in the current quarter is zero. However, because the supply curves are based on annual data, it was necessary to convert the demand curves to an annual basis to make them compatible. As a result of the annualization procedure, demand becomes a function of current as well as lagged price. This is because the lagged price terms for the most recent quarters are allocated to the current year when the aggregation from the quarterly to yearly basis is made.

Insufficient data were available to estimate end-use factor equations for three sectors: All Other Paper, Molded Pulp, and Market Pulp (except Dissolving Pulp). Problems include the multiplicity of different products included in these sectors and the difficulty of identifying demand indicators and obtaining price series. Analysis of the demand for Market Pulp is further complicated by the wide substitutability among different grades. As a result, demand/supply analyses could not be done for these sectors.

The actual demand equation used in the demand/supply model is constructed by retracing the steps outlined in equations C-1 and C-4. Multiplying the end-use factor equation* A-4 by the DRI forecast of the demand indicator, and adding the forecasted values of inventory change and exports, less imports, yields an equation relating U.S. production to the price and other variables in equation C-4.

Results of Estimation. The full results of the estimated end-use factor equations are given in Appendix 2-B.** A useful way to summarize the results is to use the concept of elasticity of demand. Price elasticity of demand is defined as the percent change in quantity demanded resulting from a given percent change in price, all other factors held constant. It gives a convenient summary of the relationships specified by a given demand equation. The formula for elasticity is:

$$\varepsilon = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}}$$

where Q is quantity demanded and P is price. A high value of ε (greater than one) means that demand is relatively price-sensitive, whereas a low value of ε implies the opposite. Products with low demand elasticities are in a better position to pass through to the customer the added costs of pollution control. The own price elasticity shows the effect of a product's own price on its demand, and the cross-price elasticity shows the effect of the price of substitute goods on its demand.

Table C-1 lists the pulp and paper industry sectors, their own-price elasticities, their substitutes, and their cross-price elasticities. In most cases, confidence intervals for these estimates are small. The table shows that the own-price elasticity estimates of most of the product sectors are relatively inelastic. Exceptions are Bleached and Unbleached Kraft Papers, Glassine and Greaseproof Papers, Cotton Fibre Papers, Uncoated Groundwood Papers, Thin Papers, and Solid Bleached Board; all with elasticities greater than one. Some product sectors are extremely inelastic. These include Tissue paper, Uncoated Freesheet, and Solid Bleached Bristols.

Several product sectors have high cross-price elasticities, implying that price rises due to pollution costs could significantly affect demand if they are not matched in the competing sectors. Glassine and

*All variables except the own price PQ and EUF in the end-use factor equation are also assumed exogenous in the demand/supply model. As with other variables, these are taken from DRI forecasts. These forecasts are described below.

** "Appendix 2-B" refers to Appendix 2-B in the Draft Report.

TABLE C-1. SUMMARY OF DEMAND ELASTICITIES

Price	Own Price Elasticity*	Substitute	Cross-Price Elasticity of Substitute
Unbleached Kraft	1.49	Plastic Film	.17
Bleached Kraft	3.86	Plastic Film	.67
Glassine	2.14	Plastic Film	1.16
Spec. Industrial	.73	n.a.	n.a.
Newsprint	.63	Uncoated Groundwood	.35
Coated Printing	.64	Uncoated Groundwood	.23
Uncoated Freesheet	.38	Uncoated Groundwood	.22
Uncoated Groundwood	2.65	Newsprint, Uncoated Book Papers	2.65
Thin Papers	1.07	Chemical Woodpulp Papers	.82
Solid Bl. Bristols	.41	n.a.	n.a.
Cotton Fiber	2.06	Chemical Woodpulp	1.12
Tissue	.06	n.a.	n.a.
Board			
Unbl. Kraft Liner.	.61	Plastic Films, Polystyrene, Hard Plastic Packaging	.42
Bl. Kraft Liner.	.61	**	.42
Bl. Kraft Folding	.73	Plastic Pouches, Film & Hard Packaging	.48
Semi-Chem Corr.	.61	**	.42
Recycled Liner.	.61	**	.42
Recycled Corr.	.61	**	.42
Recycled Folding	.73	Plastic Pouches, Film & Hard Packaging	.48
Constr. Paper & Bd.	.68	Solid Wood Products	n.a.
Molded Pulp	n.a.	n.a.	n.a.
Solid Bl. Board	1.15	Plastic Film	.39
All Other Board	.65	Plastic Pouches, Film & Hard Packaging	.07
Pulp			
Dissolving	.59	n.a.	n.a.
Market	n.a.	n.a.	n.a.
Total			

Source: DRI demand equations
*Absolute Value
**Same as for unbl. kraft liner
n.a.: data not available for emprirical estimate of elasticity

Greaseproof papers, Cotton Fibre papers, and Uncoated Groundwood papers all have cross-price elasticities greater than unity. The cross-price elasticity for Bleached Kraft Papers is also relatively high. Products which have very low cross-price elasticities include Unbleached Kraft Papers and Uncoated Freesheet. For some product sectors such as Tissue and Solid Bleached Bristols, data are not available to estimate cross-price elasticities.

The Macroeconomic Forecast. Values of the exogenous variables in the demand models, such as demand indicators, are taken from the March 1980 "trend" forecast of the U.S. economy, made by DRI's macroeconomic model for the period 1980-85. This forecast shows a recession with declines in real GNP through the last three quarters of 1980 followed by gradual recovery in 1981. Inflation is expected to abate gradually after the credit squeeze in the first half of 1980, although the "core" rate of inflation due to wage increases could remain at around ten percent through the early 1980's. In the following years, 1982-85, a predicted move toward a balanced budget is expected to reduce the share of consumer spending in GNP, while tax cuts and increased defense expenditures are predicted to boost investment spending. This shift from consumption to investment spending has implications for the relative recovery rates of different paper and board grades. It is expected that paper grades associated with advertising (Newsprint, Coated Printing Papers) and fiber boxes and other packing materials used for consumer goods will fare less well. Table C-2 shows the movements of some important variables in the forecast.

Solution of the Model

The supply and demand curves for each sector are combined to form a product sector model with can be solved to predict the equilibrium path of the market over time.* As described earlier, the demand relationship described in equations C-1 and C-4 relates price to U.S. production. The supply curve developed relates U.S. production to the marginal cost (dollar per ton) of that output. Adding the assumption of competitive behavior,

$$\text{Price} = \text{Marginal Cost} \qquad \text{(C-5)}$$

closes the system. This is the basic structure of the demand/supply models used to forecast price and output in each product sector.

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*The procedure for the five linerboard and corrugating medium sectors is somewhat more complex. The supply and demand of all five sectors is modeled jointly to capture substitute and complementary relationships.

TABLE C-2. AVERAGE ANNUAL PERCENT CHANGE OF ECONOMIC VARIABLES IN DRI CONTROL FOREC

	1979	1980	1981	1982	1983	1984	1985
Real GNP	2.3	0.2	1.5	4.3	3.4	2.6	3.8
Consumer Price Index	11.4	12.9	10.2	9.6	8.8	8.0	8.1
Consumer Expenditures except Services	1.3	0.1	0.6	3.4	3.4	2.7	3.5
Printing, Index	4.1	-1.6	0.3	6.2	3.9	3.0	4.5
Wholesale Prices (Costs)							
Energy	26.6	48.7	27.5	19.1	12.2	10.5	12.4
Chemicals	11.8	19.0	12.2	9.6	7.6	6.0	6.7

Source: DRI Pulp and Paper Review (March 1980), p. 15.

The demand side of the model is driven by values of the exogenous variables from the DRI model and lagged prices. On the supply side, total capacity is given exogenously. For each year, the model is solved for the market-clearing price and quantity. A base case is established for 1979 to 1985. This not only creates a reference case, but also establishes a series of lagged prices to start the analysis of the effects of treatment costs. Starting with 1983, supply curves embodying costs from each treatment option are used to calculate an equilibrium price and quantity for each year and option. Although mills are not required to begin treatment until 1984, they are assumed to incur costs beginning in 1983. The model also calculates total industry contribution to capital (revenues less variable costs). Projections for each treatment option are made through 1985.

Appendix D

Demand Curves

The parameters used to determine the demand for a product sector in a given year t are presented in Table D-1. The coefficients d_i are weights on the prices lagged from year t. The parameter S is the annual growth rate of demand in the sector. Under the assumption of long-run equilibrium (see Appendix C), S was taken as identical to the growth rate of supply. Note that the units of P and Q in the demand curves are different from those in the supply curves, and must be adjusted accordingly to be comparable with them.

The demand curves for Unbleached Kraft Linerboard, Semi-Chemical Corrugating Medium and Recycled Corrugating Medium actually show the demand for total fiber box shipments (in millions of square feet) as a function of price (in dollars per million square feet). A series of conversion equations is needed to determine price and output for each of these papergrades.

Some product sectors are omitted because they were not available (Molded Pulp) or no NSPS capacity was expected to be built.

Table D-1. Parameters for Product Sector Demand Curves

Product Sector	Model Coefficients*						
	c	d_0	d_1	d_2	d_3	d_4	s
Paper							
Unbleached Kraft	9453	-105.7	-194.7	-39.7	0	0	.02
Bleached Kraft	NA	NA	NA	NA	NA	NA	NA
Glassine	NA	NA	NA	NA	NA	NA	NA
Spec. Industrial	1065	-7	-3.5	0	0	0	.02
Newsprint	7579	098.6	-19.7	0	0	0	.06
Coated Printing	9147	-29.4	069.8	-6.7	0	0	.03
Uncoated Freesheet	12108	-20.3	-67.91	-20.52	0	0	.03
Uncoated Groundwood	7216	-69.9	-124.1	-30	0	0	.06
Thin Papers	NA	NA	NA	NA	NA	NA	NA
Solid Bl. Bristols	NA	NA	NA	NA	NA	NA	NA
Cotton Fibre	NA	NA	NA	NA	NA	NA	NA
Tissue	5140	-4.42	0	0	0	0	.01
Board							
Unbl. Kraft Liner.	469391	-1944	-3198	-698	0	0	.04
Bl. Kraft Liner.	NA	NA	NA	NA	NA	NA	NA
Bl. Kraft Folding	4350	-21.7	-65.9	-9.6	0	0	.02
Semi-Chemical Corr.	469391	-1944	-3198	-698	0	0	.04
Recycled Liner	NA	NA	NA	NA	NA	NA	NA
Recycled Corr.	469391	-1944	-3198	-698	0	0	.026
Recycled Folding	NA	NA	NA	NA	NA	NA	NA
Constr. Paper & Board	8983	-79.9	-119.8	-10	0	0	.01
Molded Pulp	NA	NA	NA	NA	NA	NA	NA
Solid Bl. Board	4563	-33.8	-42.5	-27.9	-4.2	-.9	.01
All Other Board	7156	-124	89.8	-11.84	0	0	.008
Pulp							
Dissolving Pulp	NA	NA	NA	NA	NA	NA	NA

*The coefficients assume price is in 1978 cents per pound and output in 1000 tons per year.

Source: DRI, Meta Systems estimates.