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Economic Impact Analysis for the Printing and Publishing NESHAP

FINAL

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EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA or the Agency) is developing an air pollution regulation for reducing emissions in the publication gravure, packaging and product gravure, and flexographic segments of the printing and publishing industry. A National Emission Standard for Hazardous Air Pollutants (NESHAP) has been developed for these industry segments under Title III of the 1990 Amendments to the Clean Air Act (CAA). The Innovative Strategies and Economics Group (ISEG) of EPA contributes to this effort by providing analyses and supporting documents that describe the likely economic impacts of the standards on directly and indirectly affected entities.

ES.1 SCOPE AND PURPOSE

This report evaluates the economic impacts of additional pollution control requirements for the printing and publishing industry that are designed to control releases of hazardous air pollutants (HAPs) to the atmosphere. The Clean Air Act's purpose is "to protect and enhance the quality of the Nation's air resources" (Section 101[b]). Section 112 of the Clean Air Act as amended in 1990 establishes the authority to set national emission standards for 189 hazardous air pollutants. NESHAPs are industry-specific. For HAPs, the Agency establishes Maximum Achievable Control Technology (MACT) standards. The term "MACT floor" refers to the minimum control technology on which MACT can be based. For existing sources, the MACT floor is the average emissions limitation achieved by the best performing 12 percent of sources (if there are 30 or more sources in the category or subcategory, or best performing five sources (if there are fewer than 30 sources in the category or subcategory). MACT can be more stringent than the floor considering costs, non-air quality health and environmental impacts, and energy requirements.

ES.2 INDUSTRY PROFILE

The printing industry is involved in the printing of materials such as books, magazines, containers, and other packaging. Printing can be grouped into publication, packaging, or product printing and is performed using primarily one of the following five printing processes: letterpress, flexography, gravure, offset lithography, and screen printing. The flexographic and gravure printing processes release HAPs through the application of ink or other materials to the substrate (material to be printed), as well as during the cleaning process, where solvents are used to clean the printing presses. EPA estimates that, in 1992, 17,500 tons of HAPs were emitted from publication gravure plants and as much as 18,000 tons from product and packaging gravure plants.[1]

The printing industry is a very diversified and sophisticated industry because of the multiplicity of printing processes used and products produced. Gravure and flexography compete with offset lithography as the dominant processes. The regulation will potentially affect all entities that use gravure and flexographic printing processes as part of their overall production processes, whether they consider themselves as part of the commercial printing industry or some other industry. Printing may be performed by the commercial printing industry or by in-house captive operations classified in other industries.

Publications are printed largely with offset lithography, with some gravure and flexography, while package printing is mostly performed by flexography, with some offset, gravure, and other processes. Publication printing is covered for the most part by the commercial printing industries identified by Standard Industrial Classification (SIC) codes 2752, Commercial Printing—Lithography; 2754, Commercial Printing—Gravure; and 2759, Commercial Printing—not elsewhere classified, which includes letterpress, flexographic, screen, and other

processes. The 1991 value of commercial printing was $51.8 billion.[2] Package printing is the application of inks or coating material to a package directly or with a label. It often includes in-line converting operations in addition to the reproduction of the image. It is estimated that the 1990 value of package production in the U.S. was roughly $73 billion, of which $58 billion represents packaging with printing.[3]

ES.3 REGULATORY CONTROL OPTIONS AND COSTS OF COMPLIANCE

MACT standards are technology-based regulations. Although a facility that is a source of emission need not install any specific pollution control technology, the regulatory requirements must be based on a technology that can achieve the specified limits. The Background Information Document (BID) details the technology basis for MACT standards. Model plants were developed to evaluate the effects of various control options on the printing and publishing industry. Selection of control options was based on the application of presently available control devices and varying levels of capture consistent with different levels of overall control. The BID presents a summary of the control options for each of the three industry segments—publication gravure, packaging/product gravure, and flexography. Table ES-1 summarizes the compliance costs associated with the regulatory requirements for each segment.

TABLE ES-1. SUMMARY OF CONTROL COSTS FOR THREE INDUSTRY SEGMENTS: PUBLICATION GRAVURE, PACKAGING/PRODUCT GRAVURE, AND FLEXOGRAPHY (10^3 $1993)

Segment	Total capital costs	Annualized capital costs	Operating expense	Monitoring and recordkeeping	Total annual cost
Publication gravure	$92,289.0	$12,292.9	$8,595.0	$216.0	$21,103.9
Packaging/produce gravure	$48,904.7	$6,514.1	$17,913.8	$636.0	$25,063.9
Flexography	$7,170.7	$955.1	$2,584.5	$64.0	$3,603.7
Total	$148,364.4	$19,762.1	$29,093.3	$916.0	$49,771.5

ES.4 ECONOMIC IMPACT ANALYSIS

A variety of approaches may be used to assess the impacts of the regulatory action; they reflect a variety of underlying paradigms. Typically, an economic model is developed to assess the facility- and market-level impacts of the regulations, including price, quantity, employment, business closure, and foreign competition impacts. Such models are firmly rooted in neoclassical economic theory and require market-level data on price and quantity for potentially affected products and detailed production data at the facility level. In the case of the printing and publishing industry; however, this information is not available at the facility- or market-level. Furthermore, this regulation affects a service (printing and publishing) as opposed to a manufactured good or product. Service industries cause problems related to identifying and differentiating the affected commodities (markets), quantifying the level of the service provided to other industries or final consumers, and identifying the producers and consumers of the service. Nevertheless, RTI developed a market model of the printing and publishing industry to assess the regulatory impacts of the NESHAP.

Printing is basically the reproduction of original type or artwork for publications, packaging materials, and products. The demand for printing derives from its use as an input into the production of publications, packaging, and printed products. The production process for publications, packaging, and products may be broken into stages so that at each stage some inputs are used to make an intermediate input that is then used with other inputs to produce the final product. Although there are five major printing processes, only two are directly affected by the regulation—flexography and gravure. The other processes (offset, letterpress, and screen) are not covered by the regulation. Therefore, this analysis includes three printing inputs: flexography,

gravure, and a composite printing input that includes offset, letterpress, and screen. Publications, packaging, and printed products are the final product that employ printing inputs so that 22 final products are included in the market model. International trade is not included in this model, so all of these products are consumed and produced domestically.

Given a single producer of each final product, each determines its use of factors in a sequence of stages, through a nested CES production function.[a] First, producers have fixed requirements of printing services and all other inputs per unit of output. Second, they can substitute between printing processes through a CES function. To facilitate the analysis, the CES function is limited to two printing processes for each final product. In the third production stage, each printing process has fixed requirements of intermediate inputs (like substrates and printing inks) and value added (labor and capital). In the fourth stage, within each printing process, we allowed for substitution between labor and capital through a CES value-added function.

As a result of regulation, the relative cost of the available printing processes will change. This in turn will force final producers to alter their production decisions and to substitute away from regulated processes (more costly) toward unregulated processes (less costly) to the extent existing production technologies allow. Thus, the regulations on the printing and publishing industry are incorporated into the model like a per-unit tax on the use of the printing inputs with statutory incidence on the buyers. The new post-compliance equilibrium is the result of a series of iterations between producer and consumer responses and market adjustments until a stable market price arises where total market supply

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[a]The CES, or constant elasticity of substitution, production function is one of the most frequently employed functional forms in modern economic analysis. As implied by its name, the elasticity of substitution between factors of production is expressed as some constant value. The Cobb-Douglas function is a special case of the CES production function with an elasticity of substitution equal to 1.

TABLE ES-2. PRICE AND QUANTITY ADJUSTMENTS DUE TO REGULATION: PRINTING INPUTS AND FINAL PRODUCTS

	Elasticity of substitution[a]			
	0.5		1.5	
	Percentage change in		Percentage change in	
Product	Price	Quantity	Price	Quantity
Printing inputs				
Flexography	-0.06	0.04	-0.05	0.07
Gravure	0.41	-0.29	0.41	-0.53
Other[b]	-0.07	0.04	-0.06	0.08
Publications, total	0.03	-0.03	0.04	-0.04
Packaging, total	-0.01	0.01	-0.01	0.01
Products, total	0.07	-0.07	0.07	-0.07

[a] The elasticity of substitution between printing processes in final production is assumed to be the same across all final products.

[b] Other printing input is a composite input that includes lithography, letterpress, and screen printing processes.

different assumed values for the elasticity of substitution between printing processes of 0.5 and 1.5 across all final products. Percentage change in market prices and quantities is significantly below 1 percent across all final products and printing inputs. The percentage increase in the market price of gravure is predicted to be 0.4 percent in response to the regulation, while the market price of flexography is predicted to decline by a negligible amount of 0.06 percent. The model results predict substitution away from gravure to flexography and other printing inputs but at a very low level as indicated by the output adjustments. Although the percentage change in market price of printing inputs does not vary by specification of elasticity of substitution, the percentage change in output with a value of 1.5 for each printing input is almost double those observed with a value of 0.5. This outcome is expected

to decline by a negligible amount of 0.06 percent. The model results predict substitution away from gravure to flexography and other printing inputs but at a very low level as indicated by the output adjustments. Although the percentage change in market price of printing inputs does not vary by specification of elasticity of substitution, the percentage change in output with a value of 1.5 for each printing input is almost double those observed with a value of 0.5. This outcome is expected as a result of the higher sensitivity of input substitution given higher values of the elasticity of substitution.

ES.5 REGULATORY FLEXIBILITY ANALYSIS

Environmental regulations such as the NESHAP for the printing and publishing industry affect all businesses, large and small, but small businesses may have special problems in complying with such regulations. The Regulatory Flexibility Act (RFA) of 1980, the 1992 revised EPA guidelines for implementing the Regulatory Flexibility Act, and the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA) requires that special consideration be given to small entities affected by Federal regulation. Under the 1992 revised EPA guidelines for implementing the Regulatory Flexibility Act, an initial regulatory flexibility analysis (IRFA) and a final regulatory flexibility analysis (FRFA) will be performed for every rule subject to the Act that will have any economic impact, however small, on any small entities that are subject to the rule, however few, even though EPA may not be legally required to do so. Therefore, the firm-level analysis specifically addresses the RFA requirements by measuring the impacts on small entities associated with the regulations on the printing and publishing industry.

The analysis evaluates the change in financial status by first computing the with-regulation financial ratios of potentially affected firms and then comparing them to the corresponding baseline ratios. Although there are a variety

of possible financial ratios providing individual indicators of a firm's health, they may not all give the same signals. Therefore, for this analysis, the focus is on changes in key measures of profitability (return on sales, return on assets, and return on equity). Furthermore, a composite of financial ratios (i.e., the Z-score)[4] is employed to measure financial viability and determine the likelihood that regulatory compliance will result in financial failure (bankruptcy) of the owning firm.

Potentially affected firms include entities that own plants employing gravure or flexographic printing processes. Based on financial information from Dun and Bradstreet and from Dow Jones Business Information Services, this analysis characterizes the financial status of 45 firms potentially affected by the regulation. The firms in this analysis include 4 of the 6 in publication gravure, 20 of the 64 in packaging and product gravure, and only 21 of the 500 to 1,000 firms involved in flexographic printing. With regulation, the change in measures of profitability are minimal with no overall disparity across small and large firms, while the likelihood of financial failure is unaffected for both small and large firms. Therefore, there is no evidence of any disproportionate impacts on small entities due to the NESHAP on the printing and publishing industry.

ES.6 REFERENCES

1. U.S. Environmental Protection Agency. Engineering Draft Report for the Printing and Publishing Industry. Prepared by Research Triangle Institute. 1994. Chapter 2.

2. U.S. Department of Commerce. 1991 Annual Survey of Manufactures. Value of Product Shipments. Washington, DC, U.S. Government Printing Office. 1992. Table 1.

3. Eldred, Nelson R. Package Printing. Plainview, NY, Jelmar Publishing Co., Inc. 1993. pp. xiii-xiv.

4. Altman, Edward. Corporate Financial Distress. New York, John Wiley and Sons, 1983.

SECTION 1
INTRODUCTION

The U.S. Environmental Protection Agency (EPA or the Agency) is developing an air pollution regulation for reducing emissions in the publication gravure, packaging and product gravure, and flexographic segments of the printing and publishing industry. A National Emission Standard for Hazardous Air Pollutants (NESHAP) has been developed for these industry segments under Title III of the 1990 Amendments to the Clean Air Act. The Innovative Strategies and Economics Group (ISEG) of EPA contributes to this effort by providing analyses and supporting documents that describe the likely economic impacts of the standards on directly and indirectly affected entities.

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This report evaluates the economic impacts of additional pollution control requirements for the printing and publishing industry that are designed to control releases of hazardous air pollutants (HAPs) to the atmosphere. The Clean Air Act's purpose is "to protect and enhance the quality of the Nation's air resources" (Section 101[b]). Section 112 of the Clean Air Act as amended in 1990 establishes the authority to set national emission standards for 189 HAPs, which are industry-specific. For HAPs, the Agency establishes Maximum Achievable Control Technology (MACT) standards. The term "MACT floor" refers to the minimum control technology on which MACT can be based. For existing sources, the MACT floor is the average emissions limitation achieved by the best performing 12 percent of sources (if there are 30 or more sources in the category or subcategory) or best performing five sources (if there are fewer than 30 sources in the category or subcategory). MACT can be more stringent than the floor when

considering costs, nonair quality health and environmental impacts, and energy requirements.

1.2 DATA SOURCES

Where possible, the Agency used publicly available data in this analysis. These information sources included U.S. Department of Commerce documents, such as the Annual Survey of Manufactures and the 1992 Census of Manufactures, and industry data, such as the Gravure Association of America (GAA) periodic compilation of statistics in Profile of the U.S. Gravure Industry and the market forecasts included in SRI International's Printing 2000. In addition, journal articles and previous work by the Agency provided information necessary to profile the industry and complete this analysis.

To determine the equipment and costs associated with a particular set of pollution controls at a potentially affected establishment, EPA engineers must be familiar with the existing printing and publishing technologies and equipment currently employed at those establishments. Although detailed information at the facility level is not publicly available, the Agency is authorized by Section 114 of the Clean Air Act to collect such information for regulatory development. Therefore, the EPA collected facility- and company-specific information through a survey of the industry or an Information Collection Request (ICR). This information assisted the economic analysis as well as the engineering analysis by identifying potential affected facilities, product markets, and companies.

1.3 ORGANIZATION OF THE REPORT

The remainder of this report is divided into four sections that support and provide details on the methodology and results of this analysis. The sections include the following:

- Section 2 provides a summary profile of the printing and publishing industry. This section is based on the industry profile prepared by Research Triangle Institute (RTI) for EPA. It begins with an overview of the industry and the major printing processes. Data are presented on products and markets, production facilities, and the companies that own and operate the facilities.

- Section 3 reviews the regulatory control options and associated costs of compliance. This section is based on the draft Background Information Document (BID) prepared by RTI in support of the national emission standards for the printing and publishing industry.

- Section 4 details the economic impact methodology for assessing the market-level effects of the regulation. This section presents the price and output adjustments for affected markets associated with the additional pollution control costs.

- Section 5 describes the methodology for assessing the company-level impacts of the regulation including an initial regulatory flexibility analysis to evaluate the small business effects of the regulation.

SECTION 2
INDUSTRY PROFILE

The printing industry is involved in the printing of materials, such as books, magazines, containers, and other packaging. Printing can be grouped into publication, packaging, or product printing and is performed using primarily one of the following five printing processes: letterpress, flexography, gravure, offset lithography, and screen printing.[a] The flexographic and gravure printing processes release hazardous air pollutants (HAPs) through the application of the ink or other materials to the substrate (material to be printed), as well as during the cleaning process, where solvents are used to clean the printing presses. EPA estimates that, in 1992, 17,500 tons of HAPs were emitted from publication gravure plants and as much as 18,000 tons from product and packaging gravure plants.[1]

The printing industry is a very diversified and sophisticated industry because of the multiplicity of printing processes used and products produced. Gravure and flexography compete with offset lithography as the dominant processes. The regulation will potentially affect all entities that use gravure and flexographic printing processes as part of their overall production processes, whether they consider themselves as part of the commercial printing industry or some other industry. Printing may be performed by the commercial printing industry or by in-house captive operations classified in other industries.

The U.S. Department of Commerce compiles industry data based on Standard Industrial Classification (SIC) codes assigned to specific industries and the products they produce. Most Census data are reported at the four-digit SIC level,

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[a]Screen printing is a fifth process that is mainly used to print surfaces that are difficult to print by other methods such as bottles, tubes, and shirts and, therefore, is only briefly mentioned in this report.

with some product data at the five-digit level. The commercial printing industry is defined by SIC codes 2752, Commercial Printing-Lithography; 2754, Commercial Printing-Gravure; and 2759, Commercial Printing, not elsewhere classified (n.e.c.), which includes letterpress, flexographic, screen, and other commercial printing. Other four-digit codes under major SIC code 27 cover other printing-related industries such as publishing, book printing, and printing-related service trades. Because the regulation would apply to all producers employing the gravure or flexographic printing processes, not just those whose primary business involves these processes, potentially any entities classified under the major SIC code 27 industries may be affected. Furthermore, entities classified under packaging industries (major SIC codes 26, 30, 32, and 34) may also be affected.

Publications are printed largely with offset lithography, with some gravure and flexography, while package printing is mostly performed by flexography, with some offset, gravure, and other processes. Publication printing is covered for the most part by the commercial printing industries identified above with the exception of book printing (SIC 2732), which mainly uses lithography. The 1991 value of commercial printing was $51.8 billion.[2]

Package printing is the application of inks or coating material to a package directly or with a label. It often includes in-line converting operations in addition to the reproduction of the image. It is estimated that the 1990 value of package production in the U.S. was roughly $73 billion, of which $58 billion represents packaging with printing.[3]

The remainder of this section provides a brief introduction to the diverse printing and publishing industry. The purpose is to give the reader a general understanding of the technical and economic aspects of the industry that must be addressed in the economic impact analysis. Section 2.1 provides an overview of the printing processes employed by the

industry with an emphasis on those affected directly by the regulation — gravure and flexography. Section 2.2 presents historical data on the various products of the industry and their markets. Section 2.3 summarizes the number of printing facilities by market segment, location, and other parameters, while Section 2.4 provides general information on the potentially affected companies that own printing facilities.

2.1 OVERVIEW OF PRINTING PROCESSES

There are five main types of printing processes: letterpress, flexography, gravure, offset lithography, and screen printing. All of these printing methods are contact or impression processes, which use an inked printing plate or image carrier to produce numerous reproductions of an original on paper or other substrates using a printing press, on which pressure is used to transfer the inked image to the paper.[4] The image carrier consists of two areas, the print or image area to which ink is applied and those areas that remain ink-free. The five printing processes are distinguished by the method of image transfer employed, which can be classified as one of four types:

- the relief method of printing from a raised surface as characterized by letterpress and flexography,
- the intaglio method of printing from recessed areas as characterized by gravure,
- the planographic method of printing from a flat surface as characterized by lithography, and
- the stencil method of printing through a porous surface as characterized by screen printing.

In addition, printing processes may be classified as direct, where the ink is transferred directly to the substrate, or offset, where the ink is transferred from the inked plate to an intermediate cylinder covered with a rubber

blanket that transfers it to the substrate. Letterpress, flexography, gravure, and screen printing are almost always direct, and lithography is almost exclusively offset, thus referred to as offset lithography.[b] Another way of distinguishing printing processes is by the system of feeding the substrate to the printing press: sheet-fed (individual sheets) or web-fed (continuous roll). Web printing presses have largely displaced sheet-fed presses in most processes because of the ease of placing converting operations in line with the press.[5]

Some of the printing processes have major subprocesses based on the substrate or products being printed. These major subprocesses include the following:

- publication printing, which includes printed materials that are not further processed into some form of packaging or nonpublication finished product;
- packaging printing, consisting of printed materials that are further processed into boxes, containers, bags, and other forms that package consumer goods; and
- product printing, covering printing done to enhance or design a product that is not used to package or display something else and is not a publication.

Gravure may be divided into three subprocesses: publication gravure, packaging gravure, and product gravure. Flexography consists mainly of publication flexography and packaging flexography, with some product printing. Offset lithography includes sheetfed offset, heatset web offset, and non-heatset web offset.

In general, the printing process begins with the text, design, photography, or artwork to be printed and ends with the final printed publication, packaging material, or product.

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[b]Offset presses may use letterpress or flexo plates or gravure cylinders, thus combining lithography with technology from these other printing processes (Foundation of Flexographic Technical Association, Inc. Flexography Principles and Practices, 4th Ed. Ronkonkoma, NY, Foundation of Flexographic Technical Association, Inc. 1991. p. 22.)

Several steps go into the entire print job, whether it is done on a contract basis as with most publication printing or by in-house captive operations as with much packaging and product printing. These individual steps include

- prepress operations,
- proofing operations,
- printing, and
- binding or finishing and converting.

A detailed discussion of each individual step is beyond the scope of this report, but the general process and product flows are diagrammed in Figure 2-1. All of the production steps illustrated in Figure 2-1 may be performed at different locations by contract platemakers, printers, and finishers/converters, or performed in-house by an integrated producer.

Printing is accomplished by presses that perform the following procedures:

- mounting plates or image carriers on a bed or cylinder (or, with gravure, the actual cylinder);
- inking the plates;
- feeding the substrate and adjusting the tension (web presses);
- transferring the inked image to the paper; and
- delivering the printed matter as sheets in a pile, or otherwise folding, rewinding on a roll, or other finishing and converting operations.[6]

As mentioned above, printing presses may print using a direct or offset method and can be either sheet-fed or web-fed.

The printing operations may be performed by either a contract printer or in-house. Contract printers purchase inputs like substrates and inks to produce printed matter,

which is then transformed into the finished product through separate binding or finishing and converting operations. In the case of in-house printing, the integrated producer would be equipped with printing presses and perform the printing operation as part of the overall production process. In many cases the printing operations of integrated producers are a relatively small part of the overall production process.

Table 2-1 provides a summary of the five printing processes, including a brief description of each, their major applications, and projected market shares.[7] Gravure and flexographic printing processes are the focus of this section. Binding, converting, and finishing operations are discussed independently of the types of printing presented in the following sections.

2.1.1 Gravure Printing Process

Gravure is a printing process in which the ink is directly transferred to the substrate using engraved copper-plated cylinders. The cylinders are engraved with minute cells, or wells, that carry the ink to the substrate. Deeply engraved wells tend to carry more ink than a raised surface, thus producing darker values. Shallow wells are engraved to produce lighter values. The surface of the printing plate is flat except for the series of recessed wells. The minute cells form dot patterns that combine to represent the letters or solid areas to be printed. Three types of cylinder-making systems are used for gravure—conventional, where the cells are the same size but vary in depth, giving a long scale of reproduction used for high-quality printing of photographs; direct transfer or variable area, used for packaging; and variable area-variable depth, used for magazine and catalog printing.[8]

There are two main types of gravure printing press designs: (1) sheet-fed, or flat-plate, gravure press and (2) web gravure press (rotogravure). Almost all gravure printing is done by rotogravure; therefore, rotogravure is the focus of

TABLE 2-1. DESCRIPTION, APPLICATIONS, AND PERCENTAGE DISTRIBUTION OF MAJOR PRINTING PROCESSES

Process	Description	Major applications	Projected percentage distribution			
			1991	1995	2000	2025
Lithography	Indirect (or offset) printing using an intermediate element (blanket) between image carrier and substrate	Magazines, newspapers, books, stationery, advertising, containers	47	47	45	35
Gravure	Printing method based on photographs and photo-mechanics capable of reproducing continuous- tone pictures	Packaging, advertising, greeting cards, art books	19	18	17	16
Flexography	Direct transfer of an image from an inked flexible plate, frequently used on a rotary press	Packaging, newspapers, magazines, directories	17	18	19	21
Letterpress	Image transferred under pressure directly to paper from inked plate	Magazines, newspapers, books, stationery, advertising	11	8	5	4
Silkscreen	Ink is passed through unblocked part of porous plate to form printed image	Signs, electronics, wallpaper, greeting cards, ceramics, decals, banners	3	3	3	3

Source: U.S. EPA, Office of Pollution Prevention and Toxics. Use Cluster Analysis of the Printing Industry. Washington, DC, May 1992. p. 7.

this description.[c] Gravure presses may be divided into lightweight presses for flexible packaging, gift wraps, paper and foil labels, and decorative films and heavyweight presses for folding cartons and vinyl sheeting.[9] The type of gravure presses commonly used to print packaging materials include narrow web, in-line presses for labels and wrappers and wide and narrow web, in-line presses for folding cartons and flexible packaging.

2.1.1.1 Gravure Printing Substrates. The web stock, or substrate, is an important input to the gravure process. A smooth, flat printing surface is best for the gravure process to make satisfactory contact with the gravure cylinder. Coated papers and board, foils, and extruded polymer films work extremely well with rotogravure. Although the substrate must be smooth, it does not need to be strong or stiff. Gravure is able to print on low basis weight papers, even tissue papers.[10]

The GAA estimates that eight different paper types were used by the publication gravure printing industry in 1987, with a total estimated use of 2.2 million tons.

Packaging gravure substrates include those used at plants printing folding cartons, flexible packaging, and label and wrapper packaging. Film types reported for gravure flexible packaging include polyester, metalized polyester, polypropylene, polyethylene, polystyrene, nylon, cellophane, vinyl, and poly/foil/poly laminates.[11]

Product gravure prints on paper and foil substrates for gift wraps in addition to substrates that consist of several layers of materials, one of which is vinyl. Products printed include wallcovering, upholstery, tablecloths, shower curtains, floor coverings, and adhesive-backed decorative film.

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[c]Exceptions include embossing presses or special presses used to print money with actual engraved plates.

2.1.1.2 Gravure Inks, Coatings, and Solvents. The gravure process requires a thin, watery ink that can be easily drawn from the plate cells to the web surface at high print speeds. It is also helpful if the ink has a strong affinity to the substrate and can be drawn into the porous surface. In addition to ink, other materials including adhesives, primers, coatings, and varnishes may be applied with gravure cylinders.[12] In a multicolor process it is important that the ink or other coating dry quickly between each station; therefore, the ink vehicle must contain a volatile portion to be evaporated. Organic solvents and alcohol are mainly used as the volatile portion, but water-based inks are becoming more popular because of their lower cost and less potential for air pollution.[13] However, a single press is not compatible for use with either system. Water-based inks require more drying capacity and a different cell design.

Data are available from the GAA for ink consumption by publication and packaging/product gravure printers. Publication gravure presses in the U.S. use toluene/xylene-based (solvent-based) ink systems exclusively.[14] Toluene is the primary solvent used in the U.S. publication rotogravure ink systems, and some plants also use xylenes and ethyl benzene in the solvent blend. All of these compounds are HAPs. Types of packaging/product gravure inks are identified by GAA and include nitrocellulose and water-based inks.

Inks contain solvents, while additional solvents may be mixed into the ink to obtain the desired viscosity. Publication gravure plants recover a large portion of spent solvents from their ink, some of which is reused and some excess which is sold back to the ink suppliers. Some virgin solvent, which has the same composition as the solvent in the inks, is purchased for replenishment purposes, and a small amount is used for cleaning the presses.

2.1.1.3 Gravure Printed Products. Publication gravure prints mainly for the magazine and periodical, catalog and directory, and advertising printing markets. Many consumer

magazines as well as Sunday magazines, which are inserted into Sunday newspapers, are printed by publication gravure. Catalogs and directories printed by publication gravure include merchandise catalogs and telephone directories. Gravure advertising printing consists mainly of direct mail advertising and newspaper inserts. In addition to these three main markets, publication gravure prints other types of commercial printing, such as decalcomanias, pressure-sensitive products, and other general commercial printing.

Packaging gravure is used to print mainly folding cartons, flexible packaging, and labels and wrappers.[d] Folding cartons are used for packaging retail products as well as for containing other packages. Gravure and offset are the major processes used to print folding boxboard.[15] Flexography may also be used.[16] Flexible packaging is made from paper, paperboard, plastic film, and foils to package food and other products and for lining other types of containers and for bags and sacks. Flexography is more common than gravure for printing flexible packaging. Labels and wrappers can be wrapped or adhered to other types of packaging, or they may be part of the package itself. For printing labels, manufacturers may use combination gravure/flexo presses. The gravure cylinder prints the halftone material and applies non-ink coatings and the flexographic cylinder prints typographic material that might have frequent changes.

Product gravure printing decorates a variety of paper, tissue, and vinyl products. Examples of gravure printed products include gift wraps, wallcoverings, vinyl products, floor coverings, tissue products, and decorative laminates.

2.1.1.4 HAP Emissions from Gravure Printing Process. The evaporated components of the ink, other coatings, and solvents may contain HAPs. HAPs may also be present in the solvents used to clean the presses and press components. The

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[d]Labels and wrappers are sometimes classified as a type of flexible packaging, and these two product categories often overlap.

rotogravure process used for publication includes a solvent recovery system. During the drying process ink is heated, releasing the HAPs into the heated air. Capture systems may vary depending on the age of the press; however, the majority of the solvent is captured from the dryer exhausts, combined with solvent-laden air captured from other presses, and routed to the solvent recovery system. HAP emissions result from incomplete recovery of captured HAP and from incomplete capture. As the printed substrate passes through the dryers, most of the HAPs are captured in the exhaust systems of the dryers. However, some of these emissions escape. For example, HAPs are emitted from the ink fountains, the web as it is swept from the dryer to the next station, the web after it leaves the last dryer and moves on to further processing, and the printed product as it leaves the plant.[17] HAPs from proofing presses, cleaning operations, ink storage tanks, and ink mixing operations are relatively minor compared to the emissions during the printing process, but they do contribute to overall emissions.

HAPs in packaging and product gravure processes are contained in the inks and other coatings applied by the gravure presses. The predominant type of ink used is based on nitrocellulose resin. Some polyamide inks are also used. Solvent systems include aromatic, aliphatic, and oxygenated hydrocarbon solventborne inks as well as water-based inks. Specific HAPs that may be contained in the product/packaging gravure inks include toluene, hexane, methyl ethyl ketone, methyl isobutyl ketone, methanol, and glycol ethers. The specific type of ink used depends on the nature of the substrate printed, the type of product or package printed, the age of the press, and existing air pollution regulations and permit requirements related to volatile organic compound (VOC) emissions.[18]

Capture systems in use at product/packaging gravure facilities include combinations of dryer exhausts, floor sweeps, collection ducting, hoods, press enclosures, total

enclosures, room enclosures, negative pressure pressrooms, partial enclosures, and ink pan covers. Air pollution is controlled using either carbon adsorption, thermal incineration, or catalytic incineration. A fourth strategy involves using waterborne technologies. However, waterborne inks may still contain HAPs (e.g., glycol ethers, methanol).[19] Furthermore, some solventborne inks are HAP free. HAP-free inks are available and are currently in use at product/packaging gravure facilities. Pollution can also be prevented by using the inks that contain low percentages of HAPs. Low-HAP inks contain a small proportion of glycol ethers, which function to reduce surface tension and improve flow characteristics and are used mainly by facilities that print paper and cardboard packaging.[20]

Because of the wide variety of substrates printed and products produced by product/packaging gravure facilities, printers must use a wide variety of inks with different performance characteristics and hundreds of different colors. Low-HAP inks may not be available in the many different ink types and colors required to meet the performance standards of the customer. The existing control devices, which in most cases are designed and operated for VOC control, may not be compatible with low HAP formulations. Therefore, some facilities that are operating efficient VOC control systems may have little incentive to reduce the HAP content of their inks.

2.1.2 Flexographic Printing Process

Flexography is a printing process in which the ink is printed directly on the substrate from raised portions of the plate cylinder. Flexography plates, as the name implies, are made of a soft, flexible material. Most flexo plates today are made by one of many ultraviolet-cured polymer processes, which are compatible with computer typesetting processes. The web is fed between an impression cylinder and the coated plate cylinder. The inking system transfers the ink onto an anilox, or engraved, roller that meters the ink and prevents

too much from being transferred to the plate cylinder. As in gravure, the anilox roll is scraped with a doctor blade. Because of the metering anilox roller, flexography is capable of high-quality half-tone printing, which is demonstrated in many flexible packaging applications where flexo is used to print on plastic films.

The many types of flexographic presses include wide web (greater than 18 inches), narrow web, in-line, common impression, and stack presses. All flexographic presses use flexible plates, fluid inks, and anilox-roll inking systems. Packaging products, by the type of flexographic presses commonly used, include the following:

- labels with narrow web in-line, stack, and common impression (CI);
- flexible packaging and paper sacks with wide web CI, stack, and in-line;
- folding cartons with narrow and wide web in-line or stack;
- sanitary food containers, beverage containers, and laminations with wide web in-line or CI;
- corrugated liners with wide web CI-stack combinations;
- fiber cans and tubes with narrow and wide web in-line or CI; and
- corrugated boxes with sheet-fed printer slotters.[21]

2.1.2.1 Flexographic Printing Substrates. An important characteristic of flexographic printing is its ability to print on a wide variety of materials: rough or smooth, coated or uncoated, paper or board, as well as plastic and metal.[22] Substrates used in flexographic presses include plastics, polyolefins, polystyrene, polyesters; various paper and paperboard stocks, glassine, tissue, sulfite, kraft, folding carton type board, corrugated board, and cup and container board; and metals and aluminum foil. Additionally, corrugated

cartons are one of the few substrates printed by sheet-fed flexography.

2.1.2.2 Flexographic Inks, Coatings, and Solvents. The ink used in flexography is of low viscosity because the ink must be fluid to print properly. Many of the inks are water-based, but alcohol or other low-viscosity, volatile liquids are also used as the ink base. Most flexographic printing (including all flexographic newspaper and corrugated carton printing) is done with waterborne inks.[23] Solvents used must be compatible with the rubber or polymeric plates; thus, aromatic solvents are not used. Some of the components of solvent-based flexographic ink include ethyl, n-propyl, and i-propyl alcohols; glycol ethers; aliphatic hydrocarbons; acetates; and esters.[24] Low-viscosity ink does not hold the dot pattern as well as the high-viscosity inks used in letterpress printing.[25]

When flexography is used to print corrugated board and most paperboard, the ink used can dry by penetration of the water into the board because corrugated board and paperboard can absorb quite a bit of water without it significantly distorting the surface. However, fast drying inks are required for plastic films and packaging papers so the web can be rewound or processed into the final product on the end of the press. Flexography is becoming popular for printing pressure-sensitive labels, a process in which the ink must dry quickly without penetration. Use of inks that dry by exposure to ultraviolet radiation have been used in label printing with much success.

2.1.2.3 Flexographic Printed Products. Wide web flexographic presses are used to print a variety of publication and packaging commodities. In the case of publication printing, flexography is used to print mainly Sunday magazines, comics, and comic books. Directories are flexoprinted and, for advertising, flexography is used to print direct mail advertising and newspaper inserts. Unlike gravure, flexography is used to print newspapers; financial

and legal materials such as SEC filing, prospectuses, annual corporate reports, and bank printing; some business forms; envelopes; and paperbacks.

Flexography is mainly used, however, for printing packaging. Most corrugated container printing is done by flexography. Other flexographically printed packaging includes folding cartons, beverage carriers (special carriers for beer and other beverages), sanitary food containers (e.g., milk and beverage cartons and sanitary single service cups and containers), plastic carrier bags, flexible packaging, multiwall sacks, paper sacks, and rigid paper set-up boxes. In addition, printed products that use the flexographic process include gift wrap, paper towels, tissues, vinyl shower curtains, and wallpaper.

2.1.2.4 HAP Emissions from Flexographic Printing Process. During the flexographic printing process HAPs are emitted from the inks and other materials applied with flexographic plates, including varnishes, primers, and adhesives. HAPs are also emitted from the solvents used to clean the flexographic presses and equipment. Additional converting operations, which are often done at the flexographic press stations or in-line with the presses, such as film blowing, laminating, coating, adhesive application, and cutting, may result in additional HAP emissions.

Waterborne inks that contain no HAPs are available for some flexographic applications. Other waterborne inks used in flexography contain relatively low proportions of HAPs, principally ethylene glycol and glycol ethers. Most of the solventborne flexographic inks contain little or no HAPs.[26] The solvent-based inks used primarily are formulated with non-HAP solvents that may contain small proportions of ethylene glycol, glycol ethers and methanol, which are HAPs. Solvent-based inks that are completely HAP free are available for some applications.[27] The ink choice is influenced by the same factors that influence ink choice for packaging and product gravure.

Air pollution capture and control systems used with flexographic processes are designed and operated for the control of VOCs. Capture systems in use at flexographic printing facilities include combinations of dryer exhausts, floor sweeps, hoods, and total enclosures. Control devices are the same as those used at product/packaging gravure facilities: carbon adsorption, catalytic incinerators, and thermal incinerators.[28] Pollution prevention opportunities through using HAP-free inks are promising in the flexographic printing industry especially in corrugated box and newspaper production, in which HAP-free inks can produce nearly identical products to those using low-HAP inks. The variety of products printed by flexography, as with packaging and product gravure, requires different substrates, and the types of inks used demand performance requirements that may not be met by low-HAP ink formulations.

2.1.3 Binding, Finishing, and Converting Processes

The printing process may only be one step in the production of a finished product. Some printed products, such as letterheads, handbills, and posters, are ready for shipment after printing with only some trimming and packaging for shipment. Most printed products, however, become part of something else and require further processes called binding, finishing, and converting operations, which convert the printed substrate into a final product. Many of the operations are performed in-line with the printing. Binding is the work required to convert printed sheets or webs of paper into books, magazines, catalogs, or folders.[29] Finishing and converting operations are required to complete printed tags, labels, advertising displays, folding boxes, and flexible packaging. Finishing and converting operations include mounting, die-cutting, and easeling of displays; folding, collating, drilling, varnishing or laminating, embossing, bronzing, flocking, die-stamping, pebbling, beveling, deckling, gilt and marble edging of printed and unprinted materials; cutting creasing, stripping and gluing of

folding paper cartons; and slotting and gluing corrugated boxes.[30]

2.2 PRODUCTS AND MARKETS

Because of the multiplicity of printed products and wide variety of differentiation, printed materials are not homogeneous products. Printed commodities are one of three types: publication, packaging, and product. Specific products of interest by type include the following:

- publication: magazines, catalogs, directories, printed advertising materials and displays, newspapers, Sunday magazines;
- packaging: corrugated containers, folding cartons (used for wet and dry foods, beverages, bakery items, candy and non-food products such as detergents, hardware, paper goods, cosmetics, medical products, tobacco products, and sporting goods),[31] rigid boxes, flexible packaging, tags, labels, sanitary food containers, paper sacks, plastic carrier bags; and
- product: gift wraps, wallcoverings, floor coverings, decorative laminates used in furniture and construction, tissue products, upholstery, tablecloths, and shower curtains.

Tables 2-2, 2-3, and 2-4 present U.S. Department of Commerce Census data for value of U.S. shipments for these major product classes. Table 2-2 presents shipments for publication printing and printed publication products.[32] In 1991, the commercial printing segments (2752, 2754, 2759) had a total of $51.8 billion in shipments. Between 1987 and 1991, the gravure printing commercial sector grew at an annual average of 4.3 percent, while flexography grew at an average yearly rate of 8.6 percent. The total value of shipments for printed publication products (2711, 2721, 2731, 2741, 2761) in 1991 was $83.4 billion with an average annual growth of 3.5 percent from 1987 to 1991.

TABLE 2-3. VALUE OF PRODUCT SHIPMENTS FOR PACKAGING MATERIALS, 1987-1991 (10^6)

Industry SIC/product code	Product description	Value of product shipments* 1987	1988	1989	1990	1991	Average annual growth 1987-1991 (%)
2652	Setup paperboard boxes	517.9	520.2	573.5	602.2	599.4	3.81
2653	Corrugated & solid fiber boxes	15,602.2	17,335.1	18,324.6	17,978.9	17,434.4	2.97
2655	Fiber cans, drums, and similar products	1,493.9	1,586.4	1,749.7	1,795.3	1,801.5	4.86
2656	Sanitary food containers	1,959.6	2,097.2	2,308.7	2,468.8	2,583.4	7.17
2657	Folding paperboard boxes	5,521.8	5,865.8	6,567.3	6,793.5	7,199.6	6.90
2671	Paper coated & laminated, packaging	2,460.1	2,712.6	2,850.1	2,979.9	3,069.6	5.72
2672	Paper coated & laminated, n.e.c.	5,497.7	6,148.2	6,674.1	6,678.3	6,933.2	6.07
26723	Pressure sensitive products	3,100.0	3,642.9	3,896.3	3,882.3	4,151.7	7.76
2673	Bags: plastics, laminated, coated	3,936.5	4,557.5	5,117.3	5,127.8	4,806.4	5.50
2674	Bags: uncoated paper, multiwall	2,360.6	2,574.2	2,638.8	2,621.3	2,527.9	1.83
3081	Unsupported plastics film & sheet	8,766.7	9,610.0	9,958.5	10,255.4	9,972.8	3.37
3083	Laminated plastics	2,093.9	2,319.6	2,333.3	2,188.7	2,049.3	-0.30
3085	Plastic bottles	2,849.6	3,322.4	3,730.9	3,888.9	4,169.6	10.09
3089	Plastics, n.e.c.	32,927.6	34,237.2	35,875.2	37,300.9	37,648.1	3.42
30894	Plastics, packaging	4,005.9	4,302.0	5,004.2	5,196.9	5,467.6	8.19
3221	Glass Containers	4,720.7	4,644.3	4,760.0	4,915.1	4,847.3	0.69
3411	Metal cans	10,652.5	10,944.1	10,995.7	12,114.3	12,207.3	3.54
3466	Crowns & closures	811.4	711.1	733.3	745.4	692.6	-3.67
	Totals	109,278.6	117,130.8	124,091.5	127,533.9	128,161.7	4.10

* Value of products shipped represents the value of shipments for the product category regardless of the industry that produces it (i.e., it includes shipments from both primary and secondary producers).

n.e.c. = Not elsewhere classified.

Source: U.S. Department of Commerce. 1991 Annual Survey of Manufactures.

TABLE 2-4. VALUE OF PRODUCT SHIPMENTS FOR PRODUCTS THAT ARE PRINTED, 1987-1991 (10^6)

Industry SIC/product code	Product description	Value of product shipments[a] 1987	1988	1989	1990	1991	Average annual growth 1987-1991 (%)
2676	Sanitary paper products	11,171.7	11,853.4	13,637.2	14,007.5	14,755.7	7.30
2677	Envelopes	2,499.5	2,650.2	2,603.7	2,602.4	2,492.3	0.00
2678	Stationery products	1,115.2	1,166.1	1,156.8	1,197.2	1,237.1	2.65
2679	Converted paper products, n.e.c.	3,385.5	3,685.9	3,626.9	3,963.8	4,122.0	5.14
26791	Wallcoverings	530.2	533.8	517.7	547.7	557.6	1.32
26792	Gift wraps	591.7	571.1	591.4	621.0	626.4	1.49
2771	Greeting cards	2,034.6	2,205.8	2,534.9	2,900.5	2,978.1	10.11
	Totals	21,328.4	22,666.3	24,668.6	25,840.1	26,769.2	5.86

[a] Value of products shipped represents the value of shipments for the product category regardless of the industry that produces it (i.e., it includes shipments from both primary and secondary producers).

n.e.c. = Not elsewhere classified.

Source: U.S. Department of Commerce. 1991 Annual Survey of Manufactures. Value of Product Shipments. Washington, DC, U.S. Government Printing Office, 1992. Table 1.

Table 2-3 presents value of shipments for packaging materials.[33,e] In 1991, value of shipments for packaging materials was $128.2 billion. Plastics, n.e.c., had the greatest value of shipments at $37.6 billion in 1991, with corrugated and solid fiber boxes ($17 billion) and metal cans ($12 billion) second and third greatest, respectively. Packaging material products have experienced steady growth over the 1987 to 1991 period, growing at an average annual rate of 4.1 percent.

Table 2-4 presents value of shipments for various printed products.[34] These product categories in aggregate have grown steadily since 1987 with an average annual growth rate of 5.9 percent over this 5-year period. Total shipments for 1991 were $26.8 billion. The leading product category is sanitary paper products with $14.8 billion in shipments for 1991.

As illustrated in Figure 2-2, the printing industry is procyclical in that it closely follows the economic performance of the U.S. as measured by gross domestic product (GDP). As shown in the figure, the cyclical pattern of growth for the printing industry mirrors that of the U.S. economy. Steady growth from 1987 to 1990 was followed by a sharp decline in growth from 1990 to 1991 as a result of a recessionary period for the U.S. economy. The average annual growth in GDP (current dollars) from 1987 to 1991 was 5.74 percent. During this same period, in the printing industry, the average annual growth rate was 5.86 percent for products, 4.2 percent for publications, and 4.1 percent for packaging.

2.2.1 Foreign Trade

Table 2-5 presents the value of U.S. imports and exports for printing and printed products for 1989 to 1991.[35] The product categories listed represent printing and printed products for which data are available. U.S. imports rose by 2.9 percent to reach $2.9 billion from 1990 to 1991. Book

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[e]Shipments for commercially printed labels and wrappers are included in data in Table 2-2.

TABLE 2-5. VALUE OF EXPORTS AND IMPORTS FOR PRODUCTS RELATED TO PRINTING, 1989-1991 (10^6)

SIC code	Product description	Exports 1989	Share[a] (%)	1990	Share[a] (%)	1991	Share[a] (%)	Imports 1989	Share[b] (%)	1990	Share[b] (%)	1991	Share[b] (%)
2711	Newspapers	28.6	0.1	37.7	0.1	40.0	0.1	96.1	0.3	62.0	0.2	52.7	0.2
2721	Periodicals	448.0	2.4	666.0	3.5	740.0	3.8	140.0	0.8	122.0	0.7	105.0	0.6
2731	Book publishing	1,288.0	9.9	1,428.0	10.0	1,500.0	9.8	746.0	6.0	845.0	6.2	925.0	6.3
275	Commercial printing	811.0	1.6	772.0	1.5	925.0	1.8	388.0	0.8	393.0	0.8	450.0	0.9
2652	Set up paperboard boxes	26.8	4.7	35.0	5.8	80.0	13.3	6.0	1.2	5.6	1.0	4.0	0.8
2653	Corrugated & solid fiber boxes	225.0	1.2	282.0	1.6	350.0	2.0	30.6	0.2	39.4	0.2	40.0	0.2
2655	Fiber cans, drums, and similar products	10.5	0.6	18.2	1.0	20.0	1.1	2.8	0.2	3.0	0.2	1.2	0.1
2656	Sanitary food containers	79.0	3.4	96.8	3.9	90.0	3.5	25.6	1.3	29.3	1.3	28.0	1.2
2657	Folding paperboard boxes	62.5	0.9	78.9	1.2	75.0	1.0	75.5	1.3	88.5	1.3	90.0	1.3
2672	Paper coated & laminated, n.e.c.	337.0	6.1	455.0	6.8	416.0	6.0	128.0	2.2	124.0	2.0	118.0	1.8
2673	Bags: plastics, laminated, coated	95.5	1.9	130.0	2.5	195.0	4.1	286.0	6.0	301.0	5.7	310.0	5.9
2674	Bags: uncoated paper, multiwall	32.0	1.2	48.0	1.8	45.0	1.8	59.6	2.3	72.2	2.7	65.0	2.5
2676	Sanitary paper products	242.0	1.8	351.0	2.5	480.0	3.3	302.0	2.5	152.0	1.1	120.0	0.9
2677	Envelopes	10.0	0.4	19.0	0.7	22.3	0.9	5.1	0.2	5.2	0.2	7.8	0.3
2678	Stationery products	39.3	3.4	66.3	5.5	70.5	5.7	45.5	3.9	48.5	4.3	49.8	4.2
2679	Converted paper products, n.e.c.	328.0	9.0	358.0	9.0	367.0	8.9	470.0	12.3	531.0	13.9	538.0	13.0
	Totals	4,063.2	2.3	4,841.9	2.6	5,415.8	2.9	2,806.8	1.6	2,821.7	1.5	2,904.5	1.6

n.e.c. = Not elsewhere classified.

Source: U.S. Department of Commerce. U.S. Industrial Outlook, 1992. Washington, DC, U.S. Government Printing Office, 1992. Chapters 10 and 25.

[a]Reflects export share of U.S. value of shipments.
[b]Reflects import share of U.S. value of domestic consumption.

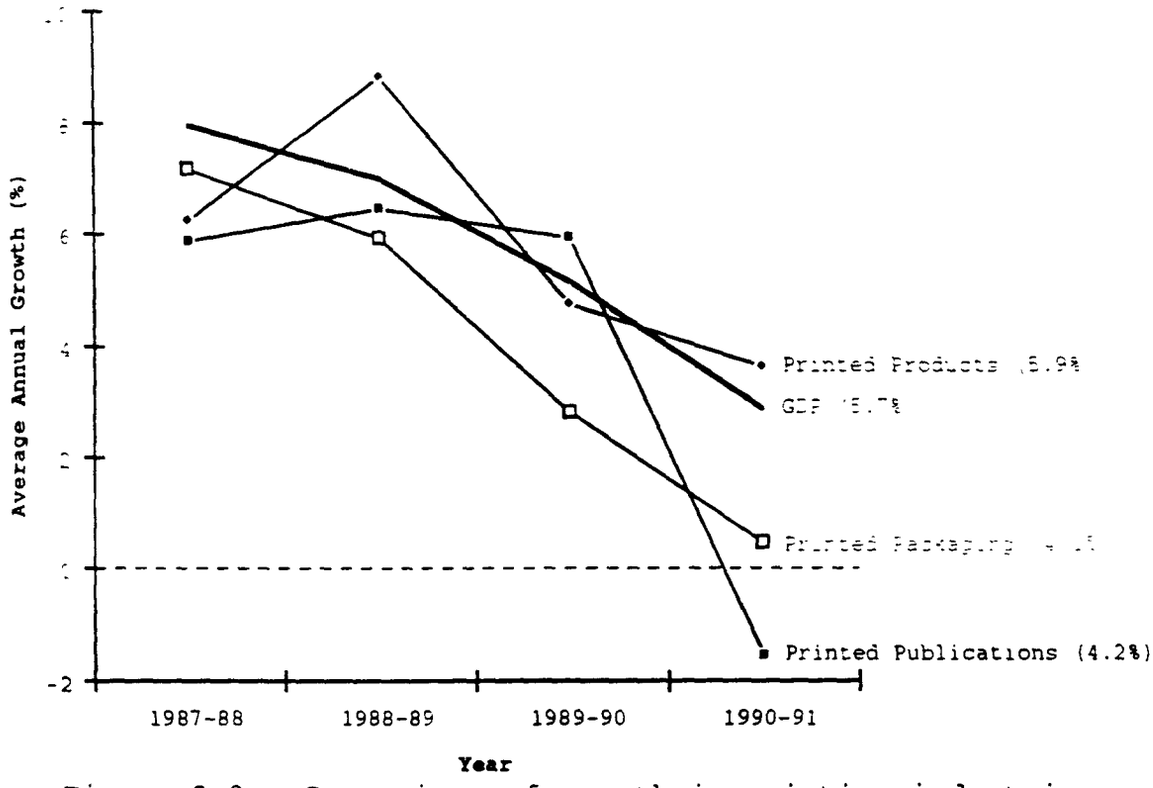

Figure 2-2. Comparison of growth in printing industries with U.S. gross domestic product: 1987-1991.

Note: Growth rates reflect annual change in current dollars. Numbers in parentheses represent average annual change from 1987 to 1991.

publishing represents the largest share of imports, with $925 million in 1991. U.S. exports rose by 32 percent to reach $5.4 billion from 1990 to 1991. Book publishing represents the largest share of exports with $1.5 billion in 1991. However, as shown in Table 2-5, neither exports nor imports represent a notable share of U.S. value of shipments or domestic consumption within the industry.

2.2.2 Future Projections

Table 2-6 presents a forecast of market trends in the U.S. printing industry for the years 1990 through 2000.[36] The table shows that growth in the industry is expected to be between 3.8 and 5.3 percent annually. Markets expected to

TABLE 2-5. VALUE OF EXPORTS AND IMPORTS FOR PRODUCTS RELATED TO PRINTING, 1989-1991 (10^6)

SIC code	Product description	Exports 1989	Share[a] (%)	1990	Share[a] (%)	1991	Share[a] (%)	Imports 1989	Share[b] (%)	1990	Share[b] (%)	1991	Share[b] (%)
2711	Newspapers	28.6	0.1	37.7	0.1	40.0	0.1	96.1	0.3	62.0	0.2	52.7	0.2
2721	Periodicals	448.0	2.4	666.0	3.5	740.0	3.8	140.0	0.8	122.0	0.7	105.0	0.6
2731	Book publishing	1,288.0	9.9	1,428.0	10.0	1,500.0	9.8	746.0	6.0	845.0	6.2	925.0	6.3
275	Commercial printing	811.0	1.6	772.0	1.5	925.0	1.8	388.0	0.8	393.0	0.8	450.0	0.9
2652	Set up paperboard boxes	26.8	4.7	35.0	5.8	80.0	13.3	6.0	1.2	5.6	1.0	4.0	0.8
2653	Corrugated & solid fiber boxes	225.0	1.2	282.0	1.6	350.0	2.0	30.6	0.2	39.4	0.2	40.0	0.2
2655	Fiber cans, drums, and similar products	10.5	0.6	18.2	1.0	20.0	1.1	2.8	0.2	3.0	0.2	1.2	0.1
2656	Sanitary food containers	79.0	3.4	96.8	3.9	90.0	3.5	25.6	1.3	29.3	1.3	28.0	1.2
2657	Folding paperboard boxes	62.5	0.9	78.9	1.2	75.0	1.0	75.5	1.3	88.5	1.3	90.0	1.3
2672	Paper coated & laminated, n.e.c.	337.0	6.1	455.0	6.8	416.0	6.0	128.0	2.2	124.0	2.0	118.0	1.8
2673	Bags: plastics, laminated, coated	95.5	1.9	130.0	2.5	195.0	4.1	286.0	6.0	301.0	5.7	310.0	5.9
2674	Bags: uncoated paper, multiwall	32.0	1.2	48.0	1.8	45.0	1.8	59.6	2.3	72.2	2.7	65.0	2.5
2676	Sanitary paper products	242.0	1.8	351.0	2.5	480.0	3.3	302.0	2.5	152.0	1.1	120.0	0.9
2677	Envelopes	10.0	0.4	19.0	0.7	22.3	0.9	5.1	0.2	5.2	0.2	7.8	0.3
2678	Stationery products	39.3	3.4	66.3	5.5	70.5	5.7	45.5	3.9	48.5	4.3	49.8	4.2
2679	Converted paper products, n.e.c.	328.0	9.0	358.0	9.0	367.0	8.9	470.0	12.3	531.0	13.9	538.0	13.0
	Totals	4,063.2	2.3	4,841.9	2.6	5,415.8	2.9	2,806.8	1.6	2,821.7	1.5	2,904.5	1.6

n.e.c. = Not elsewhere classified.

Source: U.S. Department of Commerce. U.S. Industrial Outlook, 1992. Washington, DC, U.S. Government Printing Office, 1992. Chapters 10 and 25.

[a]Reflects export share of U.S. value of shipments.
[b]Reflects import share of U.S. value of domestic consumption.

TABLE 2-6. U.S. PRINTING INDUSTRY FORECAST 1990 TO 2000

Industry segment	Forecast annual percent growth 1990 - 2000[a]
Magazines and other periodicals	2-3
Catalogs and directories	3-4
Direct mail	5-6
Labels and wraps	0-2
Inserts and coupons	3-4
Other advertising and free circulation papers	8-9
Annual reports and related products	4-5
Business forms	1-2
Business communications	2-3
Manuals and technical documentation	-2-0
Books	1-2
Printing trade services	3-4
Industry total	3.8-5.3

[a]Based on constant 1988 dollars.

Source: SRI. Printing 2000. Prepared by SRI International, Menlo Park, CA, for the Printing 2000 Task Force. Alexandria, VA, Printing Industries of America. 1990. p. ES-15.

realize particularly strong growth include other advertising (i.e., printed advertising other than direct mail, coupons, and inserts) and free circulation papers at 8 to 9 percent annually and direct mail at 5 to 6 percent annually. The growth in free circulation papers is expected to bring about an increase in the use of flexographic presses instead of non-heatset offset presses that currently dominant this market segment.[37]

Moreover, a number of traditional printing markets are projected to grow below the industry average from 1990 to

2000. These print markets include book printing and business form printing at only 1 to 2 percent annually and magazines and other periodicals at 2 to 3 percent annually. Offset printing is expected to continue to dominate the magazine and periodical publishing market.[38]

2.3 MANUFACTURING PLANTS

EPA conducted a survey of publication rotogravure, packaging/product gravure, and flexography printing plants from which the number of manufacturing plants for each of these market segments are taken. Plant data for each segment are discussed separately below.

2.3.1 Publication and Packaging/Product Gravure Plants

In 1993, 27 publication rotogravure plants operated in the U.S.[39] EPA estimates that their survey included all publication rotogravure plants in the U.S. The number of rotogravure plants have been decreasing over the last decade. The GAA confirmed that in 1988 at least 545 packaging/product plants had rotogravure presses.[40] For 1987, the U.S. Department of Commerce reports that 332 plants were classified in the gravure commercial printing industry (SIC 2754).[41] Of these 332 facilities, 33 were identified as having publication gravure printing as their primary line of business, which supports the 1993 EPA figure of 27 plants. It is also consistent that the GAA estimate of packaging/product facilities is greater than the Census estimate because the former includes gravure printing done by plants that are classified in other manufacturing industries.

2.3.1.1 Location, Presses, and Products Printed. Figure 2-3 identifies the locations of the 27 facilities in the U.S. that print publication rotogravure, and Table 2-7 lists each plant by company name, city, and state.[42] EPA surveyed all 27 of these locations and received plant and process description information. Together these plants operate a total of 159 gravure presses with an average of 8.9 printing units per

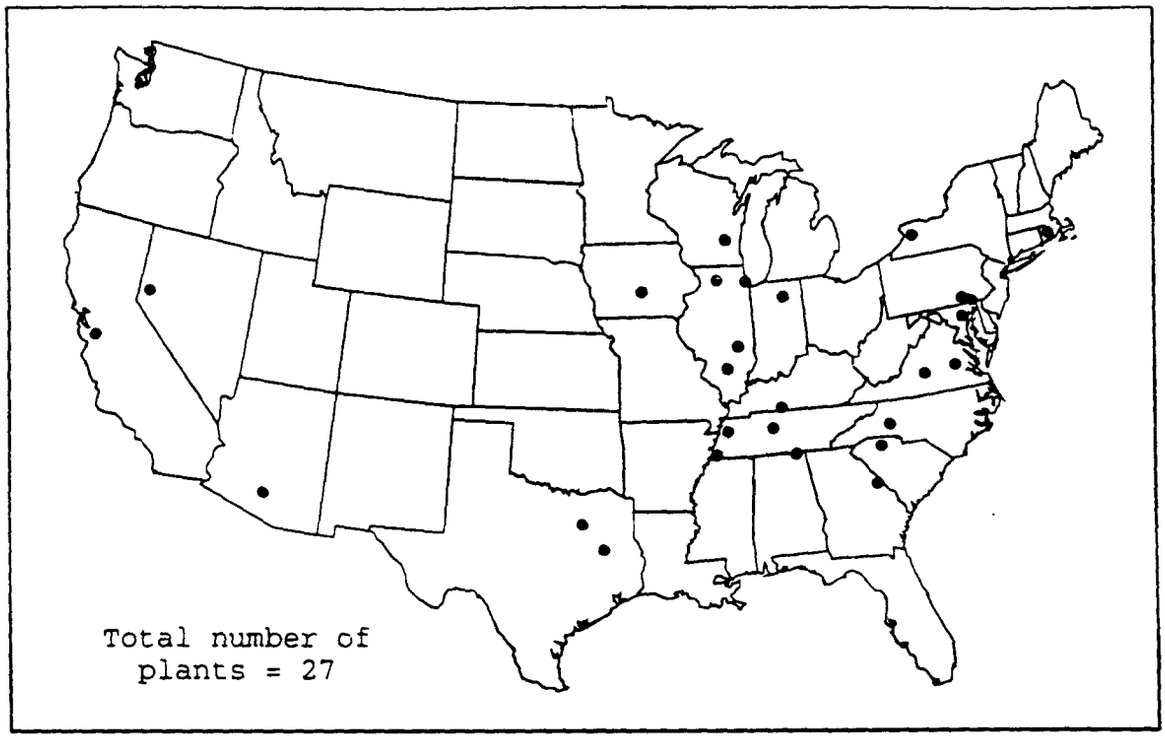

Figure 2-3. Location of publication rotogravure printing plants, U.S.

Source: U.S. Environmental Protection Agency. Background Information Document for National Emission Standards for the Printing and Publishing Industry. Prepared by Research Triangle Institute for the Office of Air and Radiation, Research Triangle Park, NC. 1994. Table 2-1.

units per press.[43] For confidentiality reasons, it is not possible to report the number of presses by actual plant from the EPA database.

The GAA conducted its own survey of publication rotogravure plants in North America and reports 160 to 165 rotogravure presses, with 1,494 printing units.[44] Almost half of the presses for which GAA was able to gather data had eight units; the second most common was presses having 10 units. The trend appears to be moving away from presses with fewer than eight units. GAA found that the average age of a gravure publication press was 16 years and that the industry is rebuilding and expanding its press equipment to keep even old presses productive. Gravure publication printers have

TABLE 2-7. PUBLICATION ROTOGRAVURE PLANTS

Company name	City	State
Brown Printing Company	Franklin	KY
R.R. Donnelley and Sons	Casa Grande	AZ
R.R. Donnelley and Sons	Lynchburg	VA
R.R. Donnelley and Sons	Newton	NC
R.R. Donnelley and Sons	Des Moines	IA
R.R. Donnelley and Sons	Mattoon	IL
R.R. Donnelley and Sons	Reno	NV
R.R. Donnelley and Sons	Warsaw	IN
R.R. Donnelley and Sons	Spartanburg	SC
R.R. Donnelley and Sons	Lancaster	PA
R.R. Donnelley and Sons	Chicago	IL
R.R. Donnelley and Sons	Gallatin	TX
Quad/Graphics	Lomira	WI
Quebecor Printing	Atglen	PA
Quebecor Printing	Depew	NY
Quebecor Printing	Dallas	TX
Quebecor Printing	Dickson	TN
Quebecor Printing	Baltimore	MD
Quebecor Printing	Memphis	TN
Quebecor Printing	Mt. Morris	IL
Quebecor Printing	Providence	RI
Quebecor Printing	Richmond	VA
Quebecor Printing	San Jose	CA
Ringier America Inc.	Corinth	MS
Ringier America Inc.	Evans	GA
World Color Press, Inc.	Salem	IL
World Color Press, Inc.	Dyersburg	TN

Source: U.S. Environmental Protection Agency. Engineering draft report for the printing and publishing industry. Prepared by Research Triangle Institute. 1994. Chapter 2.

been investing in a substantial amount of new folding equipment since 1981, and most of the presses today are equipped with some type of folding machinery. Press running speeds average 1,977 feet per minute.

Table 2-8 presents data compiled by GAA from U.S. and Canadian gravure publication plants for number of presses and units at plants producing particular products as primary, secondary, and tertiary.[45] For each product listed, reading across the columns indicates the number of presses and units in plants committed in whole or part to each product line. The greatest number of presses are used in plants that print magazines, catalogs, and advertising inserts as their primary product. Catalogs are the most favored secondary product. It is necessary to keep in mind that the number of presses listed by product in Table 2-8 is not necessarily the number devoted to printing that particular product, but rather the number

TABLE 2-8. NUMBER OF GRAVURE WEB PRESSES IN THE PUBLICATION GRAVURE INDUSTRY, 1989

	Number of presses/units in plants where product is					
	Primary		Secondary[a]		Tertiary[a]	
Product	Presses	Units	Presses	Units	Presses	Units
Magazines	47	411	17	156	13	124
Sunday magazines	11	105	26	227	3	33
Inserts	44	428	35	359	20	168
Catalogs	40	391	52	489	6	53
Advertising printing	5	40	4	34	10	87
Other	0	0	6	54	2	22
Total	147	1,375	140	1,319	54	487

[a] Secondary or tertiary capacity indicates the total numbers at plants that produce each product as a secondary or tertiary product rather than the numbers devoted only to production of that product. It is not determined how much of the secondary or tertiary producers' capacity is devoted to the product.

Source: Gravure Association of America. Profile Survey of the U.S. Gravure Industry. New York, GAA. 1989. PRESS-10.

operated by plants that print those products as either primary, secondary, or tertiary.

EPA collected survey data from 107 packaging/product facilities operating rotogravure presses. Table 2-9 lists the company names, locations, total employees, and products printed for those plants surveyed.[46] Forty-four of these facilities print on paper and cardboard only, 12 on foil and film only, and 29 print on paper or cardboard and foil or film. Another 13 print exclusively on vinyl products and 9 print miscellaneous products.

GAA compiles extensive data on presses at packaging and product gravure plants and estimates that their database identifies presses and units for 75 to 90 percent of the total producers for most packaging and product areas.[47] Based on these data, GAA has developed estimates of the total number of presses and units operating in the packaging and product gravure industry. Table 2-10 summarizes the estimated number of presses and units at U.S. packaging and product gravure plants by primary and secondary product specialty.[48] It cannot be determined how much of the press capacity at plants producing a certain product as secondary is devoted to that product.

2.3.2 Flexography Plants

An estimated 1,587 printing plants in the U.S. have flexographic presses.[49] Most facilities that operate wide web flexographic presses produce various types of packaging. Flexible packaging producers often operate both flexographic and rotogravure presses at the same facilities. Some equipment may even be a combination flexography/gravure. The selection of equipment for a particular job depends on the length of run, quality requirements, and the substrate. Because the printing portion of the total packaging value is often rather small, many facilities that produce corrugated cartons and paper bags may not consider themselves to be printers.[50]

TABLE 2-9. PACKAGING AND PRODUCT ROTOGRAVURE PLANTS

Company name	City	State	Facility employment	Product code
Alcan Foil Products	Louisville	KY	175	F
Alford Packaging	Baltimore	MD	49	P
Allied Stamp Corporation	Sand Springs	OK	100	P
Alusuisse Flexible Packaging, Inc.	Shelbyville	KY	15	M
American Fuji Seal, Inc.	Anaheim	CA	7	F
American Fuji Seal, Inc.	Fairfield	NJ	11	F
American Greetings	Corbin	KY	100	P
AMGRAPH Packaging, Inc.	Versailles	CT	13	M
Avery Dennison	Clinton	SC	90	M
Avery Dennison	Schereville	IN	161	V,W
Avery Dennison	Framingham	MA	298	P
Avery Dennison	Pasadena	CA	19	W
Butler Printing & Laminating, Inc.	Butler	NJ	60	V
Cello-Foil Products, Inc.	Battle Creek	MI	100	M
Chiyoda America Inc.	Morgantown	PA	30	P
Cleo, Inc.	Memphis	TN	130	P
Columbus Coated Fabrics	Columbus	OH	97	V,F
Congoleum Corporation	Marcus Hook	PA	88	V
Congoleum Corporation	Mercerville	NJ	11	V
Constant Services, Inc.	Fairfield	NJ	45	V
CPS Corporation	Franklin	TN	61	M
Decor Gravure Corporation	Bensenville	IL	50	V
Decorating Resources	Clifton	NJ	50	F
Decorative Specialties International, Inc.	West Springfield	MA	6	W
Decorative Specialties International, Inc.	Reading	PA	8	M
Decorative Specialties International, Inc.	Johnston	RI	155	P
Dinagraphics	Norwood	OH	150	W
Dittler Brothers	Atlanta	GA	42	W
Dittler Brothers	Oakwood	GA	42	W
Dopaco, Inc.	Downingtown	PA	63	P

(continued)

TABLE 2-9. PACKAGING AND PRODUCT ROTOGRAVURE PLANTS (CONTINUED)

Company name	City	State	Facility employment	Product code
Dopaco, Inc.	Stockton	CA	43	P
Dopaco, Inc.	Saint Clarles	IL	48	P
DRG Medical Packaging	Madison	WI	24	M
Engraph, Inc.	Fulton	NY	90	M
Engraph, Inc.	Moorestown	NJ	6	F
Eskimo Pie Corporation	Bloomfield	NJ	29	M
Federal Paper Board Co., Inc.	Durham	NC	59	P
Federal Paper Board Co., Inc.	Wilmington	NC	240	P
Fleming Packaging Corporation	Peoria	IL	57	M
Fres-Co System USA, Inc.	Telford	PA	210	F
GenCorp Inc.	Jeannette	PA	22	F
GenCorp Inc.	Salem	NH	NA	V
GenCorp Polymer Products	Columbus	MS	186	V
Graphic Packaging Corporation	Franklin	OH	17	M
Graphic Packaging Corporation	Paoli	PA	29	P
Gravure Carton & Label	Surgoinsville	TN	6	P
Gravure Packaging, Inc.	Richmond	VA	80	P
Hallmark Cards	Kansas City	MO	10	P
Hallmark Cards	Leavenworth	KS	175	P
Hargro Flexible Packaging	Edinburgh	IN	12	M
Hargro Packaging	Flemington	NJ	38	M
International Label Company	Clarksville	TN	375	P
International Label Company	Rogersville	TN	95	P
J. W. Fergusson and Sons, Inc.	Richmond	VA	98	M
James River Corporation	Hazelwood	MO	41	M
James River Paper Corporation	Darlington	SC	20	P
James River Paper Corporation	Fort Smith	AR	25	P
James River Paper Corporation	Lexington	KY	13	P
James River Paper Corporation	Portland	OR	20	M
James River Paper Corporation	Kalamazoo	MI	375	P
Jefferson Smurfit Corporation	Jacksonville	FL	21	W
Jefferson Smurfit Corporation	Chicago	IL	14	P

(continued

TABLE 2-9. PACKAGING AND PRODUCT ROTOGRAVURE PLANTS (CONTINUED)

Company name	City	State	Facility employment	Product code
Johio, Inc.	Dayton	OH	48	M
JSC/CCA	Carol Stream	IL	40	P
JSC/CCA	Stone Mountain	GA	17	P
JSC/CCA	Lockland	OH	35	P
JSC/CCA	Santa Clara	CA	48	P
JSC/CCA	North Wales	PA	44	P
Koch Label Company, Inc.	Evansville	IN	78	M
Lamotite, Inc.	Cleveland	OH	15	W
Lux Packaging Ltd.	Waco	TX	48	P
Mannington Mills, Inc.	Salem	NJ	NA	V
Mundet-Hermetite Inc.	Buena Vista	VA	70	P
Newco Inc.	Newton	NJ	60	V
Orchard Decorative Products	Blythewood	SC	80	M
Orchard Decorative Products	St. Louis	MO	87	M
Package Service Company	Northmoor	MO	4	M
Paramount Packaging Corporation	Chalfont	PA	7	F
Paramount Packaging Corporation	Murfreesboro	TN	21	F
Paramount Packaging Corporation	Longview	TX	21	F
Quick Roll Leaf Manufacturing Company	Middletown	NY	9	F
Reynods Metals Company	Richmond	VA	150	F
Reynolds Metals Company	Richmond	VA	533	M
Reynolds Metals Company	Downingtown	PA	150	M
Riverwood International USA, Inc.	West Monroe	LA	138	P
Riverwood International USA, Inc.	Bakersfield	CA	41	P
Riverwood International USA, Inc.	Cincinnati	OH	50	P
Roslyn Converters Inc.	Colonial Heights	VA	55	P
Scientific Games, Inc.	Gilroy	CA	100	W
Scientific Games, Inc.	Alpharetta	GA	40	W
Shamrock Corporation	Greensboro	NC	25	M
Shamrock Corporation	Greensboro	NC	10	P

(continued)

TABLE 2-9. PACKAGING AND PRODUCT ROTOGRAVURE PLANTS (CONTINUED)

Company name	City	State	Facility employment	Product code
Smurfit Flexible Packaging	Schaumburg	IL	24	M
Smurfit Laminations	Elk Grove Village	IL	40	M
Somerville Packaging	Newport News	VA	NA	P
Stone Container Corporation	Louisville	KY	16	P
TECHNOGRAPHICS PRINTWORLD	North Monroe	NC	140	M
The C. W. Zumbiel Company	Cincinnati	OH	52	P
Union Camp Corporation	Englewood	NJ	65	P
Union Camp Corporation	Spartanburg	SC	18	P
Union Camp Corporation	Asheville	NC	100	M
Vernon Plastics Company	Haverhill	MA	50	V
Vitex Packaging, Inc.	Suffolk	VA	51	M
Waldorf Corporation	Saint Paul	MN	123	P
Waldorf Corporation	Chicago	IL	14	P
Wrico Packaging	Chicago	IL	38	M

[a] Product codes:

F = Film/foil only
M = Paper/cardboard and film/foil
P = Paper/cardboard only
V = Vinyl products
W = Miscellaneous

Source: U.S. EPA. Engineering Draft Report for the Printing and Publishing Industry. Prepared by Research Triangle Institute. 1994. Chapter 2.

2.3.2.1 Location, Presses, and Products Printed. Figure 2-4 shows the number of estimated flexographic plants for each state.[51] Newspaper production makes up a small proportion of flexographic printing plants. The U.S. has 35 flexographically printed newspapers, and numbers are expected to grow as flexography presses replace aging letterpress equipment.[52] EPA surveyed approximately 380 companies thought to operate flexographic printing presses and received responses from approximately 500 plants operating wide web flexographic printing presses and from approximately 100 plants operating narrow web equipment.[53]

TABLE 2-10. NUMBER OF GRAVURE WEB PRESSES AND SUMMARY PRESS CHARACTERISTICS FOR THE U.S. PACKAGING AND PRODUCT GRAVURE INDUSTRY, 1989

Segment/product	Number of presses/units in plants where product is: Primary Plants[a]	Primary Presses	Primary Units	Secondary[b] Plants[a]	Secondary[b] Presses	Secondary[b] Units	Total Plants[a]	Total Presses	Total Units	Summary characteristics[c]: Average number of units per press	Average age of press (yr)	Average operating speed (ft/min)	Equipped with electrostatic assist (%)
Web presses													
Packaging													
Folding cartons[d]	92	189	1,216	7	33	212	99	222	1,428	7	13	607	53
Flexible packaging	95	240	1,478	17	48	289	112	288	1,767	7	17	693	42
Labels and wrappers	47	114	677	14	85	596	61	199	1,273	7	17	806	31
Subtotal packaging	234	543	3,371	38	166	1,097	272	709	4,468				
Product													
Gift wrap	11	52	236	6	84	478	17	136	711	5	18	1,147	NA
Floor covering	7	15	78	0	0	0	7	15	78	5	NA	175	NA
Decorative laminates	24	35	124	3	8	42	27	43	166	3	17	400	NA
Wood grain	33	69	300	NA	9	23	33	78	323	5	11	317	27
Vinyl fabrics	20	87	288	11	91	520	31	178	808	3	23	110	NA
Wall coverings	54	176	820	4	58	328	58	234	1,148	5	10	316	NA
Sanitary tissue products	NA	NA	NA	NA	NA	NA	NA	25	25	1	31	2,200	NA
Other products, n.e.c.	NA	NA	NA	NA	NA	NA	NA	245	604	NA	NA	NA	NA
Subtotal product	149	434	1,846	24	250	1,391	173	954	3,866				

[a] The Gravure Association of America did not always distinguish between plants and companies, and they sometimes reported number of presses without indicating number of companies or plants. Therefore, the plant numbers presented are only estimates and probably underestimate the true number of plants.

[b] Secondary capacity indicates the total number at plants that produce each product as a secondary product rather than the numbers devoted only for production of that product. It is not determined how much of the secondary producers' capacity is devoted to the product.

[c] The summary statistics reported are based on GAA's sample estimates.

[d] GAA estimates that plants manufacturing folding cartons operate 24 sheet-fed gravure presses with 40 units.

NA = Not available.
n.e.c. = Not elsewhere classified.
Source: Gravure Association of America. Profile Survey of the U.S. Gravure Industry. New York, GAA. 1989. pp. PRESS 12-34.

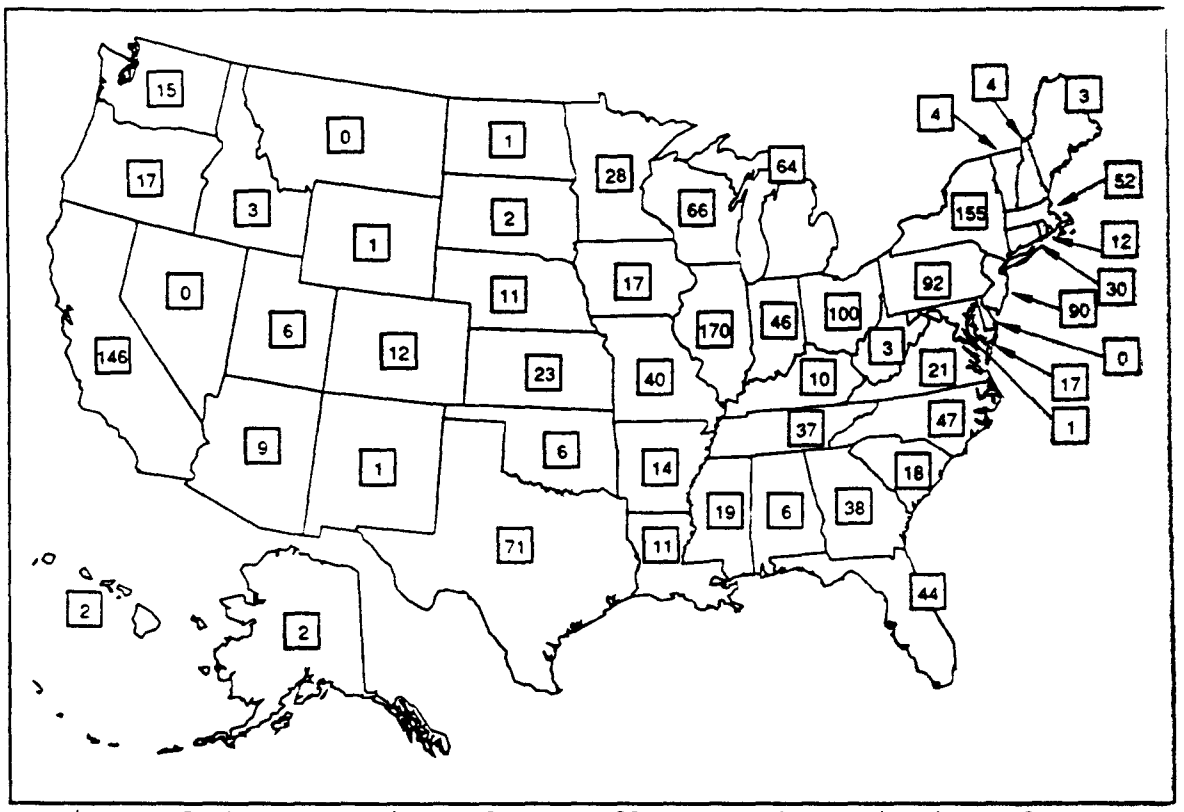

Figure 2-4. Location of U.S. flexography printing plants.

Source: U.S. EPA Office of Pollution Prevention and Toxics. Use Cluster Analysis of the Printing Industry. Washington, DC, U.S. Government Printing Office. May 1992. Table B-18.

Of the 500 wide web flexographic plants, 125 reported using no HAPs in their flexographic printing. These facilities included 49 corrugated box manufacturers, 22 paper product manufacturers, 2 product manufacturers that made at least some plastic products, 1 book manufacturer, and 51 flexible packaging manufacturers. Of the flexible packaging manufacturers, 15 printed on paper substrates, 19 printed on foil or film substrates, and the remaining 17 either printed on both or did not specify.

In addition to the EPA survey, the universe of flexographic presses can be defined as plants producing corrugated boxes and folding cartons using data from the Paperboard Group's Official Container Directory. Paperboard Packaging compiled these data and reports that in 1993 952 flexo

printer-slotters and 1,378 flexo folder-gluers operated at a total of 1,387 corrugated box plants (sheet and web plants) in the U.S.[54] Another 176 sheet and web flexo presses were operating at 480 folding carton plants. Over half of the flexographic presses are at corrugated box and folding carton plants in the East North Central, South Atlantic, and Middle Atlantic (Pennsylvania, New York, New Jersey) regions.

2.3.3 Employment at Printing Plants

The printing industry is characterized by plants with a small number of employees. For the gravure printers, almost 45 percent of the individual plants employ one to four employees. Less than 2 percent of the gravure plants employ over 1,000 employees. Figure 2-5 shows the distribution of gravure plants by average number of employees.[55] Figure 2-6 shows the distribution of flexography plants by average number of employees.[56] The flexographic printing plants tend to be larger than gravure plants.

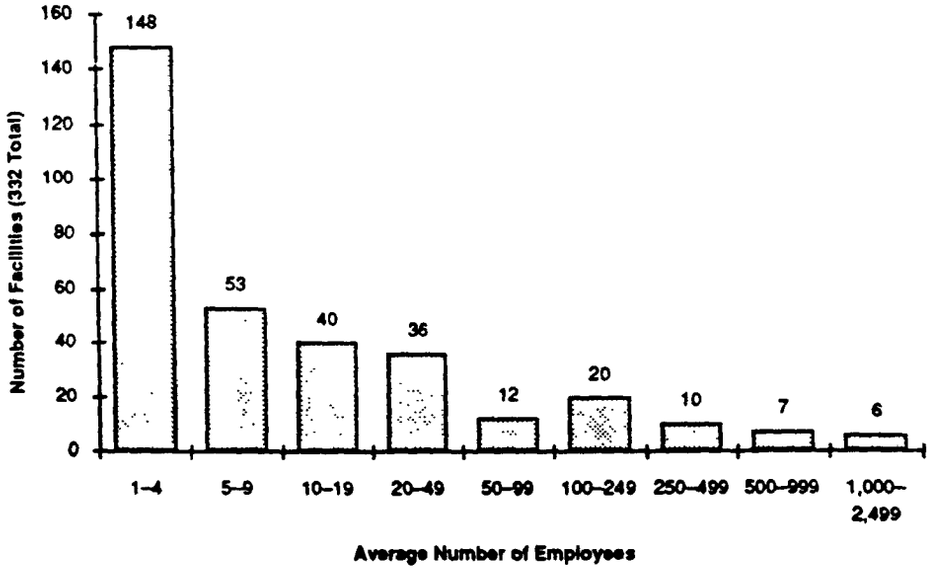

Figure 2-5. Gravure printing facilities by number of employees, 1987.

Source: U.S. Department of Commerce. 1987 Census of Manufactures. Industry Series: Commercial Printing and Manifold Business Forms. Washington, DC, U.S. Government Printing Office.

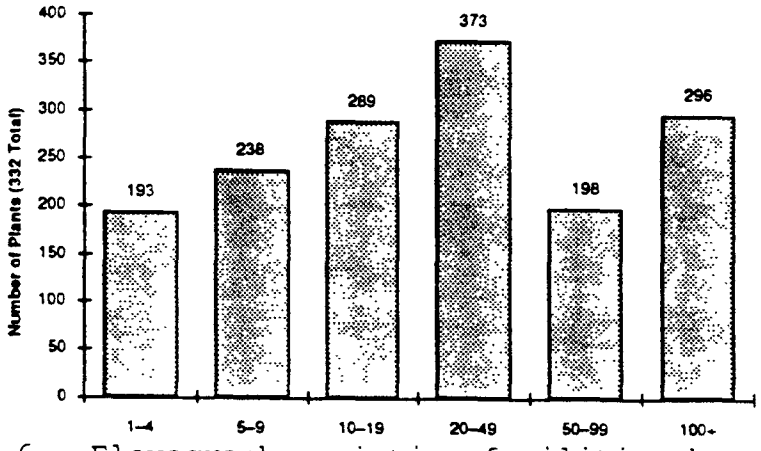

Figure 2-6. Flexography printing facilities by number of employees, 1989.

Source: U.S. EPA, Office of Pollution Prevention and Toxics. Use Cluster Analysis of the Printing Industry. Washington, DC, U.S. Government Printing Office. May 1992. p. B-35.

2.4 FIRM CHARACTERISTICS

A regulatory action to reduce HAP emissions from facilities using gravure or flexographic printing processes will potentially affect the business entities that own the regulated plants. Facilities comprise a site of land with plant and equipment that combine inputs (raw materials, fuel, energy, and labor) to produce outputs (printed products). Companies that own these facilities are legal business entities that have the capacity to conduct business transactions and make business decisions that affect the facility. The terms facility, establishment, and plant are synonymous in this analysis and refer to the physical location where products are manufactured. Likewise, the terms company and firm are synonymous and refer to the legal business entity that owns one or more facilities. As seen in Figure 2-7, the chain

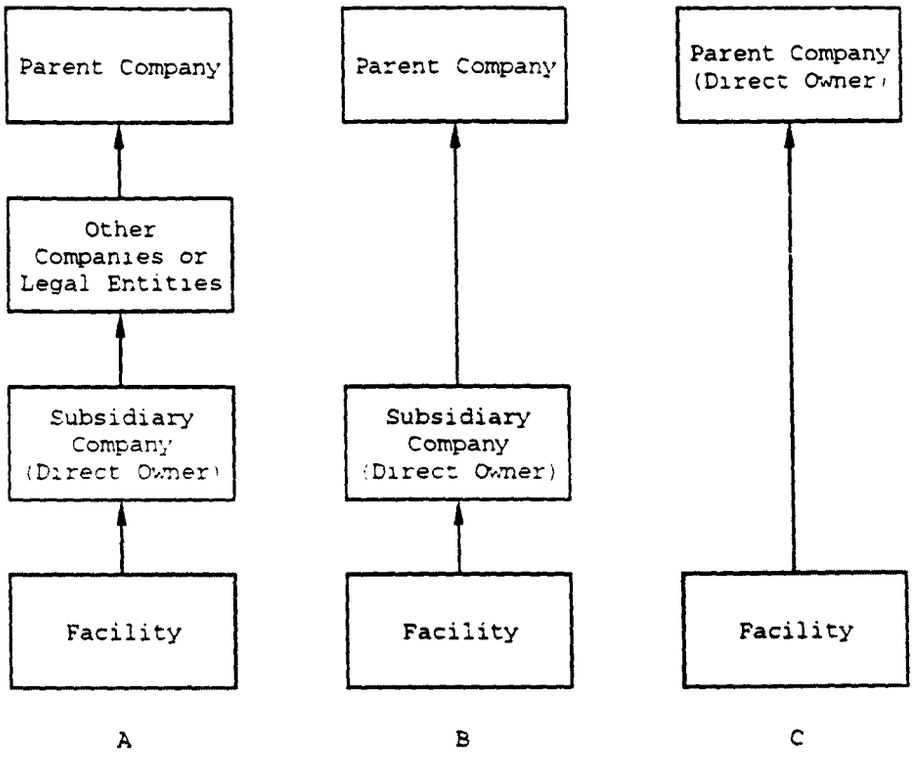

Figure 2-7. Chain of ownership.

of ownership may be as simple as one facility owned by one company or as complex as multiple facilities owned by subsidiary companies.

Potentially affected firms include entities that own plants that employ gravure or flexographic printing processes. The EPA survey indicates that in 1993 six companies owned the 27 publication rotogravure plants.[57] Furthermore, 64 companies own the 107 packaging/product rotogravure plants EPA was able to identify in their survey.[58] The EPA survey of flexographic printers identified 500 companies.[59] Tables 2-11, 2-12, and 2-13 list the U.S. publication gravure, packaging/product gravure, and flexography companies identified by the EPA survey.[60,61,62,63] All three tables present the total number of plants for each company that were identified in the EPA survey, the total number of plants each

TABLE 2-11. NUMBER OF PLANTS OWNED AND PRIMARY PRINTING CATEGORIES FOR PUBLICATION GRAVURE FIRMS, 1993

	Number of plants		Primary printing categories (% of sales)					
Company name	Publication gravure	Total	Catalogs	Publications and periodicals	Directories	Books	Specialty	Advertising inserts and other printing
R.R. Donnelley & Sons	11	40	35	17	16	11	10	10
Brown Printing Company	1	7	25	65				
Quad/Graphics	1	8	30	45				25
Quebecor Printing	10	62	11	26				35
Ringier America, Inc.	2	10	42	34		22		
World Color Press, Inc.	2	13	20	50	11			19
Total plants	27							

Sources: Printing Impressions. "The Who's Who in Printing, Industry 500." Vol. 36, No. 7. pp. 44-72.

U.S. EPA Engineering Draft Report for the Printing and Publishing Industry. Prepared by Research Triangle Institute. 1994. Table 2.2.1.2.1.

TABLE 2-12. NUMBER OF PLANTS OWNED AND PRIMARY PRINTING CATEGORIES FOR PACKAGING/PRODUCT GRAVURE PRINTING FIRMS

Company name[a]	Number of plants		Packaging gravure[c]					Product gravure[c]	
	Gravure[b]	Total	Corrugated box	Paper packaging	Plastic packaging	Mixed packaging	Packaging (%)	Paper/plastic products	Paper products
Alcan Foil Products	1					X			
Alford Industries	1	1	X				100		
Allied Stamp Corporation	1					X			X
Alusuisse Flexible Packaging, Inc.	1	3		X	X	X	100		
American Fuji Seal, Inc.	2				X				
American Greetings	1	31						X	
Amgraph Packaging, Inc.	1	1				X	100		
Avery Dennison	4					X		X	
Borden, Inc.	4							X	
Butler Printing & Laminating, Inc.	1							X	
Cello-Foil Products, Inc.	1					X			
Chiyoda America Inc.	1			X					
Cleo, Inc.	1								X
Congoleum Corporation	2							X	
Constant Services, Inc.	1							X	
CPS Corporation	1							X	
Decor Gravure Corporation	1							X	
Decorating Resources	1							X	
Decorative Specialties International, Inc.	3							X	
Dinagraphics	1							X	
Dittler Brothers	2							X	
Dopaco, Inc.	3		X						
DRG Medical Packaging	1			X	X				
Engraph, Inc.	2	15		X	X	X	100		
Eskimo Pie Corporation	1					X			
Federal Paper Board Co., Inc.	2			X					

(continued)

TABLE 2-12. NUMBER OF PLANTS OWNED AND PRIMARY PRINTING CATEGORIES FOR PACKAGING/PRODUCT GRAVURE PRINTING FIRMS (CONTINUED)

Company name[a]	Number of plants		Packaging gravure[c]					Product gravure[c]	
	Gravure[b]	Total	Corrugated box	Paper packaging	Plastic packaging	Mixed packaging	Packaging (%)	Paper/ plastic products	Paper products
Fres-Co System USA, Inc.	1				X				
GenCorp Inc.	3							X	
Graphic Packaging Corporation	3		X	X	X	X			
Gravure Carton & Label	1			X					
Gravure Packaging, Inc.	1		X						
Hallmark Cards	2	6						2	98
Hargro Flexible Packaging	2	6				X			
International Label Company	2			X					
J. W. Fergusson and Sons, Inc.	1	2		X	X	X	100		
James River Corporation	7			X	X	X		X	
Jefferson Smurfit Corporation	4		X	X	X	X			
JSC/CCA	5		X	X					
Koch Label Company, Inc.	1	1		X	X	X	100		
Lamotite, Inc.	1							X	
Lux Packaging Ltd.	1			X					
Mannington Mills, Inc.	1							X	
Mundet Inc.	2								X
Newco Inc.	1							X	
Package Service Company	1	3				X	100		
Paramount Packaging Corporation	3				X				
Quick Roll Leaf Manufacturing Company	1				X				
Reynods Metals Company	3			X	X	X			
Riverwood International USA, Inc.	3		X						
Scientific Games, Inc.	2								X
Shamrock Corporation	2			X		X		X	

TABLE 2-12. NUMBER OF PLANTS OWNED AND PRIMARY PRINTING CATEGORIES FOR PACKAGING/PRODUCT GRAVURE PRINTING FIRMS (CONTINUED)

Company name[a]	Number of plants		Packaging gravure[c]					Product gravure[c]	
	Gravure[b]	Total	Corrugated box	Paper packaging	Plastic packaging	Mixed packaging	Packaging (%)	Paper/plastic products	Paper products
Stone Container Corporation	1			X					
TECHNOGRAPHICS PRINTWORLD	1								
The C. W. Zumbiel Company	1		X						
Union Camp Corporation	3		X	X		X			
Vitex Packaging, Inc.	1			X	X				
Waldorf Corporation	2		X						
Wrico Packaging	1		X	X	X				

[a] Companies listed are those provided in the EPA Packaging/Product Gravure Printers Database. They do not necessarily comprise the total universe of packaging/product gravure printing companies. Additional company data may be gathered from the Official Container Directory, Fall 1993 and from the 1993 TLMI Products Guide, Package Printing and Converting, July 1993.
[b] Indicates the number of plants for firms listed in the EPA Packaging/Product Gravure Printers Database.
[c] Primary printing categories are indicated with an X or a percentage where available.

Sources: EPA. Packaging/Product Gravure Printers Database. 1993.

Printing Impressions. "The Who's Who in Printing, Industry 500." Vol. 36, No. 7. December, 1993. pp. 44-72.

American Printer. The Foremost Ranking of Top Printing Companies, 100+. Vol. 211, No. 4. 1993. pp. 59-74.

TABLE 2-13. NUMBER OF PLANTS OWNED AND PRIMARY PRINTING CATEGORIES FOR FLEXOGRAPHIC PRINTING FIRMS, 1993

Company name[a]	Number of plants		Primary printing categories[b]							
			Publication flexography		Packaging flexography					Product flexography
	Flexography[c]	Total	Newspapers	Books	Corrugated box	Paper	Plastic	Mixed	Packaging (%)	Paper/plastic	Paper
Abbott Box Co., Inc.	1				X						
Acorn Corrugated Box Co.	1				X						
Action Packaging	1						X				
Advance Packaging Corp.	2				X						
Akron Beacon Journal	1		X								
All-Pak, Inc.	1						X				
All-Size Corrugated Prods.	1				X						
Alusuisse Flexible Packaging, Inc.	3	3						X	100		
American Greetings Corp.	2	31								X	X
American National Can/Food Plastics	8										
American Packaging Corp.	4					X		X			
Amko Plastics, Inc.	1						X				
Anagram International, Inc.	1						X				
Arcata Graphics\Kingsport	1	6		X							
Arcon Coating Mills, Inc.	1						X				
Arkansas Poly, Inc.	1						X				
Atlanta Film Converting Co., Inc.	1						X				
Automated Label Systems Co.	1						X				
Automated Packaging Systems, Inc.	1						X				
Avery-Dennison	2					X				X	
Bagcraft Corporation of America	1	4				X			100		
Bancroft Bag, Inc	1					X					
Banner Packaging, Inc.	1	1					X		100		
Beach Products	1										X
Bell Packaging Corp.	1							X			
Bemis Company Inc.	16					X	X	X			
Bingo Paper Inc.	1					X					
Bomarko, Inc.	1	4						X	100		
Bonar Packaging, Inc.	1						X				
Bryce Corporation	6										

TABLE 2-13. NUMBER OF PLANTS OWNED AND PRIMARY PRINTING CATEGORIES FOR FLEXOGRAPHIC PRINTING FIRMS, 1993 (CONTINUED)

Company name[a]	Number of plants		Primary printing categories[b]							
			Publication flexography		Packaging flexography					Product flexography	
	Flexography[c]	Total	Newspapers	Books	Corrugated box	Paper	Plastic	Mixed	Packaging (%)	Paper/plastic	Paper
Buckeye Container	1						X				
Buckeye Packaging	1						X				
Burrows Paper Corporation	2							X			
C.P.C. Packaging, Inc.	1						X				
Cadillac Products, Inc.	3						X			X	
Castle Rock Container Company	1				X						
Cello-Foil Products, Inc.	1						X				
Cello-Wrap Printing Company, Inc.	1							X			
Central States Diversified, Inc.	1						X				
Champion International Corp.	5					X					
Charleston Packaging Company, Inc.	1							X			
Clark Container, Inc.	1						X				
Cleo, Inc.	1									X	
Compak, Inc.	1				X						
W. R. Grace & Co.	3						X				
Crystal Tissue	1									X	
Custom Poly Bag, Inc.	1						X				
Dart Container Corporation	1						X				
Deco Paper Products, Inc.	1										X
Design Containers, Inc.	1										X
Dynamic Packaging, Inc.	1						X				
Eisenhart Wallcoverings Co.	1									X	
Equitable Bag Co., Inc	1							X			
Eskimo Pie Corporation	1						X				
Excelsior Transparent Bag MFG Corp.	1						X				
Fabricon Products	3	3						X	100		
Fleetwood Container & Display	1				X						
Flex-Pak, Inc.	1						X				
Flexo Transparent, Inc.	1						X				
Focus Packaging, Inc.	1				X						
Fort Wayne Newspapers	1		X								
fp Webkote, Inc.	1							X			

(Continued)

TABLE 2-13. NUMBER OF PLANTS OWNED AND PRIMARY PRINTING CATEGORIES FOR FLEXOGRAPHIC PRINTING FIRMS, 1993 (CONTINUED)

Company name[a]	Number of plants		Primary printing categories[b]							
			Publication flexography		Packaging flexography					By-sheet flexography	
	Flexography[c]	Total	Newspapers	Books	Corrugated box	Paper	Plastic	Mixed	Packaging (%)	Paper/plastic	Paper
Frank C. Meyer Company, Inc.	1				X						
Gateway Packaging	1							X			
Gentry Poly Specialties, Inc	1						X				
Georgia-Pacific Corp.	44				X		X				X
Gilman Converted Products	1										X
Glenroy, Inc.	1							X			
Graphic Packaging Corp.	2					X		X			
Greif Bros. Corp.	1							X			
Dairy-Mix, Inc.	1						X				
Gulf States Paper Corp.	1				X						
H. S. Crocker Co., Inc.	1	3						X	100		
Hallmark Cards	2	6				X					X
Hargo Flexible Packaging Corp.	6	4					X	X	100		
Home Plastics, Inc.	1						X				
Huntsman Packaging Products, Corp.	1						X				
Interflex	1						X				
International Paper	37				X	X		X			
Interstate Packaging Corp.	1					X					
James River Corp.	17				X	X	X	X			X
Jefferson Smurfit Corp.	47				X		X	X			
John H. Harland Company	1	49									X
Kleartone, Inc.	1							X			
Koch Container	1				X						
Kookaburra USA LTD	1										X
Lin Pac, Inc.	2				X		X				
Longhorn Packaging, Inc.	1							X			
Mason Transparent Pkg	1						X				
Macon Telegraph	1		X								
Mafcote Industries	2				X						
Mail-Well Envelope	1										X

TABLE 2-13. NUMBER OF PLANTS OWNED AND PRIMARY PRINTING CATEGORIES FOR FLEXOGRAPHIC PRINTING FIRMS, 1993 (CONTINUED)

Company name[a]	Number of plants		Primary printing categories[b]							
			Publication flexography		Packaging flexography					Product flexography
	Flexography[c]	Total	Newspapers	Books	Corrugated box	Paper	Plastic	Mixed	Packaging (%)	Paper/plastic	Paper
Maine Poly, Inc.	1						X				
Malnove, Inc.	1				X						
Marglo Packaging Corp.	1						X				
Massillon Container	1				X						
McClatchy Newspapers	2		X								
Mead Corporation	1					X					
Menasha Corporation	1	9			X				48%		
Miami Herald Publishing Co.	1		X								
Mid-West Poly Pak, Inc.	1						X				
Midwest Film Corp	1							X			
Milwaukee Container	1				X						
Mohawk Northern Plastics, Inc.	1						X				
Moore, Inc.	1	150									X
NCR Corp.	2	29						X	10		X
Neenah Printing	1							X			
Nichols Paper Products Co., Inc.	1							X			
Owens-Illinois, Inc.	1						X				
Package Printing Co., Inc.	1						X				
Package Products Flexible Corp.	1						X				
Packaging Corp. of America	43				X						
Packaging Industries, Inc.	1						X				
Packaging Materials Incorporated	1						X				
Packaging Products Corp.	3						X	X			
Packaging Specialties, Inc.	1						X				
Pacquet Oneida, Inc.	1							X			
Paramount Packaging Corp.	4						X				
Percy Kent Bag Co., Inc.	1					X					
Phoenix Products Co., Inc.	2						X	X			
Pioneer Balloon Company	1									X	

(continued)

TABLE 2-13. NUMBER OF PLANTS OWNED AND PRIMARY PRINTING CATEGORIES FOR FLEXOGRAPHIC PRINTING FIRMS, 1993 (CONTINUED)

Company name[a]	Primary printing categories[b]										
	Number of plants		Publication flexography		Packaging flexography					Product flexography	
	Flexography[c]	Total	Newspapers	Books	Corrugated box	Paper	Plastic	ed	Packaging (%)	Paper/plastic	Paper
Plastic Packaging Corp.	2						X				
Plicon Corp.	1						X				
Poly Plastic Packaging, Inc.	2						X				
Polyflex Film & Converting, Inc.	1						X				
Press Telegram	1		X								
Procter and Gamble Co.	4										X
Providence Journal Company	1		X								
R. R. Donnelley & Sons Company	1	40		11							
Rand-Whitney Container Corp.	3				X						
Rex-Rosenlew International, Inc.	1	2					X		100		
Rock-Tenn Company	9				X						
Sealright Packaging Co.	5	6			X	X	X		100		
Selig Sealing Products, Inc.	1						X				
Solar Press	1	5						X			
Solo Cup Company	2										X
Southern Colortype Co., Inc.	1						X				
Specialty Container Corporation	1						X				
Spiralkote, Inc.	1							X			
Standard Packaging & Printing Corp.	1							X			
Sunrise Packaging, Inc.	1							X			
Superpac, Inc.	1							X			
Susan Crane, Inc.	1										X
Teepak, Inc.	1							X			
Tennessee Packaging	1				X						
Tennessee Press, Inc.	1						X				
The Robinette Company	1					X					
The Standard Register Company	1	35									X
Toph	2										X

TABLE 2-13. NUMBER OF PLANTS OWNED AND PRIMARY PRINTING CATEGORIES FOR FLEXOGRAPHIC PRINTING FIRMS, 1993 (CONTINUED)

Company name[a]	Number of plants		Primary printing categories[b]								
			Publication flexography		Packaging flexography					Product flexography	
	Flexography[c]	Total	Newspapers	Books	Corrugated box	Paper	Plastic	Mixed	Packaging (%)	Paper/plastic	Paper
Uniflex, Inc.	1	1					X		100		
Union Camp Corp.	15				X	X	X	X			
Viskase Corp.	1						X				
Vitex Packaging, Inc.	1							X			
Wabash Pioneer Container Corp.	1				X						
Waldan Paper Services, Inc.	1									X	
Ward/Kraft, Inc.	1										X
Webcor Packaging Corp.	1				X						
Western Publishing Co., Inc.	1	6		60							
Westvaco	21				X	X		X			X
Weyerhaeuser Paper Company	5				X						
Willamette Industries, Inc.	34				X	X					
Zim's Bagging Co., Inc.	1						X				
Total plants/firms in category	500		7	3	32	19	66	39		8	20

[a] Companies listed are those provided in the EPA Flexographic Printers Database. They do not necessarily comprise the total universe of flexographic printing companies. Further company data may be gathered from the Official Container Directory, Fall 1993 and from the "1993 TLMI Products Guide," Package Printing and Converting, July 1993.

[b] Primary printing categories are indicated with an X, or a percentage where available.

[c] Indicates the number of plants for firms listed in the EPA, Flexographic Printers Database.

Sources: EPA. Flexographic Printers Database. 1993.

Printing Impressions. "The Who's Who in Printing, Industry 500." Vol. 36, No. 7. December 1993. pp. 44-72.

American Printer. The Foremost Ranking of Top Printing Companies, 100+. Vol. 211, No. 4. 1993. pp. 59-74. (Provided company data for Hallmark Cards and American Greetings.)

company owns where available from other sources, and the primary printing categories in which each company engages.

Although the number of publication gravure companies includes all the known publication gravure plants, there are more than 64 packaging/product gravure companies and more than 500 firms using flexography. The U.S. Department of Commerce identified 304 companies that owned plants classified as gravure commercial printers in 1987.[64] The 304 includes both publication gravure and packaging/product gravure printers and does not include companies using the gravure printing process to decorate their manufactured products, which are classified in a different industry.

2.4.1 Ownership

The legal form of ownership affects the cost of capital, availability of capital, and effective tax rate faced by the firm. Business entities that own gravure or flexographic printing facilities will generally be one of three types of entities:

- sole proprietorships,
- partnerships, and
- corporations.

Each type has its own legal and financial characteristics that may influence how firms are affected by the regulatory alternatives. Table 2-14 provides information about the legal form of ownership of firms for commercial gravure printers (SIC 2754) and commercial printers, n.e.c. (SIC 2759), which includes flexographic printers.[65] The majority of commercial gravure printers and other, n.e.c. printers are single-facility corporations. Figure 2-8 compares the legal form of ownership for the commercial gravure and other, n.e.c. printers to that of all other firms in the U.S.[66,67]

2.4.2 Size Distribution

Firm size is likely to be a factor in the distribution of the regulatory action's financial impacts. Grouping the firms

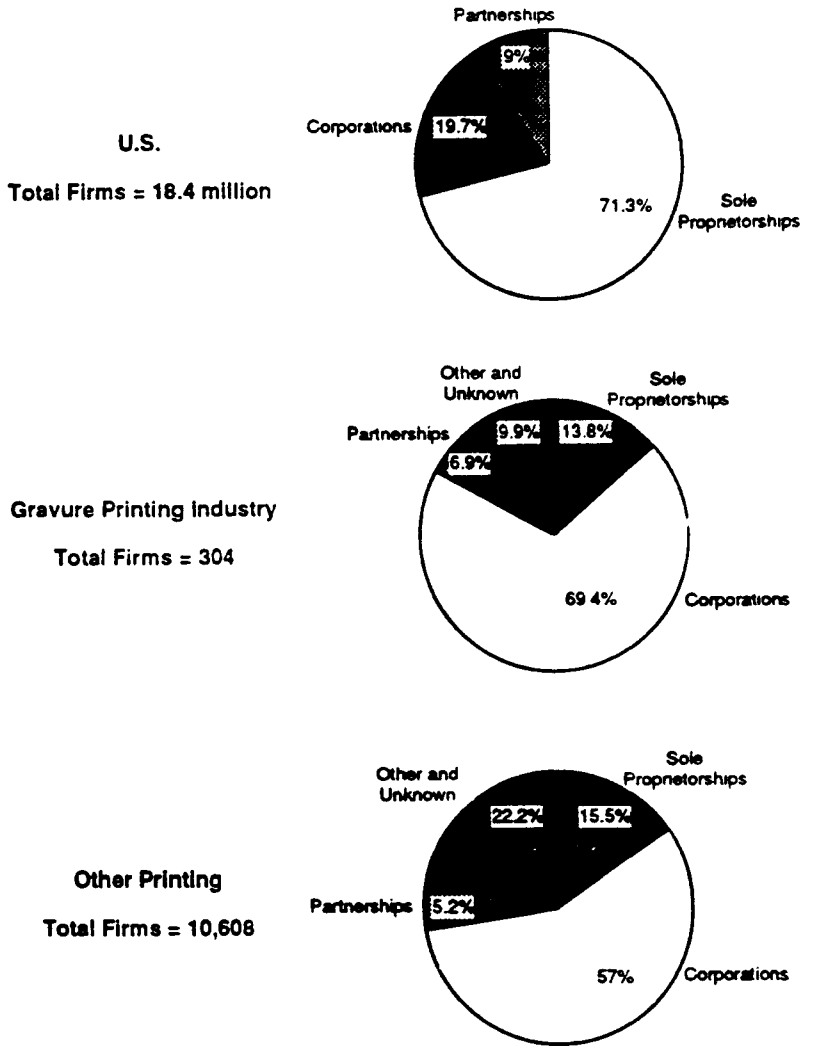

Figure 2-8. Comparison of the legal form of organization for firms in the U.S., gravure, and other printing segments of the printing industry, 1987.

Sources: U.S. Department of Commerce. 1987 Census of Manufactures. Subject Series: Type of Organization. Washington, DC, U.S. Government Printing Office. 1991. p. 5-33.

U.S. Department of Commerce. 1992 Statistical Abstract of the United States. Washington, DC, U.S. Government Printing Office. Table No. 826.

TABLE 2-15. SMALL BUSINESS ADMINISTRATION SIZE STANDARDS BY SIC CODE FOR COMPANIES THAT HAVE GRAVURE OR FLEXOGRAPHIC PRINTING CAPABILITIES

SIC code	Industry description	SBA size standard in number of employees
2652	Set up paperboard boxes	500
2653	Corrugated and solid fiber boxes	500
2655	Fiber cans, drums, and similar products	500
2656	Sanitary food containers	750
2657	Folding paperboard boxes	750
2671	Paper coated and laminated, packaging	500
2672	Paper coated and laminated, n.e.c.	500
2673	Bags: plastics, laminated, and coated	500
2674	Bags: uncoated paper and multiwall	500
2676	Sanitary paper products	500
2677	Envelopes	500
2678	Stationery products	500
2679	Converted paper products, n.e.c,	500
2732	Book printing	500
2752	Commercial printing, lithographic	500
2754	Commercial printing, gravure	500
2759	Commercial printing, n.e.c.	500
2761	Manifold business forms	500
2771	Greeting cards	500
3081	Unsupported plastics film and sheet	500
3083	Laminated plastics plate and sheet	500
3085	Plastic bottles	500
3089	Plastics, n.e.c.	500
3221	Glass containers	750
3411	Metal cans	1,000
3466	Crowns and closures	500

n.e.c. = Not elsewhere classified.

are potentially affected by the regulation, are covered by various SIC codes. The relevant industries potentially include the commercial printing and book printing industries under SIC 27, the packaging industries under SICs 26, 30, 32, and 34, as well industries under SICs 26 and 30 that produce products with gravure or flexographic printing. The SBA size standards for all of these industries are based on the number of employees, and, as Table 2-16 shows, businesses classified in most of these industries are considered small if they have fewer than 500 employees; otherwise they would be considered large.

Table 2-16 lists the companies for which data are available that will potentially be affected by the regulation to reduce HAP emissions from gravure and flexographic printers.[68] In addition to company name, Table 2-16 identifies their legal form of organization, total number of plants (classified in any industry) owned, number of employees, 1993 sales, and sales per employee. Table 2-16 shows that the potentially affected firms range in size from fewer than 50 to over 30,000 employees. None of the publication gravure companies are considered small. For packaging/product gravure companies included in the EPA survey, a total of 29 firms, or 48.3 percent, are classified as small, while the remaining 31 firms, or 51.7 percent, are classified as large. For flexographic companies, the vast majority of firms are considered small. In fact, data from Ward's Business Directory indicate that almost 94 percent of firms in SIC 2759 (Commercial Printing, n.e.c.) have fewer than 500 employees.[69]

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

- Facilities that print gravure or flexography vary by size. All else being equal, firms with large plants are larger than firms with small plants.
- Firms vary in the number of plants they own. All else being equal, firms with more plants are larger than

those with fewer plants.

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

2.4.3 Issues of Vertical and Horizontal Integration

The vertical aspects of a firm's size reflect the extent to which goods and services that can be bought from outside are produced in house. Vertical integration is a potentially important dimension in analyzing firm-level impacts because the regulation could affect a vertically integrated firm on more than one level. The regulation may affect companies for whom printing is only one of several processes in which the firm is involved. For example, a company owning facilities that have gravure or flexographic printing capacity may ultimately produce printed and nonprinted corrugated boxes, folding cartons, flexible packaging, tissue products, or wall coverings. This firm would be considered vertically integrated because it is involved in more than one level of production requiring printing and finished products that are printed. A regulation that increases the cost of printing will affect the cost of producing products that are printed during the manufacturing process.

The horizontal aspect of a firm's size refers to the scale of production in a single-product firm or its scope in a multiproduct one. Horizontal integration is also a potentially important dimension in firm-level impact analyses for any of the following reasons:

- A horizontally integrated firm may own many facilities of which only some are directly affected by the

regulation.

- A horizontally integrated firm may own facilities in unaffected industries. This type of diversification would help mitigate the financial impacts of the regulation.

- A horizontally integrated firm could be indirectly as well as directly affected by the regulation. For example, if a firm is diversified in manufacturing pollution control equipment (an unlikely scenario), the regulation could indirectly and favorably affect it.

Some firms in the printing industry are horizontally integrated.

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SECTION 3
REGULATORY CONTROL OPTIONS AND COSTS OF COMPLIANCE

MACT standards are technology-based regulations. Although a facility that is a source of emissions need not install any specific pollution control technology, the regulatory requirements must be based on a technology that can achieve the specified limits. The BID details the technology basis for MACT standards. Model plants were developed to evaluate the effects of various control options on the printing and publishing industry. Selection of control options was based on applying presently available control devices and varying levels of capture consistent with different levels of overall control. Section 3.1 presents a summary of the control options for each of the three industry segments—publication gravure, packaging/product gravure, and flexography. Section 3.2 summarizes the compliance costs associated with the regulatory requirements for each segment.

3.1 CONTROL OPTIONS

Control options for publication gravure plants are given in Table 3-1. Each control option includes the use of solvent recovery systems as the control device. The systems of demonstrated effectiveness are composed of fixed-bed activated carbon absorption units that are cyclically regenerated with steam. These systems include regeneration gas condensers and solvent/water decanters. The distinction among the control options for publication gravure plants is the capture system employed. The specification of ventilation, hooding, and ducting for incremental improvements to existing systems is site specific. The control options listed in Table 3-1 represent discrete levels of capture.

Table 3-2 lists the control options for packaging and product gravure plants. In control options A and B, a control device is used with different levels of control efficiency.

TABLE 3-1. CONTROL OPTIONS FOR PUBLICATION ROTOGRAVURE PLANTS

Option	Control device	Capture system
A	Solvent recovery system with carbon adsorption and steam regeneration	Draw 50 percent of required pressroom ventilation air through concentrator to existing solvent recovery system
B		Draw 100 percent of required pressroom ventilation air through concentrator to existing solvent recovery system
C		Construct permanent total enclosure and draw 100 percent of required pressroom ventilation air through concentrator to existing solvent recovery system

TABLE 3-2. CONTROL OPTIONS FOR PACKAGING AND PRODUCT ROTOGRAVURE PLANTS

Option	Control device	Capture system
A	Solvent recovery system, or catalytic incinerator or thermal incinerator depending on ink system in use	Treat dryer exhaust plus 50 percent of required pressroom air with control device
B		Permanent total enclosure
C	Use of ink containing less than 1.5 percent HAP	None

The control device can be selected based on the ink system in use, or, if more than one type of device is potentially suitable, on the basis of cost. All control devices presently in use in this segment of the industry can achieve efficiencies of more than 95 percent. Control option C provides for the use of low-HAP ink with no control device, if emissions do not exceed those of plants using solvent-based inks with a high-HAP content using an efficient capture and control system.

Most flexographic printing facilities, and all flexographic printing facilities outside of the flexible packaging industry, operate without control devices. Control strategies are influenced by the composition of inks and other materials applied on the press, as well as existing regulatory requirements. Control options for flexographic printing facilities are given in Table 3-3. In control options A and B, a control device is used with different levels of capture efficiency. The control device can be selected based on the ink system in use, or if more than one type of device is potentially suitable, on the basis of cost. All control devices presently in use in this segment of the industry can achieve efficiencies of more than 95 percent, at high

TABLE 3-3. CONTROL OPTIONS FOR FLEXOGRAPHIC PRINTING PLANTS

Option	Control device	Capture system
A	Solvent recovery system, or catalytic incinerator or thermal incinerator depending on ink system in use	Treat dryer exhaust plus 50 percent of required pressroom air with control device
B		Permanent total enclosure
C	Use of ink containing less than 1 percent HAP	None

concentrations of HAP in the solvent-laden air. Control option C provides for the use of low-HAP ink with no control device, if emissions do not exceed those of plants using solvent-based inks with a high-HAP content using an efficient capture and control system.

3.2 COSTS OF CONTROLS

Table 3-4 summarizes the total and annualized capital costs, operating expenses, monitoring and recordkeeping costs, and total annual cost for the regulation by industry segment. The annualized capital cost is calculated using a capital recovery factor of 0.1332 based on an equipment life of 10 years and a 7 percent discount rate. The total annual cost is calculated as the sum of the annualized capital cost, operating expense, and the monitoring and recordkeeping costs. This figure ranges from a low of $1.5 million for the flexographic industry segment to a high of $21.1 million for the packaging and product gravure industry segment. Thus, the total annual cost for the printing and publishing industry (the sum across the three industry segments) is $40.3 million.

SECTION 4
ECONOMIC IMPACT ANALYSIS

A variety of approaches may be used to assess the impacts of the regulatory action; they reflect a variety of underlying paradigms. Typically, an economic model is developed to assess the facility- and market-level impacts of the regulations, including price, quantity, employment, business closure, and foreign competition impacts. Such models are firmly rooted in neoclassical economic theory and require market-level data on price and quantity for potentially affected products and detailed production data at the facility-level. In the case of the printing and publishing industry, however, this information is not available at the facility- or market-level. Furthermore, this regulation affects a service (printing and publishing) as opposed to a manufactured good or product. Service industries cause problems related to identifying and differentiating the affected commodities (markets), quantifying the level of the service provided to other industries or final consumers, and identifying the producers and consumers of the service. Nevertheless, RTI has developed a market model of the printing and publishing industry to assess the regulatory impacts of the proposed NESHAP.

The model is a multidimensional Lotus spreadsheet incorporating various data sources to provide an empirical characterization of the U.S. printing and publishing industry and product markets. The base year of analysis reflects the economic conditions embodied in preliminary data from the Department of Commerce's 1992 Census of Manufactures for SIC codes related to the printing and publishing industry. Observations on equilibrium prices and outputs are derived from value of shipment data by defining otherwise unobservable outputs of producer goods, printing inputs, and other factors of production as those amounts that can be sold for $1 at the observed baseline equilibrium. Given the baseline conditions,

the model analyzes market adjustments for 22 final product markets, three printing inputs, as well as capital and labor services within the printing and publishing industry.

The exogenous shock to the economic model is the imposition of the regulations and the corresponding control costs. A competitive market structure is incorporated to compute the equilibrium prices and quantities of all commodities in the system. Demand for the "final" commodities in the system, that is, commodities whose demand is exogenous, is expressed in equation form. Demand elasticities are assumed for each of these final products, while the demand for printing and publishing inputs is derived from the production decisions for final products through constant elasticity of substitution (CES) production functions. The model does not incorporate international trade because exports and imports of printing and publishing are insignificant (see Section 2). The model analyzes market adjustments by employing a process of tatonnement whereby prices approach equilibrium through successive correction modeled as a Walrasian auctioneer. The major outputs of this model are market-level adjustments in price and quantity for all affected products.

The remainder of this section provides: a conceptual presentation of the production relationships involving the printing and publishing industry, the details of an operational market model to assess the regulation, and the results of the market model.

4.1 CONCEPTUAL OVERVIEW

Printing is basically the reproduction of original type or artwork for publications, packaging materials, and products. The markets for printing are links in the chain of market interactions that flow between end-use products (e.g., newspapers, magazines, packaged products, wallpaper), intermediate products (e.g., printed flexible packaging and folding cartons), printing processes (e.g., gravure and

flexography), and primary inputs (e.g., inks, substrates, artwork, manuscripts, printing plates). Figure 4-1 illustrates the multimarket interactions between each of these markets. Conventional economic reasoning argues that the chain begins with the demand for final commodities. These demands create a set of derived demands for the intermediate products, printing processes, and other commodities. Thus, the demand for printing can be seen as a derived demand from the consumers' desire for the final commodity. A consumer's demand for an attractive product (e.g., shower curtains and wallpaper) or informative and attractively packaged product (e.g., cereal or facial tissues) translates into a derived demand for packaging and printing. Because consumers value the final commodities more than the costs to provide them, producers find it in their self-interest to produce the requisite inputs for the production chain.

The five major printing processes currently employed in the U.S. are flexography, gravure, letterpress, offset lithography, and screen. Each printing process offers characteristics that make it more suitable for the markets it serves. A discussion of the different types of printing and how they provide the necessary quality and functional characteristics is not presented here, but Table 4-1 displays the typical printing processes employed for various publication and packaging products. In publication and commercial printing, offset printing makes up nearly 80 percent with gravure supplying most of the remainder and only a small portion done by flexography. For package printing, roughly 64 percent is done by flexography with the remainder mostly by offset and gravure.

The demand for printing derives from its use as an input into the production of publications, packaging, and printed products. The production process for publications, packaging, and products may be broken into stages so that at each stage some inputs are used to make an intermediate input that is then used with other inputs to produce the final product. In

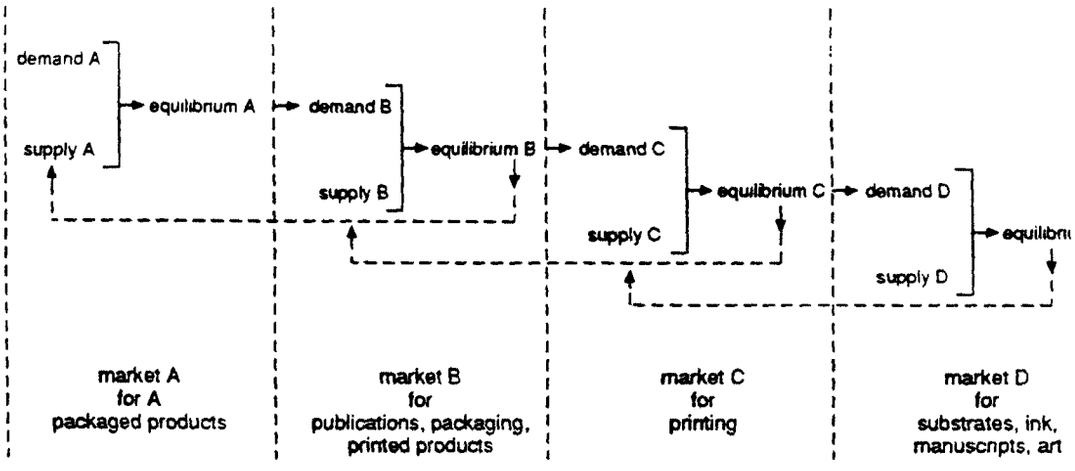

Figure 4-1. Multimarket relationships.

TABLE 4-1. PRINTING PROCESSES COMMONLY EMPLOYED FOR PUBLICATIONS AND PACKAGING

Product	Printing processes
Publications	
Advertising	F, G, O, L
Books	F, O, L
Catalogs and directories	G, O, L
Financial and legal documents	F, O, L
Magazines and periodicals	G, O, L
Newspapers	F, O, L
Packaging	
Labels, tags, and wrappers	F, G, O, L
Corrugated	F, O, L
Folding cartons	F, G, O
Flexible packaging	F, G
Paper bags	F, G
Plastic bottles	F, S
Beverage cans	O, L
Crowns and closures	F, O

Note: Printing process codes are flexography (F), gravure (G), letterpress (L), offset (O), and screen (S).

the first stage, final producers purchase printing services in the market along with other inputs to produce their particular output. The underlying production function for each output (Q) may be given by:

$$Q = F(K, L, E, Y)$$

where Q is the production of publications, packaging, or product, K is the capital stock, L is the labor input, E is the energy input, and Y is printing services. For this analysis, the production technology is assumed to be separable

so that producers require a fixed amount of the printing services per unit of output and that it is not substitutable with the other inputs--capital, labor, and energy.

Therefore, in the second stage, printing services (Y) may be viewed as an intermediate input composed of various printing processes that producers may substitute across to meet their input requirements, i.e.,

$$Y = f(X_i)$$

where the X_i's represent the available printing processes such as flexography, gravure, and offset that may be employed. Using the relative costs of each process, producers will minimize the costs per unit of printing services resulting in demands for each process by final product.

In the third stage, the production function for each printing process may be described by:

$$X = F(VA,M)$$

where X is the production of a particular printing input, VA is the value added consisting of capital and labor services, and M is intermediate inputs consisting of inks, solvents, and substrates. Producers have fixed requirements of intermediate inputs and value added per unit of printing output. Thus, in the final stage of production, producers are able to substitute between labor and capital to minimize costs per unit of value added.

As a result of regulation, the relative cost of the available printing processes will change. This in turn will force final producers to alter their production decisions and to substitute away from regulated processes (more costly) toward unregulated processes (less costly) to the extent existing production technologies allow. Thus, the regulations on the printing and publishing industry may be incorporated into the system like a per-unit tax on the use of the printing inputs, X_i, with statutory incidence on the buyers.

Figure 4-2 shows the market for a particular printing

Figure 4-2 shows the market for a particular printing input, X. The price (P_x) and quantity (Q_x) of X are determined competitively by supply (S_x) and demand (D_x). A key is to recognize that in the presence of a tax the price paid by demanders (P_{gross}) and the price paid by suppliers (P_{net}) will differ by the per-unit amount. After the regulation is imposed, the associated per-unit cost (C) will shift the demand curve as perceived by the suppliers (D_x) downward to D_x'. The new equilibrium occurs where supply equates demand as perceived by the suppliers. Thus, the regulation will lower the quantity from Q_0 to Q_1, while suppliers receive the net price of P_{net} and demanders pay the gross price of P_{gross}. Therefore, holding all else constant, those producers that employ flexography and gravure in their production process will face a new higher price of printing inputs after imposition of the regulation.

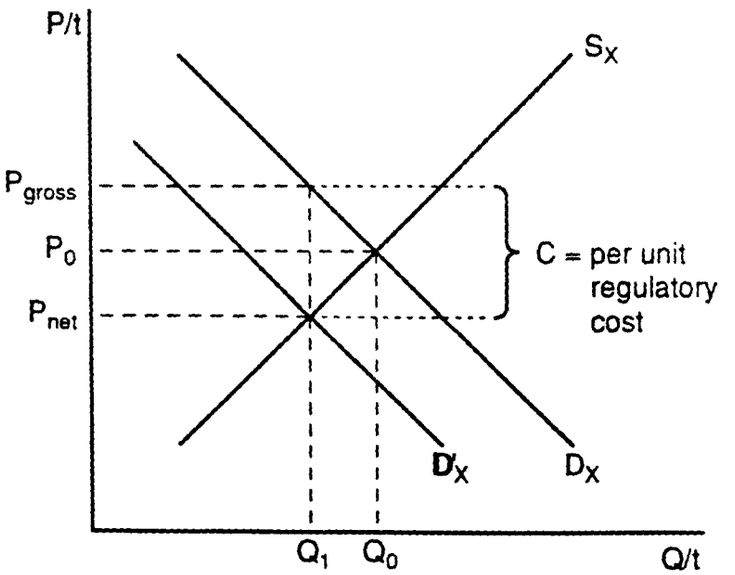

Figure 4-2. Imposition of regulatory costs on market for printing input, X.

4.2 OPERATIONAL MARKET MODEL

To estimate the economic impacts of the regulation, we developed a competitive market model based on the discussion above. The purpose of the model is to provide a structure for analyzing the market adjustments associated with regulations to control air pollution from the printing and publishing industry. To implement this model, we identified the commodities to be included in the analysis, specified the supply and demand side of the market, incorporated supply and demand specifications into a market model framework, and estimated market adjustments due to imposing regulatory compliance costs.

4.2.1 Model Dimensions

Clearly this analysis must account for all marketable commodities involved in the printing and publishing industry, in particular those affected by the regulation. The first marketable product is the printing input. Although there are five major printing processes, only two are directly affected by the regulation—flexography and gravure. The other processes (offset, letterpress, and screen) are not covered by the regulation. Therefore, this analysis includes three printing inputs: flexography, gravure, and a composite printing input that includes offset, letterpress, and screen. The second marketable product is the final product that employs printing inputs. Table 4-2 presents the 22 final products included in the market model. International trade is not included in this model, so all of these products are consumed and produced domestically.

4.2.2 Production

On the production side of the model, each of the 22 final products is produced from a combination of printing services and a composite input consisting of all other inputs including labor, capital, and energy. Industry input decisions are assumed to be made on the basis of cost minimization, and these decisions are affected by the EPA air regulations on the

TABLE 4-2. FINAL PRODUCTS INCLUDED IN THE MARKET MODEL

Publications
Advertising
Books
Catalogs and directories
Financial and legal documents
Magazines and periodicals
Newspapers
Packaging
Labels, tags, and wrappers
Corrugated
Folding cartons
Sanitary packaging
Flexible packaging
Paper bags and mulitwall sacks
Plastic bottles
Plastic bags
Metal cans
Other packaging, n.e.c.
Product
Sanitary paper products
Envelopes
Floor coverings
Wall coverings
Gift wraps
Greeting cards

n.e.c. = Not elsewhere classified.

printing industry through the alteration of relative prices for printing inputs. Printing services consist of three printing inputs—gravure, flexography, and a composite process. Gravure and flexography are the only processes affected by the proposed air regulations.

The structure of production is displayed in Figure 4-3. Given a single producer of each final product, each determines its use of factors in a sequence of stages, through a nested CES production function.[a] First, producers have fixed requirements of printing services and all other inputs per unit of output. Second, they can substitute between printing processes through a CES function to minimize costs per unit of printing services. To facilitate the analysis, the CES function is limited to two printing processes for each final product. The value of the elasticity of substitution between the two printing processes is chosen to be consistent with industry literature about substitution possibilities, but sensitivity analysis is conducted with respect to this parameter specification.

In the third production stage, each printing process has fixed requirements of intermediate inputs (substrates and printing inks) and value added (labor and capital). In the fourth stage, within each printing process, we allowed for substitution between labor and capital through a CES value-added function. The elasticity of substitution between labor and capital for each printing process is determined exogenously from literature estimates.[b]

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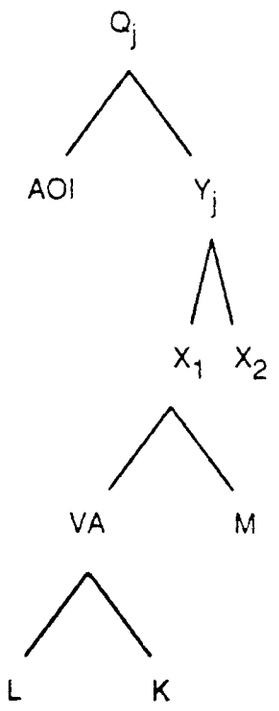
[a]The CES, or constant elasticity of substitution, production function is one of the most frequently employed functional forms in modern economic analysis. As implied by its name, the elasticity of substitution between factors of production is expressed as some constant value. The Cobb-Douglas function is a special case of the CES production function with an elasticity of substitution equal to 1.

[b]A possible extension of the model would be to separate printing inks for each process as another CES function of water-based and solventborne inks. The possible substitution between printing inks could then be included to assess the impacts of pollution prevention options.



Each producer good Q_j uses fixed proportions of printing services (Y_j) and all other inputs(AOI)

Printing services for each producer good is a CES function of printing processes (X_i) where i may be flexography, gravure, or a composite process.

Each printing process (X_i) uses fixed proportions of value added (VA) and intermediate inputs (M).

Intermediate inputs (M) are composed of substrates and printing inks used in fixed proportions for each process.

Value added (VA) for each process is a CES function of labor (L) and capital (K).

Figure 4-3. Diagram summary of production model.

Thus, the production function for each final product can be written as:

$$Q_j = \min \left[\frac{1}{\alpha_j} Y(X_{1j}, X_{2j}), \frac{AOI_j}{(1-\alpha_j)} \right], \qquad (4\text{-}1)$$

where Y_j is a CES function for final product j with two printing inputs (X_1 and X_2) as inputs, α_j is the fixed input requirement for printing services (Y_j) per unit of output, and $(1-\alpha_j)$ is the fixed input requirement for the composite input (AOI_j) per unit of output. Next, each final product uses the CES function to decide how much of printing service (Y_j) should be performed through printing process X_{1j} and how much should be performed by X_{2j}:

$$Y_j = \left[\delta_j X_{1j}^{\rho_j} + (1-\delta_j) X_{2j}^{\rho_j} \right]^{1/\rho_j}, \qquad (4\text{-}2)$$

where δ_j is a weighting parameter and $\rho_j = \frac{\sigma_j - 1}{\sigma_j}$ with σ_j being the elasticity of substitution between printing processes in the production of final product j.

Production of each printing input (X_i) takes place according to the following production function:

$$X_i = \min \left[\frac{1}{\beta_i} VA(K_i, L_i), \frac{M_i}{(1-\beta_i)} \right] \qquad (4-3)$$

where VA is a CES value added function for printing input i with labor (L_i) and capital (K_i) as inputs, β_i is the fixed input requirement for value added (VA_i) per unit of output, and $(1-\beta_i)$ is the fixed input requirement for intermediate inputs (M_i) per unit of output. In the fourth stage of production, each printing process uses the CES value-added function to allocate value added across labor (L_i) and capital (K_i):

$$VA_i = \left[\gamma_i L_i^{\rho_i} + (1-\gamma_i) K_i^{\rho_i} \right]^{1/\rho_i} \qquad (4-4)$$

where γ_i is a weighting parameter and $\rho_i = \frac{\epsilon_i - 1}{\epsilon_i}$ with ϵ_i being the elasticity of substitution between labor and capital in the production of printing input i. Each factor of production is assumed homogeneous and mobile across printing processes. The stock of capital is assumed fixed and labor is inelastically supplied.

4.2.3 Consumption

The demand for each producer good (Q_j^D) may be specified by the following equation:

$$Q_j^D = A_j [p_j]^{\eta_j} \qquad (4-5)$$

where p_j is the price of final product j, η_j is the demand

elasticity for final product j, and A_j is a multiplicative demand parameter that calibrates the demand equation for each final product j given data on price and the demand elasticity to replicate the baseline equilibrium level of demand.

Minimizing costs per unit of printing service (Y_j) yields the conditional demand for an individual printing input (X_i) by final product j written as

$$X_{ij} = \frac{\delta_j Y_j p_j}{p_i^{\sigma_j}\left[\delta_j p_1^{1-\sigma_j} + (1-\delta_j) p_2^{1-\sigma_j}\right]} \qquad (4\text{-}6)$$

where p_1 and p_2 are the price of the respective printing input i with other parameters defined as before.

The total market demand for an individual printing input (X_i) is the sum across all producing industries j, i.e.,

$$X_i^D = \sum_j X_{ij} \; . \qquad (4\text{-}7)$$

In a similar fashion, we solve for the conditional demand for the factors of production capital and labor by each printing process as given by

$$K_i = \frac{(1-\gamma_i) VA_i p_i}{r^{\epsilon_i}\left[\gamma_i w^{1-\epsilon_i} + (1-\gamma_i) r^{1-\epsilon_i}\right]} \qquad (4\text{-}8a)$$

and

$$L_i = \frac{\gamma_i VA_i p_i}{w^{\epsilon_i}\left[\gamma_i w^{1-\epsilon_i} + (1-\gamma_i) r^{1-\epsilon_i}\right]} \; . \qquad (4\text{-}8b)$$

Summing across printing processes i determines total market demand for capital and labor by the printing industry

$$K^D = \sum_i K_i \qquad (4\text{-}9a)$$

and

$$L^D = \sum_i L_i \ . \qquad (4\text{-}9b)$$

4.2.4 Model Parameterization

Model parameters are chosen to construct a baseline equilibrium data set that is replicated by the model as an equilibrium solution. The model is parameterized with preliminary data from the 1992 U.S. Census of Manufactures as shown in Table 4-3. The basic data contained in this table are used to generate the parameters for the behavioral equations of the model. This involves first decomposing the observations on value of shipments into separate observations on equilibrium prices and outputs. For this purpose, we define otherwise unobservable outputs of producer goods, printing inputs, and other production factors as those amounts that can be sold for $1 at the observed equilibrium. Therefore, the baseline equilibrium data can be separated into price and output observations with all baseline equilibrium market prices equal to unity and all baseline equilibrium outputs are those given by the value of shipment data.

Data presented in Table 4-3 also determine the amount of printing services and all other inputs for each final product and the corresponding input requirement parameters. The amount of printing services (Y) is approximated by the value of materials, ingredients, containers, and supplies. Thus, our construction of printing services includes the ink, substrate, and other materials. The amount of all other inputs (AOI) is computed as the value of shipments minus the value of materials, ingredients, containers, and supplies.

TABLE 4-3. 1992 CENSUS OF MANUFACTURES DATA BY SIC FOR FINAL PRODUCTS

Final product/SIC code	SIC description	Value added ($10^6)	Cost of materials ($10^6)	Materials, ingredients, containers, etc. ($10^6)	Value of shipment ($10^6)
Publications					
Advertising		8,118.8	6,454.1	5,370.6	14,822.968
2754-5	Advertising prtg, gravure	444.9	486.3	451.5	931.2
2752-5	Advertising prtg, litho	7,535.1	5,664.9	4,657.1	13,200
2759-5	Advertising prtg, letterpress	197.5	136.3	117.9	333.8
2759-C34	Advertising prtg, flexo	17.4	12.0	10.1	29.37
2759-8/19-23	Advertising prtg, screen	224.0	154.6	133.8	378.6
Books		13,651.7	8,204.6	3,271.2	21,856.3
2731	Book publishing	11,776.7	5,349.7	1,667.6	17,126.4
2732	Book printing	1,875.0	2,854.9	1,603.6	4,729.9
Catalogs and Directories		2,726.2	2,188.7	1,849.4	4,914.9
2754-3	Cat. and dir. prtg, gravure	417.5	456.3	423.7	873.8
2752-3	Cat. and dir. prtg, litho	2,255.4	1,695.7	1,394.0	3,951.1
2759-3	Cat. and dir. prtg, letterpress	53.3	36.8	31.8	90
Financial and legal documents		5,021.5	4,339.6	3,791.8	9,361.1
2761	Manifold business forms	3,908.5	3,506.1	3,105.0	7,111.6
2759-C32	Fin. and legal prtg, flexo	10.1	7.0	6.0	17.0
2752-4	Fin. and legal prtg, litho	1,059.2	796.4	654.7	1,855.6
2759-4	Fin. and legal prtg, letterpress	43.7	30.2	26.1	73.9

(continued)

TABLE 4-3. 1992 CENSUS OF MANUFACTURES DATA BY SIC FOR FINAL PRODUCTS (CONTINUED)

Final product/SIC code	SIC description	Value added ($10^6)	Cost of materials ($10^6)	Materials, ingredients, containers, etc. ($10^6)	Value of shipments ($10^6)
Magazines and periodicals		18,736.1	8,535.3	4,395.0	27,271.4
2721	Periodicals	15,761.8	6,213.7	3,453.5	21,975.5
2754-1	Mag. and periodical prtg, gravure	263.3	287.8	267.2	551.1
2759-C29	Mag. and periodical prtg, gravure	32.8	22.7	19.8	55.5
2752-1	Mag. and periodical prtg, litho	2,641.4	1,985.8	1,632.5	4,627.2
2759-1	Mag. and periodical prtg, letterpress	36.7	25.4	21.9	62.1
Newspapers		27,741.6	7,292.4	6,175.7	35,034.0
2711	Newspapers	27,268.6	6,936.5	5,882.5	34,203.1
2759-C36	Newspapers, flexo	2.8	1.9	1.7	4.7
2752-6/11	Newspapers, litho	455.9	342.7	281.8	798.6
2759-6/13	Newspapers, letterpress	16.3	11.3	9.8	27.6
Packaging					
Labels, tags and wrappers		4,563.5	4,340.5	3,917.7	8,904
2754-2	Labels & wrappers (gravure)	247.8	270.8	251.4	518.6
2759-7	Flexo printed labels	816.0	563.3	487.3	1,379.3
2752-2	Labels & wrappers (litho)	918.9	690.8	567.9	1,609.7
2759-2	Labels & wrappers (letterpress)	166.5	114.9	99.4	281.4
2759-8	Screen printing labels	237.8	164.2	142.0	402
2672-3	Pressure sensitive products (labels)	2,176.5	2,536.5	2,369.6	4,713.0

TABLE 4-3. 1992 CENSUS OF MANUFACTURES DATA BY SIC FOR FINAL PRODUCTS (CONTINUED)

Final product/SIC code	SIC description	Value added (10^6)	Cost of materials (10^6)	Materials, ingredients, containers, etc. (10^6)	Value of shipments (10^6)
Corrugated					
2653	Corrugated and solid fiber boxes	6,665.3	13,015.5	1,218[illegible].1	19,680.8
Folding Cartons		3,869.3	4,611.1	4,299.2	8,480.4
2657	Folding paperboard boxes	3,630.8	4,414.0	4,125.4	8,044.8
2652	Setup paperboard boxes	238.5	197.1	173.8	435.6
Sanitary packaging					
2656	Sanitary food containers	1,059.2	1,431.6	1,336.8	2,490.8
Flexible packaging		4,693.0	4,967.9	4,505.1	9,660.9
2671	Paper coating & laminating for pkg	1,507.5	2,211.0	2,106.3	3,718.5
3089-4	Plastics packaging	3,185.5	2,756.9	2,398.8	5,942.4
Paper bags & multiwall sacks		1,777.0	2,600.0	2,413.1	4,377.0
2673 excl. 2673-2	Bags, plastic, laminated and coated	771.3	765.1	686.1	1,539.4
2674	Bags: uncoated paper and multiwall	1,002.7	1,834.9	1,727.0	2,837.6
Plastic bottles					
3085	Plastic bottles	2,088.1	2,280.3	2,071.0	4,368.4
Plastic bags					
2673-2	Specialty bags and liners, plastic	2,095.9	2,070.0	1,857.3	4,166.9
Metal cans					
3411	Metal cans	9,948.4	2,227.0	2,107.2	12,175.4

(continued)

TABLE 4-3. 1992 CENSUS OF MANUFACTURES DATA BY SIC FOR FINAL PRODUCTS (CONTINUED)

Final product/SIC code	SIC description	Value added (10^6)	Cost of materials (10^6)	Materials, ingredients, containers, etc. (10^6)	Value of shipments (10^6)
Other packaging, not elsewhere classified		4,137.2	3,479.4	2,967.0	7,614.6
3466	Crowns and closures (metal)	395.5	437.4	409.6	832.9
2655	Fiber cans, drums, etc.	783.8	1,138.3	1,061.9	1,922.1
3221	Glass containers	2,956.9	1,903.7	1,495.5	4,859.6
Products					
Sanitary paper products					
2676	Sanitary paper products	8,070.8	7,396.7	7,117.6	15,467.5
Envelopes					
2677	Envelopes	1,355.2	1,482.5	1,268.0	2,837.7
Floorcoverings					
3996	Hard surface floor coverings	904.6	616.5	547.3	1,521.1
Wallcoverings					
2679-1	Wallcoverings	200.2	216.1	185.9	416.3
Gift wraps					
2679-2	Gift wrap, paper	323.0	283.3	243.7	606.3
Greeting cards					
2771	Greeting card publishing	3452.6	743.0	473.2	1,195.6

See sources on following page.

(continued)

TABLE 4-3. 1992 CENSUS OF MANUFACTURES DATA BY SIC FOR FINAL PRODUCTS (CONTINUED)

Sources: U.S. Department of Commerce. 1992.

Census of Manufactures: Prelimary Report Industry Series: Commercial Printing and Manifold Business Forms. Washington, DC, U.S. Goverment Printing Office. October 1994

Census of Manufactures: Prelimary Report Industry Series: Paperboard Containers and Boxes. Washington, DC, U.S. Goverment Printing Office. October 1994.

Census of Manufactures: Prelimary Report Industry Series: Glass Products. Washington, DC, U.S. Goverment Printing Office. September 1994.

Census of Manufactures: Prelimary Report Industry Series: Newspapers, Periodicals, Books, and Miscellaneous. Washington, DC, U.S. Goverment Printing Office. October 1994.

Census of Manufactures: Prelimary Report Industry Series: Miscellaneous Manufactures Publishing. Washington, DC, U.S. Goverment Printing Office. November 1994.

Census of Manufactures: Prelimary Report Industry Series: Miscellaneous Plastic Products, n.e.c. Washington, DC, U.S. Goverment Printing Office. November 1994.

Census of Manufactures: Prelimary Report Industry Series: Greeting cards; Bookbinding; Printing Trade Services. Washington, DC, U.S. Goverment Printing Office. September 1994.

Census of Manufactures: Prelimary Report Industry Series: Converted Paper and Paperboard Products except Containers and Boxes. Washington, DC, U.S. Goverment Printing Office. October 1994.

The input requirement parameter (α_j) of printing services per unit of final product was computed by dividing the amount of printing services by the value of shipments for each final product. The input requirement parameter (β_1) of value added per unit of printing input was computed by dividing the value added by the value of shipments for each printing input using 1992 Census of Manufactures data from SIC codes 2752, 2754, and 2759.[c] The weighting parameters that determine the allocation of printing services among the printing processes for each final product were derived using information from the Gravure Association of America (GAA)[d] and Eldred.[3]

Given the baseline market price and output observations, as shown in Table 4-4, and the functional forms of the behavioral equations the parameter values are solved to complete the consistent baseline equilibrium data set. In the case of CES production functions, an extraneous estimate of the elasticity of substitution must be provided for the printing inputs to each producing industry and for the capital and labor inputs to each printing process. To our knowledge no study has ever estimated the elasticity of substitution between printing processes. Therefore, separate model simulations were performed with assumed values of 0.5 and 1.5 across all final products to provide a sensitivity analysis of the market adjustments. This analysis incorporates Frenger's estimate of 0.3 for the elasticity of substitution between capital and labor in the printing industry.[4] Furthermore, in the absence of estimates for the demand elasticity, the analysis assumes a value of -1 for each of the 22 final products.

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[c]Data for SIC code 2754 (Commercial Printing, Gravure) were used for the gravure printing input, while SIC codes 2759B and 2759C (Commercial Printing, Flexographic) were used for the flexography printing input. The composite printing input required aggregating data for SIC codes 2752 (Commercial Printing, Lithographic), 2759-1 through 2759-6 (Commercial Printing, Letterpress), and 2759-8 (Commercial Printing, Screen).[1]

[d]Specifically, data on the value of shipments by each printing process for final products and/or market share were obtained from GAA.[2]

TABLE 4-4. BASELINE MARKET PRICE AND OUTPUT OBSERVATIONS FOR FINAL PRODUCTS AND PRINTING INPUTS

	Market price	Total output (10^6)	Printing input (10^6)			
			Flexography	Gravure	Other	Total
Publications, total		113,310.7	1,375.9	4,286.9	19,191.2	24,854.0
Advertising	$1	14,873.0	0.0	590.8	4,779.8	5,370.6
Books	$1	21,856	0.0	65.4	3,205.8	3,271.2
Catalogs and directories	$1	4914.9	0.0	466.1	1,383.4	1,849.4
Fin. & legal documents	$1	9,361	758.4	0.0	3,033.4	3,791.8
Magazines & periodicals	$1	27,271	0.0	3,164.6	1,230.7	4,395.3
Newspapers	$1	35,034	617.6	0.0	5,558.1	6,175.7
Packaging, total		81,919.2	30,290.4	3,529.3	3,840.7	37,660.5
Labels, tags, & wrappers	$1	8,904	3,604.3	313.4	0.0	3,917.7
Corrugated	$1	19,681	11,309.4	0.0	876.7	12,186.1
Folding cartons	$1	8,480	3,382.0	917.2	0.0	4,299.2
Sanitary packaging	$1	2,491	1,069.4	267.4	0.0	1,336.8
Flexible packaging	$1	9,661	4,149.4	355.7	0.0	4,505.1

(continued)

TABLE 4-4. BASELINE MARKET PRICE AND OUTPUT OBSERVATIONS FOR FINAL PRODUCTS AND PRINTING INPUTS (CONTINUED)

	Market price	Total output (10^6)	Printing input (10^6)			
			Flexography	Gravure	Other	Total
Paper bags	$1	4,377	2,219.6	193.5	0.0	2,413.1
Plastic bottles	$1	4,368	1,119.5	951.5	0.0	2,071.0
Plastic bags	$1	4,166.9	1,326.6	530.6	0.0	1,857.3
Metal cans	$1	12,175.4	301.0	0.0	1,806.2	2,107.2
Other packaging, n.e.c.	$1	7,614.6	1,809.1	0.0	1,157.9	2,967.0
Products, total		25,044.5	6,887.2	2,344.9	603.5	9,835.6
Sanitary paper products	$1	15,467.5	6,783.1	334.5	0.0	7,117.6
Envelopes	$1	2,837.7	0.0	1,014.4	253.6	1,268.0
Floor coverings	$1	1,521.1	0.0	459.7	87.6	547.3
Wall coverings	$1	416.3	104.1	81.8	0	185.9
Gift wraps	$1	606.3	0.0	170.6	73.1	243.7
Greeting cards	$1	4,195.6	0.0	283.9	189.3	473.2
Printing input, totals			61,985	21,104	5,432	88,521

4.2.5 Incorporating Regulatory Control Costs

The starting point for assessing the market impact of the regulations is to incorporate the regulatory control costs into the production decisions for final products. The final products included in this analysis were chosen because of their employment of either gravure or flexographic printing. All final products employing gravure are affected by the regulation with the associated costs determined by classification (i.e., publication gravure or packaging product gravure). Alternatively, not all final products using flexography are affected by the regulation. The final product category of labels, tags, and wrappers is unaffected since it uses narrow web flexography, which is not covered by the regulations. Furthermore, the engineering analysis to develop compliance costs found that newspapers and corrugated producers were currently in compliance and thus incur no additional control costs.

The per-unit cost of the regulation is calculated for publication gravure, packaging and product gravure, and flexography based on the total annual compliance cost estimated for each segment by the engineers (see Table 3-4 in Section 3). The total annual compliance cost includes the annualized capital cost, the operating expenses, as well as the monitoring and recordkeeping costs. To ensure consistency among the estimates of total compliance costs for the printing and publishing industry by the market model and the engineering analysis, the per-unit cost of the regulation was derived by dividing the total annual compliance cost for a particular segment by the corresponding affected baseline output from the market model for that segment. For publication gravure, the per-unit cost of the regulation is estimated at 0.49¢, while the per-unit cost of the regulation for packaging and product gravure is estimated at 0.46¢. For flexography, the per-unit cost of the regulation is estimated at 0.02¢.

The estimated per-unit compliance cost (c) for each industry segment is incorporated into the model structure through the conditional demand equations for printing inputs (Eq. [4-6]). For affected final products, we substituted a gross price, $p_i^* = (p_i + c)$, for the net price (p_i) of printing input i, i.e.,

$$X_{ij} = \frac{\delta_j Y_j p_j}{(p_i + c_{ij})^{\sigma_j}\left[\delta_j (p_1 + c_{1j})^{1-\sigma_j} + (1 - \delta_j)(p_2 + c_{2j})^{1-\sigma_j}\right]} \cdot \quad (4\text{-}6')$$

For example, the gross price of gravure for use in publications without accounting for market adjustments would be $1.005 (e.g., the baseline market price of $1 plus the per-unit compliance cost). The market adjustments described below will act to reduce the gross price faced by consumers of affected products, like publication gravure, through a reduction in the net price received by producers of gravure.

4.2.6 Market Equilibria

Appendix A includes a complete list of exogenous and endogenous variables, as well as model equations. The new post-compliance equilibrium is the result of a series of iterations between producer and consumer responses and market adjustments until a stable market price arises where total market supply equals total market demand for each producer good, printing process, and factor of production, with no excess profits. That is,

$Q_j^S = Q_j^D$, for all final products (j),

$X_i^S = X_i^D$, for all printing inputs (i),

and

$K^S = K^D$ and $L^S = L^D$.

This market clearing process is simulated given the per-unit compliance costs, producer and consumer behavioral equations, and market adjustment mechanisms to arrive at the with-regulation equilibrium.

The process for determining equilibrium prices (and outputs) is modeled as a Walrasian auctioneer. The auctioneer calls out a price for each product and evaluates the reactions by all participants (producers and consumers), comparing quantities supplied and demanded to determine the next price that will guide the market closer to equilibrium (i.e., market supply equal to market demand). Simply stated, the price revision rule employs a simple Walrasian rule that raises the price of a product in excess demand, lowers the price of a product in excess supply, and leaves unchanged the price of a product with own demand equal to own supply. Decision rules were established to ensure that the process will converge to an equilibrium and to specify the conditions for equilibrium. The result of this approach is a vector of with-regulation product prices that equilibrates supply and demand for all markets.

4.3 MARKET IMPACTS

Market-level impacts of the regulation include the market adjustments in price and quantity for all final products and printing inputs. However, the structure of the market model precludes using these market adjustments to estimate the changes in the aggregate economic welfare following traditional applied welfare economics principles. Therefore, the economic welfare impacts are discussed below along with an approximation of the social cost of the regulation.

4.3.1 Price and Quantity Impacts

Market adjustments are a result of moving from the baseline to with-regulation equilibrium. Given the regulatory control costs, the interaction of producer responses and price revision mechanism, modeled as a Walrasian auctioneer, along

with the simultaneous coordination of the final product and input markets, results in a new with-regulation equilibrium consisting of new prices and quantities for all product markets (22 final products and three printing inputs).

Table 4-5 provides the market adjustments associated with the regulation for separate model simulations employing different assumed values for the elasticity of substitution between printing processes of 0.5 and 1.5 across all final products. Percentage change in market prices and quantities is significantly below 1 percent across all final products and printing inputs. The percentage increase in the market price of gravure is predicted to be 0.4 percent in response to the regulation, while the market price of flexography is predicted to decline by a negligible amount of 0.06 percent. The model results predict substitution away from gravure to flexography and other printing inputs but at a very low level as indicated by the output adjustments. Although the percentage change in market price of printing inputs does not vary by specification of elasticity of substitution, the percentage change in output with a value of 1.5 for each printing input is almost double those observed with a value of 0.5. This outcome is expected as a result of the higher sensitivity of input substitution given higher values of the elasticity of substitution.

Table 4-6 provides the projected reallocation of capital and labor services within the printing industry in response to the regulation. As expected, given the market adjustments detailed above, the model predicts a very small reallocation of capital and labor services away from gravure to flexography and other printing inputs. Also, the output adjustments are higher under the simulation with the assumed value of 1.5 for the elasticity of substitution between printing inputs.

4.3.2 Economic Welfare Impacts

The value of a regulatory policy is traditionally measured by the change in economic welfare that it generates. Welfare impacts resulting from the regulatory controls on the printing and publishing industry will extend to the many

TABLE 4-5. PRICE AND QUANTITY ADJUSTMENTS DUE TO REGULATION: PRINTING INPUTS AND FINAL PRODUCTS

	Elasticity of substitution[a]			
	0.5		1.5	
	Percentage change in		Percentage change in	
Product	Price	Quantity	Price	Quantity
Printing Inputs				
Flexography	-0.06	0.04	-0.05	0.07
Gravure	0.41	-0.29	0.41	-0.53
Other[b]	-0.07	0.04	-0.06	0.06
Final Products				
Publications, Total	0.03	-0.03	0.04	-0.04
Advertising	-0.02	0.01	-0.00	0.07
Books	-0.05	0.05	-0.04	0.04
Catalogs and directories	0.05	-0.06	0.06	-0.06
Final and legal documents	-0.07	0.06	-0.06	0.06
Magazines and periodicals	0.27	-0.27	0.27	-0.27
Newspapers	-0 06	0.04	-0.05	0.05
Packaging, Total	-0.01	0.01	-0.01	0.01
Labels, tags, and wrappers	-0.03	0.03	-0.02	0.02
Corrugated	-0.07	0.07	-0.06	0.06
Folding cartons	0.05	-0.05	0.06	-0.06
Sanitary packaging	0.04	-0.04	0.05	-0.05
Flexible packaging	-0.01	0.01	-0.00	0.00
Paper bags	-0.01	0.01	-0.00	0.00
Plastic bottles	0.15	-0.16	0.16	-0.16
Plastic bags	0.08	-0.08	0.09	-0.09
Metal cans	-0.06	0.06	-0.05	0.05
Other printing, necessities	-0.03	0.04	-0.03	0.04

(continued)

TABLE 4-5. PRICE AND QUANTITY ADJUSTMENTS DUE TO REGULATION: PRINTING INPUTS AND FINAL PRODUCTS (CONTINUED)

	Elasticity of substitution[a]			
	0.5		1.5	
	Percentage change in		Percentage change in	
Product	Price	Quantity	Price	Quantity
Products, Total	0.07	-0.07	0.07	-0.08
Sanitary paper products	-0.05	0.05	-0.04	0.04
Envelopes	0.30	-0.30	0.31	-0.31
Floor coverings	0.32	-0.32	0.33	-0.33
Wall coverings	0.15	-0.15	0.16	-0.15
Gift wraps	0.26	-0.25	0.26	-0.26
Greeting cards	0.20	-0.20	0.19	-0.20

[a] The elasticity of substitution between printing processes in final production is assumed to be the same across all final products.

[b] Other printing input is a composite input that includes lithography, letterpress, and screen printing processes.

TABLE 4-6. REALLOCATION OF CAPITAL AND LABOR IN PRODUCTION OF PRINTING INPUTS DUE TO REGULATION

	Elasticity of substitution[a]			
	0.5		1.5	
	Percentage change in		Percentage change in	
Printing input	Capital	Labor	Capital	Labor
Flexography	0.04	0.04	0.06	0.07
Gravure	-0.29	-0.28	-0.53	-0.52
Other[b]	0.04	0.05	0.08	0.09

[a] The elasticity of substitution between capital and labor services in printing processes is assumed to be the same across all final products.

[b] Other printing input is a composite input that includes lithography, letterpress, and screen printing processes.

consumers and producers of printing and publishing services. In a market environment, consumers and producers of a good or service derive welfare from a market transaction. The difference between the maximum price consumers are willing to pay for a good and the price they actually pay is referred to as consumer surplus. Consumer surplus is measured as the area under the demand curve and above the price of the product. Similarly, the difference between the minimum price producers are willing to accept for a good and the price they actually receive is referred to as producer surplus. Producer surplus is measured as the area above the supply curve to the price of the product. These areas may be thought of as consumers' net benefits of consumption and producers' net benefits of production, respectively.

The structure of the market model for the printing and publishing industry precludes estimating the economic welfare impacts in the traditional fashion. An alternative is to approximate the social cost of the regulation using the total annual compliance cost as estimated by the engineers. The total capital cost is annualized over its expected life (10 years) at a 7 percent discount rate. The annual operating expenses and administrative costs (i.e., monitoring and recordkeeping) are added to the annualized capital cost to arrive at the total annual social cost approximation. For the NESHAP on the printing and publishing industry, the total annual social cost approximation is $40.0 million with publication gravure accounting for $17.4 million, packaging and product gravure accounting for $21.1 million, and flexography accounting for $1.5 million. The difference between this estimate of social cost and that derived through economic welfare analysis is the deadweight loss to society of the inefficient reallocation of resources. Typically, the deadweight loss is very small relative to the total annual compliance cost so that the approximation of total annual social cost described above is of the correct magnitude.

4.4 REFERENCES

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SECTION 5
FIRM-LEVEL ANALYSIS

A regulatory action to reduce air emissions from the printing and publishing industry will potentially affect owners of the regulated plants. Firms or individuals that own the facilities are legal business entities that have the capacity to conduct business transactions and make business decisions that affect the facility. The legal and financial responsibility for compliance with a regulatory action ultimately rests with the owners of the printing and publishing plant who must bear the financial consequences of their decisions. Thus, an analysis of the firm-level impacts of EPA regulations involves identifying and characterizing affected entities; assessing their response options by modeling or characterizing the decision-making process and projecting how different parties will respond to a regulation; and analyzing the consequences of those decisions. Analyzing firm-level impacts is important for two reasons:

- Even though a plant is projected to be profitable with the regulation in place, financial constraints affecting the firm owning the facility may mean that the plant changes ownership.

- The Regulatory Flexibility Act (RFA), the EPA guidelines for conducting Regulatory Flexibility Analyses, and the Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996 requires that the impact of regulations on all small entities, including small companies, be assessed.

Environmental regulations such as the NESHAP for the printing and publishing industry affect all businesses, large and small, but small businesses may have special problems in complying with such regulations. The RFA of 1980 requires that special consideration be given to small entities affected by Federal regulation. Under the 1992 revised EPA guidelines for implementing the RFA, an initial regulatory flexibility analysis (IRFA) and a final regulatory flexibility analysis

(FRFA) will be performed for every rule subject to the Act that will have any economic impact, however small, on any small entities that are subject to the rule, however few. Therefore, this firm level analysis specifically addresses the RFA requirements by measuring the impacts on small entities associated with the regulations on the printing and publishing industry. This should also provide enough analyses of small entities to satisfy the analytical requirements of the SBREFA.

The general steps involved in analyzing company-level impacts include identifying and analyzing the possible option facing owners of affected facilities and analyzing the impacts of the regulation including impacts on small companies and comparing them to impacts on other companies.

5.1 ANALYZE OWNERS' RESPONSE OPTIONS

Generally, it is assumed that, when choosing a compliance option, owners will act in a way that maximizes the net present value (NPV) of the firm. As shown in Figure 5-1, owners of affected plants are assumed to choose among the following options:

- install pollution control equipment,
- discontinue regulated processes within the facility, and
- comply via process and/or input substitution (pollution prevention).

Firms compare their with-regulation total revenues with their with-regulation total costs, including annualized liquidation value. If profits are positive (TR>TC), the plant should continue operating; if not, it should shut down. This option is referred to as voluntary exit because equity holders as opposed to debt holders make the exit decision. Exit may take the form of liquidation of the assets, a distressed sale of the facility to another firm, or conversion of the facility to other uses.

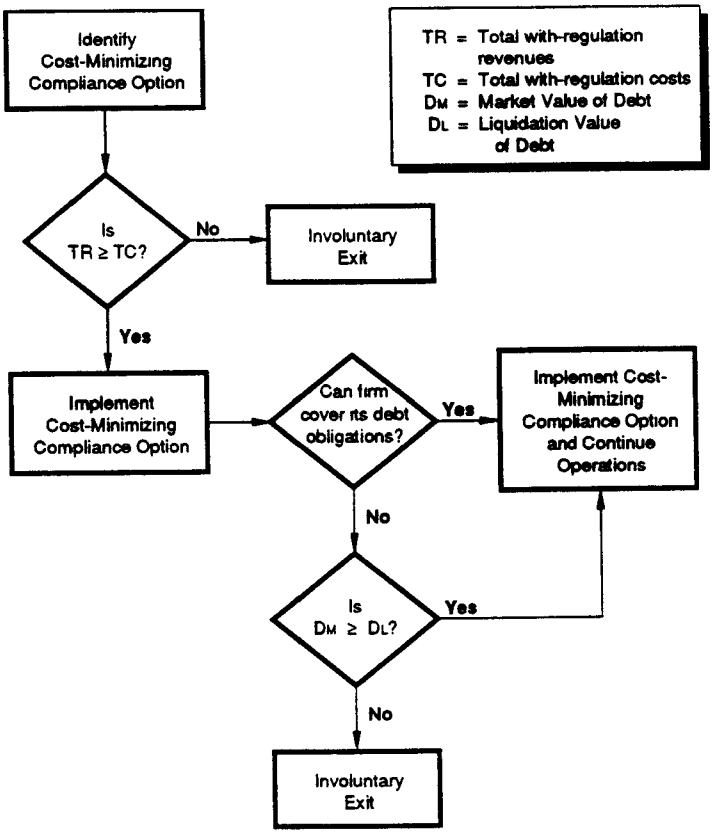

Figure 5-1. Characterization of owner responses to regulatory actions.

If the firm chooses to implement the cost-minimizing control option, to continue to operate the facility, and to continue to meet its debt obligations, operations will continue. However, if the firm cannot meet its interest payments or is in violation of its debt covenants, the debt holders take control of the exit decision. If the market value of debt under continued operations is greater than the liquidation value of debt, then debt holders will allow the facility to continue to operate. The owners will implement the cost-minimizing compliance option and continue to operate the plant. If, however, the market value of debt under continued operations is less than its liquidation value,

operations. Exit will likely take the form of liquidation of assets or distressed sales of the facility. Any of the above decisions may change the financial status of the firm.

This analysis evaluates the change in financial status by first computing the with-regulation financial ratios of potentially affected firms and comparing them to the corresponding baseline ratios. These financial ratios may include indicators of liquidity, asset management, debt management, and profitability. Although there are a variety of possible financial ratios providing individual indicators of a firm's health, they may not all give the same signals. Therefore, for this analysis, the focus is on changes in key measures of profitability (return on sales, the return on assets, and the return on equity). Furthermore, a composite of financial ratios (i.e., the Z-score[1]) is employed to measure financial viability and determine the likelihood that regulatory compliance will result in financial failure (bankruptcy) of the owning firm.

The severity of the rule's impacts on small entities may be measured once the small entities are identified. Small entities include small businesses, small organizations, and small governmental jurisdictions and may be defined using the criteria prescribed in the RFA or other criteria identified by EPA. Small businesses are typically defined using SBA general size standard definitions for SIC codes. Firms owning plants that have gravure or flexographic printing capabilities are covered by various SIC codes. The main relevant industries potentially include the commercial printing and book printing industries under SIC 27, the packaging industries under SICs 26, 30, 32, and 34, as well industries under SICs 26 and 30 that produce products with gravure or flexographic printing. The SBA size standards for all of these industries are based on the number of employees so that businesses in most of these industries are considered small if they have fewer than 500 employees; otherwise they are considered large.

Potentially affected firms include entities that own plants employing gravure or flexographic printing processes. For the base year of 1993, the EPA survey indicates that 6 companies owned the 27 publication rotogravure plants and 64 companies owned the 107 packaging/product rotogravure plants. Furthermore, the EPA survey of flexographic printers identified 500 companies. Companies in this analysis include those owned directly by the shareholders/owners and those owned by a "parent" company for which complete financial information was readily available. Therefore, 45 firms involved in the printing and publishing industry are included in this analysis.

5.2 IMPACTS OF THE REGULATION

This analysis characterizes the financial status of 45 firms potentially affected by the regulation. The baseline financial profile is based on financial information from Dun and Bradstreet for 11 private firms and from Dow Jones Business Information Services for 34 public firms. The firms in this analysis include 4 of the 6 in publication gravure, 20 of the 64 in packaging and product gravure, and only 21 of the 500 to 1,000 firms involved in flexographic printing.

To compute the with-regulation financial ratios, pro-forma income statements and balance sheets reflecting the with-regulation condition of affected firms are developed based on projected with-regulation costs (including compliance costs) and revenues (including the with-regulation price and quantity changes projected using a market model). However, in this case, the results from the market model do not allow for calculation of facility revenue changes, thereby precluding the inclusion of market adjustments in projecting company-level revenue changes. As a consequence, for this analysis, it is assumed that revenues are constant and that the regulatory costs are fully absorbed--a worst case scenario. Table 5-1 shows the adjustments made to the baseline financial

TABLE 5-1. CALCULATIONS REQUIRED TO SET UP WITH-REGULATION FINANCIAL STATEMENTS

Financial statement category	Calculations
Income statement	
Annual revenues	No change from baseline
Cost of sales	No change from baseline
Gross profit	Annual revenues—cost of sales
Expenses due to regulation	Administration: Monitoring and recordkeeping costs of regulation operating: operating and maintenance expenses of regulation
Other expenses and taxes	(Gross profit—estimated expense due to regulation) • baseline ratio of other expenses and taxes to gross profit
Net income	Gross profit—estimated expense due to regulation—other expenses and taxes
Balance Sheet	
Cash	No change from baseline
Accounts receivable	No change from baseline
Other current assets	No change from baseline
Total current assets	Baseline total current assets—[(1 - debt ratio) times total capital cost]
Fixed assets	Baseline fixed assets + total capital cost
Other noncurrent assets	No change from baseline
Total assets	Total current assets + fixed assets + other noncurrent assets
Accounts payable	No change from baseline
Other current liabilities	No change from baseline
Total current liabilities	Accounts payable + other current liabilities
Noncurrent labilities	Baseline noncurrent liabilities + (debt ratio times total capital cost)
Total labilities	Total current liabilities + noncurrent liabilities
Net worth	Total assets—total liabilities

statements to develop the with-regulation financial statements that form the basis of this analysis.

Several adjustments are made to the financial statements of each firm to account for the regulation-induced changes at all facilities owned by the firm. Because the market adjustments predicted by the market model are not linked to facilities, the firm-level analysis does not account for both directly and indirectly affected firms. Thus, only those firms that own an affected facility and incur compliance costs are evaluated in this analysis. Directly affected firms typically incur three types of costs because of the regulation: capital, operating, and administrative. The capital cost is an initial lump sum associated with purchasing and installing pollution control equipment. Operating costs are the annually recurring costs including costs associated with operation and maintenance of control equipment, while administrative costs are annually recurring costs that include emission monitoring, reporting, and recordkeeping costs. Table 5-2 provides an indication of the burden of the regulatory costs on firms. This table shows the mean and maximum levels of total capital costs and total annual compliance cost (annualized capital plus the annual operating and administrative cost) as a percentage of baseline total costs by size and type of firm.

In the annual income statement, the baseline operating expenses are increased by the aggregate change in operating and maintenance costs across printing facilities owned by the firm, while the administrative, selling, and general expenses of the firm also increase by the aggregate change in monitoring and recordkeeping costs across its facilities.

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

TABLE 5-2. MEASURES OF COMPLIANCE COSTS AS A PERCENTAGE OF BASELINE TOTAL COSTS BY SIZE AND TYPE OF FIRM

Item	Small firms			Large firms			All firms
	Public	Private	Total	Public	Private	Total	
Total number of firms	2	7	9	32	4	36	45
Number of firms with costs	1	2	3	5	3	8	11
Total annual compliance costs							
Mean (percent)	0.24	0.99	0.83	0.08	0.33	0.10	0.12
Maximum (percent)	0.49	4.12		1.37	0.82		4.12
Total capital cost							
Mean (percent)	0.48	1.96	1.63	0.21	1.34	0.33	0.29
Maximum (percent)	0.97	8.09		2.72	3.59		8.09

- debt financing,
- equity financing, or
- a mixture of debt and equity financing.

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

Leverage indicates the degree to which a firm's assets have been supplied by, and hence are owned by, creditors versus owners. Leverage should be in an acceptable range, indicating that the firm is using enough debt financing to take advantage of the low cost of debt but not so much that current or potential creditors are uneasy about the ability of the firm to repay its debt. The debt ratio (d) is a common measure of leverage that divides all debt, long- and short-term, by total assets. Capital structure does not appear to have a significant impact on firm value over a wide range of debt ratio values. Consequently, it is assumed that the current capital structure, as measured by the debt ratio, reflects the optimal capital structure for each firm. Thus, each firm's debt ratio for 1993 determines the amount of capital expenditures on pollution control technology that will be debt financed.

Thus, in the assets side of the balance sheet of affected firms, current assets decline by (1 - d) times the total

capital cost (E^K), while the value of property, plant, and equipment (fixed assets) increases by the total capital cost (i.e., the value of the pollution control equipment). Thus, the overall increase in a firm's total assets is equal to that fraction of the total capital cost that is not paid out of current assets (i.e., $d \bullet E^K$).

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

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

5.2.1 Profitability Analysis

Financial ratios may be categorized as one of five fundamental types:

- liquidity or solvency,
- asset management,
- debt management,
- profitability, or
- market value.[2]

Profitability is the most comprehensive measure of the firm's performance because it measures the combined effects of liquidity, asset management, and debt management. Analyzing profitability is useful because it helps evaluate both the

incentive and ability of firms in the printing and publishing industry to incur the capital and operating costs required for compliance. More profitable firms have more incentive than less profitable firms to comply because the annual returns to doing business are greater. In the extreme, a single-facility firm earning zero profit has no incentive to comply with a regulation imposing positive costs unless the entire burden of the regulation can be passed along to consumers. This same firm may also be less able to comply because its poor financial position makes it difficult to obtain funds through either debt or equity financing.

As shown in Table 5-3, three ratios are commonly used to measure profitability, including return on assets, return on equity, and return on sales. For all these measures, higher values are unambiguously preferred over lower values. Negative values result if the firm experiences a loss.

Table 5-4 provides the summary statistics for each measure of profitability. The summary statistics include the mean, minimum, and maximum values for each measure at baseline and with-regulation across small, large, and all firms in the industry. A comparison of the values at baseline and after imposing of the regulation provides much detail on the distributional changes in these profitability measures across firms.

TABLE 5-3. KEY MEASURES OF PROFITABILITY

Measure of profitability	Formula for calculation
Return on sales	$\frac{\text{Net income}}{\text{Sales}}$
Return on assets	$\frac{\text{Net income}}{\text{Total assets}}$
Return on equity	$\frac{\text{Net income}}{\text{Owner's equity}}$

TABLE 5-4. SUMMARY STATISTICS FOR KEY MEASURES OF PROFITABILITY IN BASELINE AND WITH-REGULATION BY FIRM SIZE CATEGORY

Measure of profitability/summary statistics	Baseline			With regulation		
	Small firms	Large firms	All firms	Small firms	Large firms	All firms
Return on sales						
Mean	4.82	1.28	0.97	4.43	1.24	0.92
Minimum	1.16	-14.69		1.13	-14.78	
Maximum	8.68	10.11		8.68	10.11	
Return on assets						
Mean	9.88	1.75	1.65	8.71	1.72	1.53
Minimum	3.16	-14.83		3.08	-14.70	
Maximum	14.68	14.73		14.68	14.73	
Return on equity						
Mean	20.23	-1.81	1.27	17.92	-1.93	1.00
Minimum	13.3	-182.76		10.3	-183.80	
Maximum	33.03	74.91		33.03	73.50	

As Table 5-4 illustrates, the mean return on sales declines by 5 percent for all firms after imposing the regulation. The observed decline for large firms is 3 percent, while the mean return on sales for small firms declined by 8 percent. Further, the mean return on assets slightly declines for all firms with the regulation from 1.65 percent to 1.53 percent. A decline in the mean return on assets is also found for small (12 percent) and large (2 percent) firms alike. As measured across all firms, the with-regulation mean return on equity declines from 1.27 percent to 1 percent. As a group, the financial impacts associated with the regulation are negligible and show no overall disproportionate impact across small and large firms.

5.2.2 Bankruptcy Analysis

The distinction between plants and firms is an important one in discussing their economic viability. A market analysis focuses on the economic viability of printing and publishing plants — close the plant if marginal revenue (price) is below marginal cost. Alternatively, the firm-level analysis addresses the viability of companies as legal entities. Their viability is conditional on their ability to meet their legal liabilities at the firm level.

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

The objective of the firm-level bankruptcy analysis is to determine the likely effect of the regulatory options on the financial and legal viability of firms within the printing and publishing industry, with special emphasis on possible disparities between small and large firms.

A composite ratio of financial condition, called the Z-score, is computed to characterize baseline and with-regulation financial condition of potentially affected firms. The Z-score is a multidiscriminant function used to assess bankruptcy potential and was developed specifically for manufacturing firms.[3] This approach has the advantage of combining information from several financial variables, which examined individually may yield contradictory messages of the

firm's financial health. This approach has the advantage of simultaneously addressing liquidity, asset management, debt management, profitability, and market value.

The function is given in the following equation:

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 0.999X_5 \quad (5\text{-}1)$$

where

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

The market value component (X_4) uses stock price data. Consequently, the Z-score is only applicable to firms with publicly traded stock. This analysis will employ a modified function developed for private firms referred to as the Z'-score, given in the following equation:

$$Z' = 0.717X_1 + 0.847X_2 + 3.107X_3 + 0.42X_4 + 0.998X_5 \quad (5\text{-}2)$$

where Z' is the overall index, X_1 through X_3 and X_5 are as defined for Z above, while the book value of equity is substituted for the market value in X_4.

Taken individually, each of the ratios given above is higher for firms in good financial condition and lower for firms in poor financial condition. Consequently, the greater a firm's bankruptcy potential, the lower its overall index score. Once data for a given company have been input, the model yields a Z-score, or Z'-score, which is used to predict future company bankruptcy based on previously estimated categories. A Z-score below 1.81 indicates that bankruptcy is likely, and a score above 2.99 indicates that bankruptcy is unlikely. Z-scores between 1.81 and 2.99 are indeterminate. Similarly, a Z'-score below 1.23 indicates that bankruptcy is likely, and a score above 2.90 indicates that bankruptcy is

unlikely. Z'-scores between 1.23 and 2.90 are indeterminate.

Table 5-5 shows the baseline distribution of publicly traded firms by Z-score prediction and the distribution of firms that do not issue publicly traded stock by Z'-score prediction. Predicted failure rates across firm size reveal that 44 percent (4 of 9) of the small firms and 36 percent (13 of 36) of the large firms are likely to fail in the baseline.

TABLE 5-5. BASELINE BANKRUPTCY PREDICTION

Bankruptcy prediction	Firm size by employment		
	Less than 500	Greater than 500	Total
Publicly traded companies[a]			
Likely	0	10	10
Indeterminate	0	12	12
Unlikely	2	10	12
Subtotal	2	32	34
Other companies[b]			
Likely	4	3	7
Indeterminate	2	1	3
Unlikely	1	0	1
Subtotal	7	4	11
All companies			
Likely	4	13	17
Indeterminate	2	13	15
Unlikely	3	10	13
Total	9	36	45

[a] Bankruptcy prediction is based on the Z-score for companies with publicly traded stock. If a company's Z-score is less than 1.81, the model predicts that bankruptcy is likely. If a company's Z-score is greater than 2.99, the model predicts that bankruptcy is unlikely. Z-scores between 1.81 and 2.99 fall in the indeterminate range, and the model makes no prediction for these companies.

[b] Bankruptcy prediction is based on the Z'-score for companies that do not issue publicly traded stock. If a company's Z'-score is less than 1.23, the model predicts that bankruptcy is likely. If a company's Z'-score is greater than 2.90, the model predicts that bankruptcy is unlikely. Z'-scores between 1.23 and 2.90 fall in the indeterminate range, and the model makes no prediction for these companies.

The predicted failure rates do not compare favorably with average reported failure rates for the U.S. The 1990 failure rate averaged 0.92 percent for U.S. manufacturing firms, 0.49 percent for U.S. service firms, and 0.76 percent for all U.S. firms.[4]

A possible explanation for the high failure predictions for firms in the printing and publishing industry, as measured by the Altman Z-score, is an unintended bias in the sample of 45 firms used in this analysis. A large number of these firms are involved in the forest products industry, which is capital intensive. For example, in 1991, the paper and allied products industry (represented by SIC code 26) had the highest percentage of new capital expenditures to value of shipments (6.9 perent) across all U.S. manufacturing industries.[5] A decade of capital expenditures to retool existing plants and invest in new ones also brings along a large level of current debt for these firms that would correspond to a poor Z-score.

Table 5-6 provides the with-regulation bankruptcy prediction by firm size. With regulation, the likelihood of financial failure is unaffected for both small and large firms. No firm moves from the unlikely to indeterminate range or from the indeterminate to the likely to become bankrupt range. Therefore, there is no evidence of any disproportionate impacts on small entities because of the proposed NESHAP on the printing and publishing industry.

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Table 5-6 provides the with-regulation bankruptcy prediction by firm size. With regulation, the likelihood of financial failure is unaffected for both small and large firms. No firm moves from the unlikely to indeterminate range or from the indeterminate to the likely to become bankrupt range. Therefore, there is no evidence of any disproportionate impacts on small entities because of the NESHAP on the printing and publishing industry.

TABLE 5-6. WITH-REGULATION BASELINE BANKRUPTCY PREDICTION

Bankruptcy prediction	Firm size by employment					
	Less than 500	Percentage change	Greater than 500	Percentage change	Total	Percentage change
Publicly traded companies[a]						
Likely	0	0.0%	10	0.0%	10	0.0%
Indeterminate	0	0.0%	12	0.0%	12	0.0%
Unlikely	2	0.0%	10	0.0%	12	0.0%
Subtotal	2	0.0%	32	0.0%	34	0.0%
Other companies[b]						
Likely	4	0.0%	3	0.0%	7	0.0%
Indeterminate	2	0.0%	1	0.0%	3	0.0%
Unlikely	1	0.0%	0	0.0%	1	0.0%
Subtotal	7	0.0%	4	0.0%	11	0.0%
All companies						
Likely	4	0.0%	13	0.0%	17	0.0%
Indeterminate	2	0.0%	13	0.0%	15	0.0%
Unlikely	3	0.0%	10	0.0%	13	0.0%
Total	9	0.0%	36	0.0%	45	0.0%

[a] Bankruptcy prediction is based on the Z-score for companies with publicly traded stock. If a company's Z-score is less than 1.81, the model predicts that bankruptcy is likely. If a company's Z-score is greater than 2.99, the model predicts that bankruptcy is unlikely. Z-scores between 1.81 and 2.99 fall in the indeterminate range, and the model makes no prediction for these companies.

[b] Bankruptcy prediction is based on the Z'-score for companies that do not issue publicly traded stock. If a company's Z'-score is less than 1.23, the model predicts that bankruptcy is likely. If a company's Z'-score is greater than 2.90, the model predicts that bankruptcy is unlikely. Z'-scores between 1.23 and 2.90 fall in the indeterminate range, and the model makes no prediction for these companies.

5.3 REFERENCES

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2. Brigham, Eugene F., and Louis C. Gapenski. Financial Management: Theory and Practice. 6th Ed. Orlando, FL, The Dryden Press, 1991.

3. Ref. 1.

4. Dun's Analytical Services. Industry Norms and Key Business Ratios. Dun and Bradstreet Credit Services. 1991.

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APPENDIX A

MARKET MODEL OF THE PRINTING AND PUBLISHING INDUSTRY: SUMMARY

This appendix provides a complete list of the exogenous and endogenous variables, as well as the model equations.

A.1 EXOGENOUS VARIABLES

α_j Fixed input requirement for printing services per unit of output for each final product j = 1 to 22.

δ_j CES printing process weighting parameter for each final product (j).

σ_j CES elasticity of substitution between printing processes for each final product (j).

β_i Fixed input requirement for value added per unit of output for each printing process i = 1 to 3.

γ_i CES factor weighting parameter for each printing process (i).

ε_i CES elasticity of substitution between capital and labor for each printing process (i).

K^S, L^S Supply of factors of production in printing and publishing industry.

A_j Demand function parameters for final products (j) (multiplicative constants).

η_j Demand elasticity for final product (j).

c_{ij} Regulatory control costs (per unit of output) for printing process (i) used in final product (j).

A.2 ENDOGENOUS VARIABLES

p_j Price of final products j = 1 to 22.

p_i Price of printing process i = 1 to 3, in net rents per unit.

p^*_{ij} Gross price ($p_i + c_{ij}$) of the i^{th} printing process of the j^{th} final product.

r, w Price of capital and labor services, respectively, employed in the printing and publishing industry.

Q^S_j Market production of the j^{th} final product.

A.2 ENDOGENOUS VARIABLES (continued)

AOI_j — All other inputs in the production of the j^{th} final product.

Y_j — Printing services in the production of the j^{th} final product.

X_{ij} — Use of the i^{th} printing process in the CES function Y_j for each final product (j).

X_i^S — Market production of the i^{th} printing process.

M_i — Intermediate inputs in the production of the i^{th} printing process.

VA_i — Value added in the production of the i^{th} printing process.

K_i, L_i — Captial and labor use, in service units, of the i^{th} printing process.

Q_j^D, X_i^D — Market demands for final products j = 1 to 22 and printing processes i = 1 to 3.

A.3 MODEL EQUATIONS

Production Function for Final Products:

$$Q_i = \min \left[\frac{1}{\alpha_j} Y(X_{1j}, X_{2j}), \frac{AOI_j}{(1-\alpha_j)} \right]$$

CES Function for Printing Services:

$$Y_j = \left[\delta_j X_{1j}^{\rho j} + (1-\delta_J) X_{2j}^{\rho j} \right]^{1/\rho j}$$

where

$$\rho_j = \frac{(\sigma_j - 1)}{\sigma_j}$$

A.3 MODEL EQUATIONS (continued)

Production Function for Printing Processes:

$$X_i = \min \left[\frac{1}{\beta_i} VA(K_i, L_i), \frac{M_i}{(1-\beta_i)} \right]$$

CES Function for Value Added:

$$VA_i = \left[\gamma_i L_i^{\rho_i} + (1-\gamma_i) K_i^{\rho_i} \right]^{1/\rho_i}$$

where

$$\rho_i = \frac{(\varepsilon_i - 1)}{\varepsilon_i}$$

Market Demand of Final Products:

$$Q_j^D = A_j [p_j]^{\eta_j}$$

Market Demand of Printing Inputs:

$$X_i^D = \sum_j X_{ij}$$

where

$$X_{ij} = \frac{\delta_j Y_j p_j}{p_1^{\sigma_j} \left[\delta_j p_1^{1-\sigma_j} + (1-\delta_j) p_2^{1-\sigma_j} \right]}, \text{ without regulation}$$

and

$$X_{ij} = \frac{\delta_j Y_j p_j}{(p_1 + c_{1j})^{\sigma_j} \left[\delta_j (p_1 + c_{1j})^{1-\sigma_j} + (1-\delta_j) (p_2 + c_{2j})^{1-\sigma_j} \right]}, \text{ with regulation}$$