SECTION 1
INTRODUCTION

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. The U.S. Environmental Protection Agency (EPA) estimates that in 1992, 19,200 tons of HAPs were emitted from publication gravure plants and as much as 19,500 tons from product and packaging gravure plants.[1]

EPA is developing an air pollution regulation for reducing HAP emissions from publication gravure, packaging/product gravure, and flexographic printing processes. EPA's Office of Air Quality Planning and Standards (OAQPS) is preparing a National Emission Standard for Hazardous Air Pollutants (NESHAP) under the authority of Title III of the 1990 Amendments to the Clean Air Act (CAA) for industries which use these printing processes.

The printing industry is a very diversified and sophisticated industry owing to the multiplicity of printing processes utilized and products produced. Gravure and flexography compete with offset lithography as the dominant processes. The regulation will potentially affect all

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

entities which 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, 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]

Section 2 of this profile characterizes the supply side of the printing industry, including a detailed discussion of the gravure and flexographic printing processes, inputs to each process, the associated products, and costs of production. In Section 3, the focus is the demand side, concentrating on the desired characteristics of the various printing processes and their primary consumers by use and industry. The organization of the printing industry, both commercial and packaging, is discussed in Section 4, including a description of U.S. printing plants and the firms that own these plants. Finally, historical statistics on the U.S. production, consumption, and foreign trade of printing and publication, packaging, and other printed products are presented in Section 5.

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.G.P.O. 1992. Table 1.

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

SECTION 2
THE SUPPLY SIDE

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.[1] The image carrier consists of two areas, the print or image area to which ink is applied and those areas which 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.

Figure 2-1 illustrates the relief, intaglio, and planographic printing methods, while Figure 2-2 displays the print characteristics of each, as well as for the stencil, or porous, method.[2,3]

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 which transfers it to the substrate. Letterpress, flexography, gravure, and screen printing are almost always direct, and lithography is almost exclusively offset, thus

Relief Method
Letterpress and
Flexographic Printing

Planographic Method
Offset Printing

Intaglio Method
Gravure Printing

Figure 2-1. Print methods.

Source: Snook, G. A. Handbook for Pulp and Paper Technologists. Canada, Joint Executive Committee of the Vocational Education Committees of the Pulp and Paper Industry. 1982. p. 324.

Figure 2-2. The four methods of printing.

Source: Bruno, Michael H. "Principles of Contact (Impression) Printing Processes." In Printing Fundamentals, Alex Glassman, ed. Atlanta, TAPPI. 1985. p. 5.

referred to as offset lithography.[a] 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 due to the ease of placing converting operations in line with the press.[4]

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

- publication printing, which includes printed materials that are not further processed into some form of packaging or non-publication finished product;
- packaging printing, consisting of printed materials that are further processed into boxes, containers, bags, and other forms which 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. Several steps go into the entire print job, whether it is done

[a]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. 1991. Flexography Principles and Practices, 4th Ed. Ronkonkoma, NY, Foundation of Flexographic Technical Association, Inc. p. 22.)

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 2-3. All of the production steps illustrated in Figure 2-3 may be performed at different locations by contract platemakers, printers, and finishers/converters, or performed in-house by an integrated producer.

Prepress operations are preparatory steps which include copy preparation, typesetting, photography, assembly of the films into a layout or form, and platemaking. Prepress steps ensure that tone values are correct, the images are in the correct position, and the proper plate is selected and treated so that the waste necessary for the pressman to get the job into the proper position on the sheet and to get the right color is kept to a minimum. This adjustment procedure is called make ready.[5] Next is a proofing operation where the engraved plate or cylinder is proofed before being mounted on the printing press for printing the full number of reproductions needed. Any color proofing is also performed at this stage. Most of the prepress operations are performed by contract service houses, except for publication gravure which produce their own engraved cylinders.[6]

Following the proofing step are the printing operations. Printing is accomplished by presses which perform the following procedures:

- mounting plates or image carriers on a bed or cylinder

(or as with gravure the actual cylinder);

- inking the plates;

Figure 2-3. Basic flow diagram of the printing process.

- 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.[7]

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

Furthermore, printing presses may be distinguished by the configuration of their printing units, which are modular and contain all printing functions. The three main types, which vary by the relative relationship of the print units, include: stack presses, common impression (CI) presses, and in-line presses. Stack presses have vertically oriented individual press stations with both the unwind and rewind sections on the same side as the print stations, making them easily accessible for rapid changeovers between pressruns. CI presses have the print stations situated around the circumference of a single large impression cylinder. In-line presses have the print stations in a horizontal row, which is advantages when used in conjunction with additional converting equipment.

All printing processes use in-line presses, but flexographic presses are often common impression presses or stack presses. Gravure presses are limited to in-line configurations due to the great weight of the cylinders. Presses may print one or more colors, but if more than one color is printed, it usually requires a separate printing unit comprised of inking, plate, and impression mechanisms for each color. Additionally, printing processes equipped with solvent recovery systems (all U.S. publication rotogravure plants) recover excess solvent not used in the production process and sell it back to the ink manufacturers.[8]

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.[9] Gravure and flexographic printing processes are the focus of this section, but information on letterpress and offset lithography is provided for comparison and discussion of substitution possibilities. Screen printing is not addressed here since it has a minor share of the printing market and does not compete directly with flexography and gravure. Binding, converting, and finishing operations are discussed independently of the types of printing presented in the following sections.

2.1 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, which 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 which 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

Table 2-1

variable area-variable depth, used for magazine and catalog printing.[10]

Figure 2-4 represents the gravure plate in its cylindrical form.[11] The web, or continuous sheet of rolled paper, is fed between the plate cylinder and impression cylinders while ink is applied to the plate by either dipping or squirting the ink onto it with a jet. A doctor blade scrapes excess ink from the non-printing (flat) surface of the plate before the ink is transferred to the substrate.

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 this description.[b] Figure 2-5 illustrates a simplified rotogravure press showing the web path through the printing and drying sections of the press.[12] Each printing unit is called a print station and the printed web is dried between each station. Different colored inks are applied in succession and as shown in Figure 2-5 a separate cylinder, ink supply, and dryer are required for each station. Four stations are typically required to print each side of the web.

Gravure presses may also 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.[13] 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.

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

Figure 2-4. Gravure plate cylinder.

Source: Kline, James E. Paper and Paperboard Manufacturing and Converting Fundamentals. 2nd Ed. San Francisco, Miller Freeman Publications, Inc. 1991. p. 174.

Figure 2-5. Gravure press design.

Source: Kline, James E. Paper and Paperboard Manufacturing and Converting Fundamentals. 2nd Ed. San Francisco, Miller Freeman Publications, Inc. 1991. p. 175.

2.1.1 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.[14]

Table 2-2 presents the Gravure Association of America's (GAA) estimates of total paper tonnage used by the publication gravure printing industry in 1987.[15] The eight different paper types indicated in Table 2-2 are used by the publication gravure printing industry, with a total estimated use of 2.2 million tons.

Packaging gravure substrates are presented in Tables 2-3 through 2-5 for plants printing folding cartons, flexible packaging, and label and wrapper packaging. The GAA estimates that their sample of 13 folding carton plants accounts for 26 percent of all gravure plants printing folding cartons. Substrate usage at these plants is presented in Table 2-3.[16] For gravure flexible packaging and labels and wrappers the GAA reports the tonnages compiled from survey respondents who manufacture these types of packaging, shown in Tables 2-4 and 2-5.[17,18] Since the manufacture of flexible packaging and labels and wrappers overlaps across plants, it is difficult to estimate the total tonnage of substrates that are used for each type of packaging. However, these tables provide some idea of the types of substrates used. Film types reported for gravure flexible packaging include polyester, metalized polyester, polypropylene, polyethylene, polystyrene, nylon, cellophane, vinyl, and poly/foil/poly laminates.[19] GAA provides a low estimate of total gravure label and wrapper tonnage between 93,000 tons and 100,000, but emphasizes that much label production goes unreported as commercial printing

TABLE 2-2. PAPER USAGE BY THE PUBLICATION GRAVURE INDUSTRY, 1987 (10^3 TONS)

Paper Type	Quantity
C2S groundwood	1,100.0
Roto News Grade A	345.0
Uncoated groundwood	200.0
Roto News Grade B	180.0
Roto News Grade C	163.0
Roto News Grade D	151.0
C2S freesheet	75.0
Uncoated freesheet	3.6
TOTAL	2,217.6

Source: Gravure Association of America. Profile Survey of the U.S. Gravure Industry. New York, GAA. 1989. p. SUB-2.

TABLE 2-3. SUBSTRATE USAGE BY 13 GRAVURE FOLDING CARTON PLANTS, 1987 (TONS)[a]

Substrate Type	Quantity
Cylindar board (SWS)	101,741
Unbleached paperboard	55,253
Combination linerboard	54,585
Uncoated freesheet	35,931
Bleached paperboard	35,736
Unbleached Kraft	8,358
Coated one side	7,650
C2S freesheet	2,227
Bleached Kraft	2
TOTAL	301,483

[a]GAA estimates that the total substrate tonnage reported by these 13 plants represents 26 percent of total gravure folding carton tonnage.

Source: Gravure Association of America. Profile Survey of the U.S. Gravure Industry. New York, GAA. 1989. p. SUB-5.

TABLE 2-4. SUBSTRATE USAGE BY 19 GRAVURE FLEXIBLE PACKAGING PLANTS, 1987 (TONS)[a]

Substrate Type	Quantity
Coated one side	89,602
Bleached paperboard	59,114
Film	44,968
Unbleached Kraft paper	40,438
Foil, supported	20,345
Uncoated freesheet	18,001
Bleached Kraft paper	15,187
Foil, unsupported	4,030
Coated 2 sides freesheet	1,658
Grease proof paper	1,513
Bleached rib ductl.	1,164
Laminates other than foil	1,009
Linerboard, solid	386
Cylindar board (SWS)	104
Other specialty papers	83
Unbleached paperboard	50
TOTAL	297,652

[a]Some of the substrates accounted for here may go into producing the plant's secondary products (e.g., folding cartons or labels).

Source: Gravure Association of America. Profile Survey of the U.S. Gravure Industry. New York, GAA. 1989. p. SUB-7.

TABLE 2-5. SUBSTRATE USAGE BY 11 GRAVURE LABEL AND WRAPPER PLANTS, 1987 (TONS)[a]

Substrate	Quantity
Coated one side	39,741
Coated 2 sides freesheet	10,861
Uncoated freesheet	5,100
Film	3,300
Coated 2 sides groundwood	2,523
Foil, supported	2,515
Bleached paperboard	1,420
Metalized paper	572
Unbleached Kraft paper	341
Uncoated groundwood	250
TOTAL	66,623

[a]GAA estimates that the total substrate tonnage reported by these 11 plants roughly represents 67 to 72 percent of total gravure label and wrapper tonnage.

Source: Gravure Association of America. Profile Survey of the U.S. Gravure Industry. New York, GAA. 1989. p. SUB-9.

due to it being part of a flexible packaging operation or in-house package production.

Some substrate data are available for certain gravure printed products, such as gift wraps, wallcoverings, and other vinyl products. Giftwrap production uses the following substrates:

- 40 lb. coated two sides,
- 50 lb. coated two sides,
- 33 to 40 lb. supercalendared stock,
- coated one side,
- foil laminates,
- metalized paper,
- supported foil, and
- polypropylene film.[20]

Product gravure also prints on substrates that consist of several layers of materials, one of which is vinyl. Products printed include wallcovering, upholstery, table cloths, shower curtains, floor coverings, and adhesive backed decorative film. Polyvinyl chloride is used as a substrate component and as a dispersion coating layer for wallcoverings. It is a major component also of several of the gravure decorated products listed above. In 1988, polyvinyl chloride consumption in wallcoverings manufacture was 74 million pounds and 170 million pounds were consumed by other products that involve gravure printing.[21] However, these figures include vinyl use for unprinted versions of these products also. Wallcovering manufacture also consumed 25 million pounds of polystyrene in 1988.

2.1.2 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.[22] 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 due to their lower cost and less potential for air pollution.[23] 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. The sample quantities shown in Table 2-6 represent an estimated 41 percent of total ink consumption by publication gravure printers in 1987.[24] Publication gravure presses in the U.S. use toluene/xylene based (solvent based) ink systems exclusively.[25] 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 in Table 2-7, which presents GAA's sample of ink consumption by 42 gravure packaging plants and 27 product gravure plants.[26] The sample plants represent the following percentages of total value of shipments for that product category: 16.4 percent for folding cartons; 11.6 percent for flexible packaging; and 19.4 percent for labels and wrappers.

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. GAA estimates that for a 12 month period between 1987 and 1988, publication gravure printers recovered 543.6 pounds of solvent and used 401 million pounds of purchased or recycled solvent in their printing operations.[27] The GAA data yield a ratio of 72.9 percent between the total ink consumed and the total solvent

TABLE 2-6. INK CONSUMPTION BY 16 GRAVURE PUBLICATION PLANTS, 1987 (10^3 POUNDS)

Ink Type	Quantity
(Group W) Water base inks	0
(Group I) Aliphatic hydrocarbon	4,500
(Group I) Aromatic hydrocarbon	31,323
(Group V) Aliphatic hydrocarbon	0
(Group V) Aromatic hydrocarbon	3,000
(Group VI) Aliphatic hydrocarbon	27,204
(Group VI) Aromatic hydrocarbon	96,578
Others	0
TOTAL	162,604
PROJECTED TOTAL INK	396,596

Source: Gravure Association of America. Profile Survey of the U.S. Gravure Industry. New York, NY: Gravure Association of America. 1989. p. INK-2.

table 2-7

recovered. Most of the ink delivered to publication gravure plants is by tank trucks and ink is pumped to the presses from a tank farm.

2.1.3 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.[c] 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.[28] Flexography may also be used.[29] 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. Labels and wrappers can be wrapped or adhered to other types of packaging, or may be part of the package itself. Flexography is more common than gravure for printing flexible packaging. For printing labels, manufactures may use combination gravure/flexo presses. The gravure cylinder prints the halftone material and applies non-ink coatings and

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

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.

2.1.4 Advantages and Disadvantages of Gravure Printing Process

Advantages of the gravure printing process include:

- prints at the highest speed of any process,
- high productivity and low waste,
- excellent consistency of color reproduction as the press design avoids mechanical ghosting,
- excellent for reproducing facial tones and skin colors as different cells can be engraved to different depths to vary the thickness of the printing ink film,
- cylinders resist wear so that long runs with millions of impressions are practical,
- production costs are modest after cylinders are prepared so that repeat runs are relatively inexpensive,
- prints well on low strength and lightweight papers, and
- heavy ink films help give bright, glossy prints.[30]

Disadvantages of the gravure printing process include:

- cylinder preparation is a lengthy and costly procedure making the process economical only for long runs or often repeated short runs,
- does not print well on rough or unlevel paper and board,
- small type, particularly reverse type, is often ragged,
- poor resolution of fine details,

- difficult to make corrections in the cylinder,
- costly storage of the large, costly cylinders, and
- technology has failed to keep up with flexography and offset lithography.[31]

2.1.5 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 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.[32] HAPs from proofing presses, cleaning operations, ink storage tanks, and ink mixing operations are relatively minor in comparison to the emissions during the printing process, but 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 which 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 VOC emissions.[33]

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. Existing air pollution control is one of three types: carbon adsorption, thermal incineration, or catalytic incineration. A fourth strategy is use of waterborne technologies. However, waterborne inks may still contain HAPs (e.g. glycol ethers, methanol).[34] Furthermore, some solventborne inks are HAP free. HAP free inks thus are available and are currently in use at product/packaging gravure facilities. Pollution prevention is also gained 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 which print paper and cardboard packaging.[35]

The wide variety of substrates printed and products produced by product/packaging gravure facilities necessitates the use of a wide variety of inks with different performance characteristics and hundreds of different colors. Low HAP inks may not be available therefore in all 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 which are operating efficient VOC control systems may have little incentive to reduce the HAP content of their inks.

2.2 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 the computer typesetting processes. Figure 2-6 illustrates a basic flexography printing unit.[36] 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 which 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. Flexography press designs are specific to individual printing applications, but basically consist of the plate and inking system shown in Figure 2-6 alone, or equipped with a variety of different dryers.

There are many types of flexographic presses including wide web (greater than 24 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:

- labels with narrow web in-line, stack and 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,

Figure 2-6. Flexographic printing unit.

Source: Kline, James E. Paper and Paperboard Manufacturing and Converting Fundamentals. 2nd Ed. San Francisco, Miller Freeman Publications, Inc. 1991. p. 167.

- 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.[37]

2.2.1 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.[38] 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, aluminum foil. Additionally, corrugated cartons are one of the few substrates printed by sheet-fed flexography.

2.2.2 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.[39] 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.[40] Low-viscosity ink does not hold the dot pattern as well as the high-viscosity inks used in letterpress printing (discussed below).

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.

2.2.3 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 flexo printed 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 (i.e., milk and beverage cartons, and sanitary single service cups and containers), plastic carrier bags, flexible packaging, multiwall sacks, paper sacks, rigid paper set-up boxes. In addition, printed products which use the flexographic process include gift wrap, paper towels, tissues, vinyl shower curtains, and wallpaper.

2.2.4 Advantages and Disadvantages of Flexographic Printing Process

Advantages of the flexographic printing process include:

- good print color consistency,
- prints well on rough substrates,
- prints on a wide variety of substrates, including low strength and lightweight papers,
- low waste generation comparable to gravure and sheetfed offset and less than web offset,
- better suited for short run production than gravure due to its relative ease of plate making and press set up,
- plates cost far less than gravure cylinders,
- prints faster than sheetfed offset,
- prints large solids evenly and without voids, and
- rapidly evolving technology that keeps improving quality and productivity.[41]

Disadvantages of the flexographic printing process include:

- shallow-relief plates can plug easily with dust or dirt,
- must carefully control printing pressure,
- not practical to adjust colors on press,
- currently not possible to make a smooth transition of dot size in vignettes, especially at one and two percent dots,
- speeds are usually less than gravure and web offset,
- plates cost more than offset plates and preparation is a lengthy procedure, and
- perception as a cheap printing process, and therefore poor quality, has hampered its growth.[42]

2.2.5 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 which 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.[43] The solvent based inks primarily used are formulated with non-HAP solvents which may contain small proportions of ethylene glycol, glycol ethers and methanol which are HAPs. Solvent based inks which are completely HAP free are available for some applications.[44] 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.[45] Pollution prevention opportunities through use of 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, require different substrates, and the types of inks used demand performance requirements which may not all be met by low HAP ink formulations.

2.3 LETTERPRESS PRINTING PROCESS

Similar to flexography, in letterpress printing the ink is transferred to the paper or other substrate via raised letters or plate surfaces. High viscosity ink, or oil based ink, is used which adheres to the raised portion of the plate without filling in the non-printing portions of the plate. Three types of letterpress designs are the platen press (used for job printing on paper and paperboard, envelopes, imprinting, embossing, steel-rule diecutting, and hot roll gold leaf stamping), flatbed press (no longer manufactured in the U.S. but still used for some general job and commercial printing and imprinting), web-fed rotary news press, and the common impression cylinder press. The web-fed rotary news press is primarily used to print newspapers, but they have been replaced in most small and many large operations by web offset presses (discussed below). The common impression cylinder press prints webs or individual sheets and has been the large-tonnage press used for publication printing. However, today the sheet-fed form is almost obsolete and the web-fed form is soon to follow.

2.4 OFFSET LITHOGRAPHY PRINTING PROCESS

Offset lithography is different from the other printing processes discussed thus far in that the ink is not transferred directly from the plate to the substrate. In offset printing the ink is transferred by a rubber-covered mat called a blanket on an intermediate cylinder. Lithography is based on the principle that oil and water do not mix. The

offset plate has a flat surface and is made so that the ink adheres only to the image portion of the plate, while water adheres to others. Therefore ink and water must be applied to the plate simultaneously. All offset inks are high-viscosity and include nondrying types used on news presses; oxidizing types for sheet-fed presses, which require up to 24 hours to dry; heat-set types for web-fed presses; and ultraviolet-set types used on both web and sheet-fed presses.

The two main types of offset presses are sheet-fed and web offset presses. Sheet-fed litho presses have traditionally been used for only the highest quality advertising or magazines, which does not necessarily mean they produce better quality work than other printing processes. The fastest growing web offset press in the United States is the blanket-to-blanket or perfecting press. It is widely used to print publications and for direct mail advertising and may be equipped with various conversion equipment. Use of the blanket allows these presses to be more tolerant of rough paper than letterpress or gravure. Offset printing is becoming increasingly competitive in publication printing with improvements in word processing and offset platemaking.[46]

Advantages of this process include versatility with respect to sheet sizes, surface roughness, and size of the job; low preparatory and plate costs; ability to print carbonless copy without excess marking; and the use of positive image printing plates whereas non-offset processes require a negative image plate that is more difficult to proof. Web offset presses have a superior ability to print lines or other forms of ruling which makes it a popular method for printing business forms such as computer printout paper, order forms, and register receipt forms. The disadvantages of this process are that it is comparatively slow, generates a higher ratio of waste, and requires greater operator skill to deliver high quality.[47]

2.5 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.[48] 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 the slotting and gluing of corrugated boxes.[49]

Various types of packaging have printing as a process in their manufacture. Table 2-8 lists packaging types and their uses.[50] Folding types include corrugated containers and folding cartons. Corrugated board produced at a corrugating plant is often printed and converted into boxes at the same plant. Common operations performed on corrugated board include printer-slotters, diecutters, and printer-slotter-folders. A printer-slotter machine in addition to printing, which is usually done with letterpress, also cuts the tabs in the box. Sometimes the manufacturer will ship the boxes to the purchaser in this condition. Other times the boxes are further processed. A diecutter may be attached to in-line

printing stations to cut tab and score the areas to be folded

table 2-8

for more complex folding operations. The printer-slotter-folder is an efficient machine which in addition to employing flexographic printing, the tabs are cut, and boxes folded.

Folding cartons are another type of folding package. As with corrugated containers, the printing process is only one step. Folding cartons are made from heavy paper or paperboard, and printed, cut and folded into the basic carton shape, and sealed or glued so they can be folded flat for shipping. These types of cartons are generally fed through a filling line by the user and packaged for shipping. Set up boxes under the rigid type packaging are containers that cannot be folded for shipping. Similarly they may be printed during the manufacturing process.

The converting operations involved with flexible packaging are varied and numerous, but basically consist of equipment that accept rolls or sheets of the substrate and prints, cuts, folds, and glues it into its final form. Coating and laminating operations may precede printing of the web. Certain grades of paperboard and most paper are coated pigment coated to improve printing characteristics. Functional coating and laminating may be done to improve the barrier characteristics of the package. Coatings may also be applied to the already printed, cut, and scored blanks.

2.6 COSTS OF PRODUCTION

The costs that a printing firm faces include capital, labor, materials, fuel and electricity, and other costs. This section discusses the first four of these categories. Other costs, which include administrative fees, insurance payments, property taxes, and research and development are not covered due to a lack of information.

2.6.1 Capital Cost

Capital costs for printing firms include buildings, other structures, machinery, and equipment. This category may also include capital costs associated with previous regulatory action. The stock of capital for these companies changes from year to year due to additions from new investment and reductions from depreciation and divestment. Table 2-9 provides the end-of year gross book value of depreciable assets for 1987 and new capital expenditures made by firms in the gravure printing segment and other printing segment of the commercial printing industry (SIC 275) for 1987 to 1991.[51,52] As of the end of 1987, the gross book value of depreciable assets was $2.1 billion for the gravure segment and $2.9 billion for the other printing segment.[53] As shown, in 1991, companies in the gravure segment of the industry made $136.3 million in new capital expenditures, while companies in the other printing segment made $544.3 million in new capital expenditures.

In addition, the U.S. Department of Commerce provides manufacturing pollution abatement capital expenditures for the commercial printing industry (SIC 275) and its major components. Table 2-10 presents pollution abatement capital expenditures for 1991 by media (i.e., air, water, and solid waste) and basis of abatement technique (i.e., end-of-line techniques and changes-in-production processes) for air and water media and type of pollutant abated (hazardous and nonhazardous) for solid waste.[54] Pollution abatement capital expenditures by the gravure printing segment totaled $8.4 million, or 32.9 percent of the total for the commercial printing industry. Thus, in 1991, capital expenditures for pollution abatement accounted for 6.2 percent of total new capital expenditures for the gravure segment. Furthermore, in 1991, capital expenditures to control air pollutants dominated spending to control other media by totaling $7.5 million, or 89.3 percent of total expenditures by the gravure printing

TABLE 2-9. END OF YEAR GROSS BOOK VALUE OF DEPRECIABLE ASSETS AND NEW CAPITAL EXPENDITURES FOR SEGMENTS OF THE COMMERCIAL PRINTING INDUSTRY, 1987-1991 (10^6)

Year	End-of-Year Value	New Capital Expenditures
Gravure (SIC 2754)		
1987	2,099.9	175.5
1988	N.A.	183.9
1989	N.A.	178.7
1990	N.A.	176.1
1991	N.A.	136.3
Other (SIC 2759)[a]		
1987	2,863.8	299.4
1988	N.A.	278.8
1989	N.A.	329.1
1990	N.A.	381.8
1991	N.A.	544.3

[a] SIC 2759 includes letterpress, flexographic, screen, and other printing processes not classified as lithography or gravure. Prior to 1987, data for flexography were included under SIC 2751, letterpress.

NA = Not Available.

Sources:

U.S. Department of Commerce. 1990. 1987 Census of Manufactures, Industry Series: Commercial Printing and Manifold Business Forms. Washington, DC, U.S. Government Printing Office. Table 3b.

U.S. Department of Commerce. 1990, 1991, 1992. 1988, 1990, and 1991 Annual Survey of Manufactures: Statistics for Industry Groups and Industries. Washington, DC, U.S. Government Printing Office. Table 5.

table 2-10

segment. The vast majority, 94.7 percent, of this total capital expenditure went for end-of-line techniques, while the remaining $0.4 million went to eliminate air pollutants through changes-in-production processes.

2.6.2 Labor Cost

Table 2-11 displays industry employment and earnings statistics for gravure printing (SIC 2754) and other printing (SIC 2759) from various years.[55],[56] From 1990 to 1991, total employment in the gravure printing segment declined by 8.6 percent, to approximately 22,000, while total payroll fell by 1 percent to a level of $693.7 million in 1991. During this same time period, total employment in the other printing segment (that includes flexography) increased by 0.5 percent, to roughly 133,800, while total payroll increased by 3.1 percent to just over $3 billion. In the gravure printing segment, the hourly wage of production workers rose by 4.9 percent from 1990 to 1991, reaching $13.52 in current 1991 dollars. In the other printing segment, the hourly wage of production workers rose by only 1.9 percent from 1990 to 1991, reaching $9.31 in current 1991 dollars.

2.6.3 Materials, Fuel, and Electricity

Table 2-12 provides the total cost of materials for the gravure printing segment (SIC 2754) and other printing segment (SIC 2759) from 1982 to 1991.[57,58] This cost category includes:

- all raw materials (such as substrates, inks, and process chemicals), semifinished goods, parts, containers, scrap, and supplies put into production or used as operating supplies or repair and maintenance during the year;
- work done by others on materials or parts furnished by manufacturing establishments (contract work);

TABLE 2-11. EMPLOYMENT AND EARNINGS FOR SEGMENTS OF THE COMMERCIAL PRINTING INDUSTRY, 1987-1991

	All Employees		Production Workers			
Year	Number (10^3)	Payroll (10^6)	Number (10^3)	Wages (10^6)	Hourly Wage ($/hr)	Real Hourly Wage[a] ($/hr)
Gravure (SIC 2754)						
1987	23.8	668.5	19.1	494.2	12.48	12.48
1988	24.0	693.2	19.4	521.2	13.13	12.60
1989	23.2	688.2	18.9	512.9	12.92	11.89
1990	23.9	700.4	19.5	522.1	12.89	11.47
1991	22.0	693.7	17.9	527.2	13.52	11.49
Other (SIC 2759)[b]						
1987	126.2	2,489.9	88.7	1,503.1	8.66	8.66
1988	127.7	2,602.6	89.4	1,565.8	8.27	7.94
1989	126.9	2,743.2	89.2	1,616.8	8.99	8.27
1990	133.2	2,963.7	93.8	1,754.9	9.14	8.13
1991	133.8	3,055.1	92.1	1,778.2	9.31	7.91

[a] Real hourly wage expressed in constant 1987 dollars using the GDP deflator.

[b] SIC 2759 includes letterpress, flexographic, screen, and other printing presses not classified as lithography or gravure. Prior to 1987, data for flexography were included under SIC 2751, letterpress.

Sources:

U.S. Department of Commerce. 1990. 1987 Census of Manufactures, Industry Series: Commercial Printing and Manifold Business Forms. Washington, DC, U.S. Government Printing Office. Table 1a-1.

U.S. Department of Commerce. 1990, 1991, 1992. 1988, 1990, and 1991 Annual Survey of Manufactures: Statistics for Industry Groups and Industries. Washington, DC, U.S. Government Printing Office. Table 2.

TABLE 2-12. COST OF MATERIALS IN THE COMMERCIAL PRINTING INDUSTRY, 1987-1991 (10^6)

Year	Cost of Materials	
	Current Dollars	Constant 1982 Dollars
Gravure (SIC 2754)		
1987	1,545.5	1,530.0
1988	1,901.8	1,775.5
1989	1,983.4	1,765.2
1990	1,883.4	1,638.6
1991	1,839.9	1,600.7
Other (SIC 2759)[b]		
1987	3,707.6	3,670.5
1988	4,011.9	3,731.1
1989	4,069.5	3,621.9
1990	4,347.7	3,869.4
1991	4,459.2	3,879.5

Sources:

[a] Constant 1982 dollars calculated using producer price index for intermediate materials.
[b] SIC 2759 includes letterpress, flexographic, screen, and other printing presses not classified as lithography or gravure. Prior to 1987, data for flexography were included under SIC 2751 letterpress.

U.S. Department of Commerce. 1990. 1987 Census of Manufactures, Industry Series: Commercial Printing and Manifold Business Forms. Washington, DC, U.S. Government Printing Office. Table 1a-1.

U.S. Department of Commerce. 1990, 1991, 1992. 1988, 1990, and 1991 Annual Survey of Manufactures: Statistics for Industry Groups and Industries. Washington, DC, U.S. Government Printing Office. Table 2.

- products bought and resold in the same condition;
- electric energy purchased; and
- fuels consumed for heat, power, or the generation of electricity.

Figure 2-7 displays the composition of total materials costs in the gravure printing segment for 1987 with a detailed breakdown of the materials cost other than fuels, electricity, resales, and contract work.[59] This figure focuses on the gravure printing segment since the information for flexographic printing is embedded within the entire other printing segment and, thus, may not accurately reflect the distribution of materials cost for that segment.

In 1987, total materials cost, not including fuel and electricity, was roughly 47 percent of the value of shipments in the gravure segment of the commercial printing industry. Substrates are the largest material input to the gravure printing process. As presented in Figure 2-7, in 1987, substrates (including paper, rolls and sheets) accounted for 43 percent of the materials cost for the gravure printing segment, while printing inks accounted for 21 percent. Although the gravure process does not print newspapers, newsprint is shown to have a share of 8 percent because establishments may print newspapers via a different process as a secondary product.

Substrates and printing inks are the primary inputs into the printing process. Table 2-13 presents the quantity and value of shipments for gravure and flexographic ink production.[60] The total value of shipments reported by the Department of Commerce for printing ink in 1987 is $2,360.7 million. Gravure and flexographic inks both represent about 18 percent of the total value of shipments from all printing inks. GAA cites Rauch Associates independent market study of the ink industry which estimates that an additional six percent of the total quantity of gravure ink produced as

Figure 2-7. Composition of materials cost in the gravure printing segment, 1987.

Note: Resales are products bought and resold in the same condition, and contract work is done by others on materials or parts furnished by manufacturing establishments.

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, March 1990, Tables 3a

and 7.

table 2-13

reported by the U.S. Bureau of the Census should be added to account for the captive gravure ink production not reported in the Census totals.[61]

Furthermore, the U.S. Department of Commerce provides manufacturing pollution abatement operating costs for the commercial printing industry (SIC 275) and its major components. Table 2-14 presents pollution abatement operating costs for 1991 by media (i.e., air, water, and solid waste).[62] Operating costs by the gravure printing segment totaled $47.9 million, or 31.1 percent of the total for the commercial printing industry. In 1991, operating costs to control air pollutants dominated spending to control other media by totaling $30 million, or 62.6 percent of total expenditures by the gravure printing segment.

2.6.4 Elasticity of Substitution

Table 2-15 provides estimates from Frenger of the elasticity of substitution between inputs (δj) for the printing and publishing industry.[63] These estimates reflect the elasticity of the cost-minimizing ratio of inputs to a change in their relative price, when cost, output, and other prices are held constant. In general, the elasticities tend to be high for those inputs considered substitutable in the short run, i.e., material and labor ($\delta j = 1.24$), material and energy ($\delta j = 0.91$), and energy and labor ($\delta j = 0.91$). Thus, it seems reasonable to expect variable input substitution elasticities in this industry to be higher than that for capital and labor.

TABLE 2-14. POLLUTION ABATEMENT OPERATING COSTS FOR THE COMMERCIAL PRINTING INDUSTRY, 1991 (10^6)

Industry	Air	Water	Solid Waste		Totals Across Air, Water, and Solid Waste
			Hazardous	Nonhazardous	
Total Commercial Printing	82.2	10.3	18.9	42.7	154.0
Lithographic Printing	31.6	4.2	10.3	30.4	76.6
Gravure Printing	30.0	5.7	6.5	5.6	47.9
Other Commercial Printing	20.5	0.4	2.0	6.6	29.6

Source: U.S. Department of Commerce. 1993. Current Industrial Reports: Pollution Abatement Costs and Expenditures, 1991. Washington, DC, U.S. Government Printing Office. p. 42.

TABLE 2-15. ELASTICITIES OF SUBSTITUTION BETWEEN INPUTS FOR THE PRINTING AND PUBLISHING INDUSTRY

Input Pairs	Elasticity of Substitution
Material-Energy	0.91
Material-Labor	1.24
Material-Capital	0.45
Energy-Capital	0.83
Labor-Capital	0.30
Energy-Labor	0.91

Source: Andersson, Å.E., and R. Brännlund. "The Demand for Forest Sector Products." In the Global Forest Sector. Markku Kallio, Dennis P. Dykstra, and Clark S. Binkley, eds. New York, John Wiley & Sons. 1987. p. 267.

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17. Ref. 6., p. SUB-7.

18. Ref. 6., p. SUB-9.

19. Ref. 6., pp. PRESS-17-8.

20. Ref. 6., pp. PRESS-17-14.

21. Ref. 6., pp. PRESS-14-15.

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23. Ref. 12.

24. Ref. 6., p. INK-2.

25. Ref. 8.

26. Ref. 6., pp. INK-4-13.

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33. EPA, Engineering Draft Report for the Printing and Publishing Industry. Prepared by Research Triangle Institute. 1994. Chapter 3.

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41. Ref. 4., pp. 84-5.

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44. Ref. 33.

45. Ref. 33.

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50. Ref. 11., p. 197.

51. U.S. Department of Commerce. 1987 Census of Manufactures: Industry Series: Commercial Printing and Manifold Business Forms. Washington, D.C, Government Printing Office, March 1990, Table 3b.

52. U.S. Department of Commerce. 1990, 1991, 1992. 1988, 1990, and 1991 Annual Survey of Manufactures: Statistics for Industry Groups and Industries. Washington, DC, Government Printing Office. Table 5.

53. Ref. 51.

54. U.S. Department of Commerce. Current Industrial Reports: Pollution Abatement Costs and Expenditures, 1991. Washington, DC, Government Printing Office. 1993. pp. 20-21.

55. Ref. 51., Table 1a-1.

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58. Ref. 56.

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60. U.S. Department of Commerce. 1987 Census of Manufactures: Industry Series: Miscellaneous Chemical Products. Washington, D.C., Government Printing Office, 1990. p. H-16.

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SECTION 3
CONSUMPTION

This section characterizes the demand side of the market for printing and those products that are printed. It describes the printing processes and their printed publications, packaging, and products in terms of their characteristics, uses and consumers, and consumption substitution possibilities.

3.1 PRODUCT CHARACTERISTICS

As Lancaster describes, goods are of interest to the consumer because of the properties or characteristics they possess; these characteristics are taken to be an objective, universal property of the good.[1] Therefore, the demand for a commodity is not simply for the good itself but instead for a set of characteristics and properties that are satisfied by a particular commodity. The demand for printing is not just for the process itself, but for a set of characteristics or properties the printing provides.

Printing is basically the reproduction of original type or artwork for publications, packaging materials, and products. The required properties and characteristics may differ or be more or less important depending upon what is being printed. However, most consumers regardless of their specific printing needs demand certain quality characteristics from the printing. The general printing quality characteristics include:

- Uniformity of color across individual printed items,
- Uniformity of color across any single printed item,
- Color register (degree of alignment of two or more colors in a print),

- Freedom from spots, broken letters, and uneven cloudy areas,
- Sharpness of image,
- Ink adhesion, and
- Rub resistance.[2]

In addition to the reproductive quality of the printing measured by the above characteristics, printing also provides functional characteristics demanded by particular types of consumer (i.e., publisher, packager, product manufacturer). The goal is to achieve quality printing that serves a particular purpose in the most cost-effective way.

3.2 USES AND CONSUMERS OF PRINTING

Characteristics demanded will vary by type of consumer (e.g. publisher, advertiser, packager, or other product manufacturer). Each type of consumer seeks slightly different functions from their printed material. For advertisers and publishers of books, magazines, and newspapers, the printed material is the product and printing is generally their primary concern in its manufacture. A packager or package buyer sees the printing as one component of the package (in addition to materials and design) that functions to sell and promote the product. Product manufactures require printing to decorate, enhance, and provide color and pattern variety to their product.

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., packaging flexography and publication gravure), and primary inputs

(e.g., inks, substrates, artwork, manuscripts, printing plates). Figure 3-1 illustrates the multi-market 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 and 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.

A discussion of the different types of printing and how they provide the necessary quality and functional characteristics is reserved for Section 3.3, but a brief mention of the typical uses for the main processes for the three printing areas--publication, packaging, and product--is warranted here. The fact that five major printing processes (flexography, gravure, letterpress, offset lithography, and screen) coexist indicates that each has characteristics that are more suitable than others for the markets it serves. Any printing process can produce high quality printing, but certain processes are better suited technically and economically to each printing category. In publication and commercial printing, offset printing makes up nearly 80 percent with gravure supplying most of the rest, and only a small portion done by flexography.[3] For package printing, roughly 64 percent is done by flexography with the remainder printed mostly by offset and gravure.

The remainder of this section focuses on publication and packaging demand for printing. A large amount of data are

available for the packaging market sector. Most importantly,

Figure 3-1. Multimarket relationships.

many of the functional properties and substitution possibilities between printing processes discussed apply across publication, packaging, and product printing.

3.2.1 Publication Printing

This section describes the functional properties of publications and publication printing as well as the major consumers of these materials by class of consumer.

3.2.1.1 Functional Properties of Publication Printing.

The purpose of publication printing is to reproduce original written text or images. Printing is the major manufacturing component of the product. Therefore with publications, the printing is the main functional characteristic of the final product, while the other product characteristics are the ideas, information, and creative work to be communicated by the publisher, author, or artist. Publications such as newspapers, magazines, periodicals, and books serve to entertain and inform the consumer. For printed advertising media, the printing serves to reproduce the text and images as well as the advertising message. The function of advertising

materials is not only to communicate information, but to persuade, entice, and influence the consumer of the commodity or service being advertised. In this sense, advertising printing functions in much the same way as package printing discussed below.

3.2.1.2 Publication Printing by Consumer Type. Figure 3-2 shows the percentage of value of shipments for the gravure segment of the commercial printing industry by class of customer.[4] Figure 3-2 pertains to publication gravure as most packaging and product gravure are covered by the corresponding package or product SIC codes. The largest percentage of value of shipments of commercial gravure printing goes to retailers (51.7 percent). Retailers include eating and drinking establishments, retail stores and outlets, and mail order houses. The second largest (23.8 percent) consuming segment is manufacturers which includes all shipments to all types of manufacturers including publishers. The 17.5 percent shipped to wholesalers includes shipments to companies that are purchasing primarily to resell the products to other businessmen or institutions. Only 4.9 percent of total commercial gravure shipments go to all other sectors including service, transportation, mining, construction, and communication industries. Finally, the smallest consumer segment is federal, state, and local governments, less than one percent. Only 2.1 percent of the commercial gravure shipments are shipped to other facilities owned by the same company.

3.2.2 Packaging Printing

This section describes the functional properties of packaging and package printing as well as the main consumers of these materials, including industry sectors and corporate entities.

Figure 3-2. Percentage of value of shipments for the gravure segment of the commercial printing industry by class of customer, 1987.

Note: Less than 0.1 percent are shipped to federal, state, and local governments.

Source: U.S. Department of Commerce. 1987 Census of Manufactures. Subject Series: Distribution of Sales by Class of Customer. Washington, DC, U.S. Government Printing Office. 1992. p. 4-14.

3.2.2.1 Functional Properties of Packaging and Package Printing. A package serves four purposes: protection, communication, promotion, and convenience. A label or tag, which is sometimes considered a type of flexible packaging generally serves the last three purposes. In addition to the print quality, a packager or package buyer is interested in the package's barrier properties, transparency, strength, and color. For packagers, although printing can greatly enhance or detract from the packaged product, it is only one of many packaging concerns. The package design, convenience, and protection are equally important components.

Eldred defines packaging printing and how it contributes to these purposes as

> . . . the application of inks or coating material to a package, directly or with a label, to enhance sales, to convey information or to protect the printing or the surface of the package. It includes printing, coating, embossing, and decoration of the package.[5]

The total design of a package, including the printing, affects product sales and market share and can often yield higher returns than advertising. The function of the design is to translate the marketer's ideas into a printed product that will please the customer. Consumers make statements about themselves by the products they consume. The package design enunciates the consumers statement and, thus, is responsible for a significant part of the consumer's emotional involvement and ultimate satisfaction with the product.[6]

Visual impact is a major objective. Packagers and package buyers see the printing as a vehicle to sell, promote, and increase profits. The quality of the printing is linked to the successful promotion of the product. Poor reproduction creates a negative product image. The graphics represent the product, and the higher the perceived quality of the graphics, the more likely the customer is to consider the product a high-quality item.

Package printing identifies the product as well as the manufacturer or seller. It is a direct link between the producer and consumer. Package printing therefore involves:

- Eye-catching graphics,
- Corporate imagery and identification,
- Identification of contents and information about them,
- Legal requirements concerning contents and their use or restrictions,
- Graphic representation of color, type and appearance of the contents, and

- Bar codes indicating price, lot number, and inventory.[7]

Package printing is not only a means to identify the contents of the package, but it reflects the corporate identity and attracts the retail customer to buy the package.

3.2.2.2 Packaging Consumption by Consumer Type. As one of the greatest demands for printing is based on the derived demand for packaging it is useful to look at the industry sectors and corporate entities that consume various forms of packaging. Product proliferation in today's marketplace has created a demand for a wide variety of printed packaging.

Table 3-1 presents the packaging expenditures by user industry and Table 3-2 shows the consumption of specific types of packaging by four-digit industry SIC codes.[8] As indicated by both tables, the food, beverage, drugs, soaps, and toiletries industries are the largest consumers of packaging. As shown in Table 3-2, paperboard containers and boxes accounted 33.7 percent of the value of packaging consumption—the largest share across all packaging materials.

At the corporate level, Table 3-3 shows the leading consumers of packaging materials and containers for 1989.[9] Also given in the table are their total purchases for packaging and their principle products. Here again, the top companies tend to produce products in the food, beverage, drugs, soaps, and toiletries industries.

TABLE 3-1. PACKAGING EXPENDITURES BY USER INDUSTRY, 1989[a]

Industry	10^6	Expected Growth (%)[b]	Trends
Foods	24,142	8.5	Growing demand for minimally processed or fresh foods with fewer preservatives and extensive ingredient information; continued demand for products in convenient, easy-to-prepare forms.
Beverages	13,520	8.8	Continued plastics growth; new sizes, multipack and display cartoning.
Drugs, soaps, and toiletries	6,561	12.0	Strong growth in drugs -- shelf-presence war challenges packaging; continued changes in closures, and blister expansion. Continued conflict between liquid and powder soaps; development of super-concentrated detergents; all-in-one detergent-softener; user of recycled PET. Bottles, tubes and cartons cover C&T packaging in glitzy, eye grabbing forms, colors, and labels.
Electrical machinery	4,785	5.5	Some competition for corrugated in large appliance; expansion of POS graphics or smaller appliances.
Fabricated metals	3,260	13.2	Rapid growth of visible, peggable hardware packaging.
Other chemicals	2,404	2.3	Impact of new UN and ECC standards.
Non/electrical machinery	1,638	10.6	Development of fire retardant packages and fire resistant cushioning.
Instruments	1,508	4.0	Disposability and ease of use drives packaging for medical, dental, and surgical products.
Tobacco	720	9.1	Decreasing U.S. consumption offset by exports; great increases in brands and production rates, continued antismoking pressure.

(continued) TABLE 3-1.
PACKAGING EXPENDITURES
BY USER INDUSTRY, 1989[a]
(CONTINUED)

Industry	$ Million	Expected Growth[b]	Trends
Other primary materials-- paper, petroleum, rubber, metals, stone, ceramics, glass	12,296	7.9	No details given.
Consumer products-- apparel, furniture, shoes, leather goods, sporting goods, toys			
Total	70,834	8.5	

[a]Value of packaging materials, containers and supplies.
[b]Reflects expected growth over 5-year period from 1989-1994.

Source: Packaging (July) - based on survey of 250 companies: includes the value of self-manufactured containers. Rauch Guide to the U.S. Packaging Industry. Bridgewater, NJ, Rauch Associates. 1989. pp. 11-12.

table 3-2

table 3-2

table 3-2

TABLE 3-3. LEADING CONSUMERS OF PACKAGING MATERIALS AND CONTAINERS, 1989

Rank	Company	Purchases (10^6)[a]	Principal Product(s)
1	Philip Morris	2,569	Cigarettes, food, beer
2	Anheuser Busch	2,300*	Beer
3	Pepsico	1,461	Soda
4	Procter & Gamble	1,386	HH chemicals, food
5	Coca-Cola	1,162	Soda
6	Coca-Cola Enterprises	1,087	Soda
7	RJR Nabisco	909	Cigarettes;food
8	Seagram USA	713	Beverages
9	Sara Lee	575*	Frozen baked foods
10	Unilever US	520	Tea, soap, cosmetics
11	Adolph Coors	490*	Beer
12	Whitman	429	Food, soda
13	Brown-Forman	416	Wine/spirits
14	Kimberly-Clark	414	Tissue products
15	Borden	400*	Food
16	Campbell Soup	381	Soup, food
17	Eastman Kodak	380	Photography, drugs
18	Stroh Brewing	364	Beer
19	CanAgra	350*	Food
20	Avon Products	338*	Cosmetics
21	Scott Paper	326	Paper products
22	G. Heileman Brewing	325*	Beer
23	American Home Products	319*	Food
24	General Mills	315*	Food
25	Nestle Foods	296	Food
26	Grand Metropolitan	296	Food
27	Clorox	295	HH chemicals

28	Cadburry-Schweppes	280	Soda

(continued)TABLE 3-3. LEADING CONSUMERS OF PACKAGING MATERIALS AND CONTAINERS, 1989 (CONTINUED)

Rank	Company	Purchases (10^6)	Principal Product(s)
29	Revlon Group	266	Cosmetics
30	H.J. Heinz	240*	Food
31	Quaker Oats	239	Food
32	Ocean Spray Cranberries	231	Juices
33	S.C. Johnson & Son	216	HH chemicals
34	Johnson & Johnson	191	Health products
35	DuPont	185*	Chemicals
36	Dean Foods	180*	Dairy products
37	Dow Chemical	180*	Chemicals
38	Geo. A. Hormel & Co.	166*	Meats
39	American Cyanamid	163	Chemicals
40	CPC International	163	Food
41	Bristol-Myers Squibb	162	Pharmaceuticals
42	Warner-Lambert	162	Pharmaceuticals
43	Hershey Foods	161	Candy
44	General Motors	160	Automotive
45	Ralston-Purina	154	Pet foods, other
46	Colgate-Palmolive	146	Hygiene products
47	Castle & Cooke	145	Fresh fruits and vegetables
48	Kellogg	143	Food
49	Greyhound Dial	137	Soaps
50	Dr. Pepper/Seven-up	133	Soda
		23,019	

2nd 50 leading packagers	3,559	-
	26,578	
Other packagers	44,393	-
Total	70,834	

[a] Asterisk indicates reported data.

Source: Packaging (July) - based on survey of 250 companies: includes the value of self-manufactured containers. Rauch Guide to the U.S. Packaging Industry. Bridgewater, NJ, Rauch Associates. 1989. pp. 9-10.

3.3 SUBSTITUTION POSSIBILITIES IN CONSUMPTION

Any printing process can be made to produce good printing. A quote by Eldred illustrates this point.

> There is a widely held misbelief that some printing processes give better reproduction than others. The best process gives the best results for the money, with quality appropriate for the package. Gravure is sometimes considered expensive and flexo cheap, but this is no more true than with any other well-considered or poorly considered choice. Every printing process can and does give outstanding printing as well as poor printing.[10]

The choice of printing process is made on the basis of printing and converting economics, the requirements of the package, and the nature of the substrate rather than on the basis of the package design.

The printing process is usually chosen by someone other than the designer. Each printing process has certain advantages and disadvantages given certain substrates, inks, package designs, and print and color requirements. Different packaging materials require different printing techniques and one print process may be better suited over another. In package design, the substrate is chosen to protect the product, to make its use convenient, and to produce attractive printing. For example, corrugated boxes cannot tolerate strong compression during the printing process, therefore

flexography is better suited than gravure because quality printing from flexography requires less compression.

A summary of typical printing process choices by publication and package type is provided in Tables 3-4[11] and 3-5.[12] Publishers and packagers usually have a limited selection of cost-effective printing process for any package. Flexography, rotogravure, lithography, letterpress, and screen as well as less common printing processes (embossing, foil stamping, ink jet, and thermography) all have their places in

TABLE 3-4. PRINTING PROCESSES COMMONLY USED TO PRINT PUBLICATIONS

Publication Type	Printing Process
Magazines and periodicals	lithography, gravure, letterpress
Sunday magazines	lithography, gravure, flexography, letterpress
Catalogs and directories	lithography, gravure, letterpress
Direct mail advertising	lithography, gravure, letterpress, flexography
Display advertising	lithography, screen, letterpress
Preprinted newspaper inserts	lithography, gravure, letterpress, flexography
Financial and legal printing	lithography, letterpress, flexography
Newspapers	lithography, letterpress, flexography
Books	lithography, letterpress, flexography

Sources:

Developed from a comparison of value of shipments across printing processes in:

U.S. Department of Commerce. 1987 Census of Manufactures, Industry Series: Commercial Printing and Manifold Business Forms. Washington, DC, U.S. Government Printing Office. March 1990. Table 6a.

U.S. Department of Commerce. 1987 Census of Manufactures, Industry Series: Newspapers, Periodicals, Books, and Miscellaneous Publishing. Washington, DC, U.S. Government Printing Office, 1990, Table 6a.

TABLE 3-5. PRINTING PROCESSES COMMONLY USED TO PRINT PACKAGING

Package Type	Printing Process
Labels	Flexo, gravure, offset, letterpress, screen
Tags and wrappers	Flexo, gravure, offset, letterpress, screen
Corrugated	Flexo, letterpress, offset
Top liner	Flexo, gravure (especially in Japan)
Folding cartons	Offset, gravure, flexo
Flexible packaging	
Foil	Flexo, gravure
Plastic	Flexo, gravure
Paper bags	Flexo, gravure
Grocery bags (paper or plastic)	Flexo
Beverage cans	"Dry litho" (offset letterpress), offset
Metal boxes and 3-piece cans	Offset, screen
Plastic bottles	Flexo, screen
Caps and closures	Offset, flexo
Plastic (butter) tubs	Flexo
Squeeze tubes (toothpaste tubes)	Flexo
Metal caps	Offset
Plastic caps	Flexo
Blister packs	Offset, flexo

Source: Eldred, Nelson R. Package Printing. Plainview, NY. Jelmar Publishing Co., Inc. 1993. p. 139.

packaging, and while they are not interchangeable there is always a multiple choice.

Characteristics of the printing process make them suitable for some jobs and unsuitable for others. In choosing a printing process it is also important to keep costs down. The preparatory work and plates are usually a one-time cost, while the ink, substrate and press time depend on the length of the run. Also, keeping the number of colors down without sacrificing the graphics will keep the up front preparation costs down. Some of the characteristics can be more easily changed by skill and careful planning than others can. Although there are exceptions and it is difficult to rank each printing process, Table 3-6 presents comparisons of the five major printing processes.[13] Various characteristics a publisher, packager, or product manufacturer may look for are listed down the left and each process to the right is ranked with a 1 denoting the most preferred process.

Once the printing process has been selected, the design must be one that will reproduce well. The key is how well the designer makes use of the printing process. The designer must be aware of the limitations inherent in the printing characteristics of the chosen substrate--film or foil, corrugated, carton board, coated and uncoated paper, metal, glass or plastic. Substrate material may have to be changed if the one chosen cannot be suitably printed in a cost effective manner. A designer who understands printing knows how to challenge the printing press without defeating it and how to create a design that takes advantage of the characteristics of the printing process and the substrate to achieve the maximum results. The packager, artist, designer, service house, and printers/converters work together as a team to ensure that the package design and artwork are compatible with the printing process to be used so the printing will fully enhance the product to be packaged. All the printing processes can achieve quality printing, given that proper

planning goes into the design and artwork for the package.

TABLE 3-6. COMPARISON OF FIVE MAJOR PRINTING PROCESSES[a]

Characteristics	Flexo	Gravure	Offset	Letterpress	Screen
Reproduction of Type	3	5	2	1	4
Reproduction of Solids	3	2	5	4	1
Reproduction of Highlights	3	1	1	3	5
Reproduction of Shadows	5	3	1	2	3
Resolution	3	4	1	2	5
Register Control	1	3	3	1	5
Color Consistency	2	1	5	4	2
Plate Cost	3	5	1	3	1
Speed of Platemaking from Original	2	5	1	2	2
Ease of Plate Correction	4	5	2	1	2
Plate Length of Run	2	1	3	3	5
Paper Cost	1	1	5	2	2
Tolerance for Paper Roughness	3	5	2	4	1
Paper Strength Requirements	1	1	5	4	1
Tolerance for Low Basis Weight	1	2	5	4	3
Ink Cost	1	1	4	3	5
Thickest Ink Film	4	2	5	3	1
Operator Skill Required	2	3	3	5	1
Press Make-ready Time	4	3	2	5	1
Economy on Long Runs	2	1	3	3	5
Economy on Short Runs	3	5	2	4	1

Source: Eldred, Nelson R. Package Printing. Plainview, NY. Jelmar Publishing Co., Inc. 1993. p. 141.

[a]A ranking of "1" indicates the preferred process.

1. Lancaster, Kelvin J. A New Approach to Consumer Theory. Journal of Political Economy. 74:132-157. 1966.

2. Eldred, Nelson R. Package Printing. Plainview, NY, Jelmar Publishing Co., Inc. 1993. p. 452.

3. Ref. 2., p. 16.

4. U.S. Department of Commerce. 1987 Census of Manufactures, Subject Series: Distribution of Sales by Class of Customer. Washington, DC, U.S. Government Printing Office. 1992. p. 4-14.

5. Ref. 2., p. xiii.

6. Ref. 2., p. 128.

7. Ref. 2., p. xv.

8. Rauch Associates. Rauch Guide to the U.S. Packaging Industry. Bridgewater, NJ, Rauch Associates. 1989. pp. 11-12 and pp. 6-7.

9. Ref. 8., pp. 9-10.

10. Ref. 2., p. 139.

11. Table developed using the value of shipments data across printing processes as reported in U.S. Department of Commerce. 1987 Census of Manufactures. Industry Series: Commercial Printing and Manifold Business Forms. Washington, DC, U.S. Government Printing Office, March 1990, Table 6a. and U.S. Department of Commerce. 1987 Census of Manufactures. Industry Series: Newspapers, Periodicals, Books, and Miscellaneous Publishing. Washington, DC, U.S. Government Printing Office, 1990, Table 6a.

12. Ref. 10.

13. Ref. 2., p. 141.

SECTION 4
INDUSTRY ORGANIZATION

This section describes the structure of the printing industry, the facility characteristics, and firm characteristics.

4.1 MARKET STRUCTURE

In addressing the economic impacts of air pollution regulations, market structure is of interest because of the effect it has on the behavior of producers and consumers. A market is generally considered the locus where producers and consumers interact to trade goods and services. Economic theory usually takes the market as given; however, when considering regulatory impacts, the analyst must define products and producers that constitute the market.

4.1.1 Products

Due to the multiplicity of printed products and wide variety of differentiation, printed materials are not homogeneous products. As mentioned in Section 2, 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),[1] rigid boxes, flexible packaging, tags, labels, sanitary food containers, paper sacks, plastic carrier bags;

- Product: gift wraps, wallcoverings, floor coverings, decorative laminates used in furniture and construction, tissue products, upholstery, table cloths, and shower curtains.

Table 4-1 shows 1990 value of shipments by each printing process for specific types of packaging.[2]

TABLE 4-1. VALUE OF PRINTED PACKAGING, 1990
(U.S. SHIPMENTS -- 10^9)

Package Type	Flexo	Offset	Gravure	Letterpress	Screen & Misc.
Corrugated	12.9	0.5	--	0.5	--
Plastics					
Flexible packaging	7.0	--		--	--
Bags	1.5	0.5	0.5		
Other[a]	2.0				
Folding cartons[b]	1.5	2.3	1.0	0.5	--
Multiwall sacks	0.6	--	0.2	--	--
Paper bags[c]	4.5	1.2	0.3	--	--
Labels[d]	2.0	4.0	0.4	0.5	0.4
Sanitary packaging	2.0	--	--	--	--
Metal cans	0.5	1.0	--	2.0	
All other	2.5	--	--	0.5	1.1
	37.0	9.5	6.2	4.0	1.5

Total sales of packages = $73.0 billion; total of printed packages = $58.2 billion

[a] Includes plastic grocery bags.
[b] Includes milk cartons and beverage carriers.
[c] Includes grocery sacks, specialty and boutique bags, etc.
[d] Much label printing is to be found classified as commercial printing.

Source: Eldred, Nelson R. Package Printing. Plainview, NY, 1993. Jelmar Publishing Co., Inc. 1993. p. xvii.

Note: Figures cited are only approximations, and lack of numbers in some categories does not indicate lack of activity, only that such activity is minimal.

4.1.2 Producers

The number of producers in a particular market is defined by the geographic bounds of the market. For gravure publication there are a small number of plants, and they primarily serve national markets. For packaging and product gravure and flexography there are many more plants, and they generally serve regional and local markets. For example, there are a large number of corrugated box plants throughout the country located in close proximity to users of the containers.[3] The bulkiness of the product dictates that the cost of shipping and storage will be high, therefore corrugated box plants generally fill small local orders. This is typical for most packaging products, packaging plants in general tend to be widely dispersed throughout the country. Packaging products that are lighter and not as bulky, such as paper, plastic, and foil bags, are not as highly decentralized. Although for some packaging products, sales may be highly concentrated among a few firms, they tend to operate many small widely scattered plants rather than a few centralized plants.[4] Much of the printing in the packaging and product segment, as with the manufacture of corrugated boxes, is integrated with the overall production process.

4.1.3 Market Behavior

Once the market structure is defined, the analyst models the behavior of consumers and, most importantly, producers of printed products. The discussion on behavior generally focuses on monopolistic, oligopolistic, or competitive pricing. Making inferences about the behavior of producers often requires developing a measure of the concentration of an industry or market. A concentration measure should reflect the ability of firms to raise prices above the competitive level. Less concentrated markets are predicted to be more competitive and should result in a low value of the concentration measure, while a higher value should indicate a

higher price-cost margin or a higher likelihood of noncompetitive behavior on the part of producers. A widely used measure is the concentration ratio. The n-firm concentration ratio reflects the share of total industry sales accounted for by the n largest firms. Unfortunately, concentration ratios only describe one point on the entire size distribution of sellers or producers.

Table 4-2 presents 1987 concentration ratios for the commercial printing industry segments covered by this regulation.[5] It is important to note that the data presented are by Standard Industrial Classification (SIC) code for two industries as defined by the U.S. Department of Commerce: Commercial Printing, Gravure (SIC 2754) and Commercial Printing, not elsewhere classified (n.e.c.) (SIC 2759). Data for SIC 2754 includes most of the publication gravure printing universe and some of the gravure packaging universe (mainly the label and wrapper commercial printing segment). SIC 2754 does not however capture gravure printing operations that are integrated with the production processes of an industry classified under a different SIC code. SIC 2759 includes data for flexographic printing done on a commercial basis (i.e. not as part of an integrated production process), but also includes data for other n.e.c. printing processes, mainly letterpress and screen printing. For most of the Census flexography data it was not possible to separate flexography from the rest of the Commercial Printing, n.e.c. industry category. The reader should bear these limitations in mind when interpreting the Census data presented in Table 4-2 and throughout the balance of this chapter.

Table 4-2 shows that the commercial gravure industry is fairly concentrated with the top four companies attributing to over half of the value of shipments for the industry. Gravure commercial printing also tends to be more concentrated than the Other commercial industry, which includes flexography.

Table 4-2

Concentration is not very high in the packaging segments where gravure and flexographic printing are most common. For rigid boxes, flexible packaging, folding cartons, corrugated containers, the top four firms account for 35 percent or less of total value of shipments for each industry category.[6]

The Herfindahl index shown in Table 4-2 provides additional information on market concentration. This index measures concentration by summing the squares of the market shares (based on value of shipments) of all firms in the industry. The U.S. Department of Justice uses Herfindahl indexes to assess the potential for monopoly power in markets, and considers a market with an index of 1,000 or less to be relatively unconcentrated and a market with an index of 1,800 or more to be highly concentrated.[7] Therefore neither of the indexes for the commercial printing industries of interest here indicate very high levels of concentration. Furthermore, the respective indexes only measure the value of shipments for the firms operating in the commercial segment versus the integrated segment of the gravure and flexographic industries.

4.2 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.

4.2.1 Publication and Packaging/Product Gravure Plants

In 1993 there were 27 publication rotogravure plants operating in the U.S.[8] 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 Gravure Association of America (GAA) confirmed that in 1988 there were at least 545

packaging/product plants that had rotogravure presses.[9] For 1987, the U.S. Department of Commerce reports that 332 plants were classified in the gravure commercial printing industry (SIC 2754).[10] 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.

4.2.1.1 Location, Presses, and Products Printed. Figure 4-1 identifies the locations of the 27 facilities in the U.S. that print publication rotogravure and Table 4-3 lists each plant by company name, city, and state.[11] 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 press.[12] For confidentiality reasons, it is not possible to report the number of presses by actual plant from the EPA database.

The Gravure Association of America conducted their own survey of publication rotogravure plants in North America and reports 160 to 165 rotogravure presses, with 1,494 printing units.[13] Almost half of the presses GAA was able to gather data on 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 also 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.

Figure 4-1. Location of publication rotogravure printing plants, U.S.

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

TABLE 4-3. 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.

GAA also surveyed the use of electrostatic assist, which is a method used to assist the transfer of ink from the cylinder cells to the paper and allows the use of lower impression pressure, higher press speeds, and reduces web breaks. Approximately 80 percent of the press units use electrostatic assist technology. Gravure proofing presses, which are used to proof cylinders prior to printing in order to detect errors in engraving are used by gravure publication plants. These presses use special inks which simulate the results from high speed printing, and run at much slower speeds (average is 340 feet per minute).

Table 4-4 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.[14] 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 which 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 4-4 are not necessarily the number devoted to printing that particular product, but rather the number operated by plants which print those products as either primary, secondary, or tertiary.

EPA collected survey data from 107 packaging/product facilities operating rotogravure presses. Table 4-5 lists the company names, locations, total employees, and products printed for those plants surveyed.[15] 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.

TABLE 4-4. NUMBER OF GRAVURE WEB PRESSES IN THE PUBLICATION GRAVURE INDUSTRY, 1989

	No. 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 which 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.

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.[16] 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 4-6 summarizes the estimated number of presses and units at U.S. packaging and product gravure plants by primary and secondary product specialty.[17] It can not be determined how much of the press capacity at plants producing a certain product as secondary is devoted to that product.

TABLE 4-5. 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 4-5. 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 4-5. 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 4-5. 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	-9	P
Stone Container Corporation	Louisville	KY	16	P
TECHNOGRAPHICS PRINTWORLD	North Monroe	NC	140	W
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:

P = Paper/Cardboard Only
F = Film/Foil Only
V = Vinyl products
M = Paper/Cardboard and Film/Foil
W = Miscellaneous

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

table 4-6

Paperboard Packaging magazine compiled data from 480 U.S. folding carton manufacturing plants listed in the Paperboard Group's Official Container Directory and reports that 112 gravure presses (both sheet and web) were in operation at these folding carton plants in 1993.[18] Over 60 percent of these presses were located at plants in the East North Central (Wisconsin, Michigan, Ohio, Illinois, and Indiana) and South Atlantic (Delaware, Maryland, West Virginia, Virginia, North Carolina, South Carolina, Georgia, and Florida) regions of the country.

4.2.2 Flexography Plants

An estimated 1,587 printing plants in the U.S. have flexographic presses.[19] Most facilities which 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 combination flexography/gravure. The selection of equipment for a particular job depends on the length of run, quality requirements, and the substrate. Because often the printing portion of the total packaging value is rather small, many facilities that produce corrugated cartons and paper bags may not consider themselves to be printers.[20]

4.2.2.1 Location, Presses, and Products Printed. Figure 4-2 shows the number of estimated flexographic plants for each state.[21] Newspapers 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.[22] EPA surveyed approximately 380 companies thought to operate flexographic printing presses. Responses were received from approximately 500 plants operating wide web flexographic printing presses and from approximately 100 plants operating narrow web equipment.[23]

Figure 4-2. Location of Flexography Printing Plants, U.S.

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, one 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 at 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 there were 952 flexo printer-slotters and 1,378 flexo folder-gluers operating at a total of 1,387 corrugated box plants (sheet and web plants) in the U.S.[24] 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.

4.2.3 Printing Capacity

The U.S. Department of Commerce's Survey of Plant Capacity reports capacity utilization rates by SIC code, which are estimated from the Census Bureau's 1990 Survey of Plant Capacity Utilization. Full production capacity utilization rates for the fourth quarter of 1989 and 1990 for the commercial printing industries (SIC 2752, 2754, 2759) are shown in Table 4-7.[25] Full production capacity is defined as the maximum level of production an establishment could attain under normal operating conditions. The rates reported in Table 4-7 are ratios of the actual level of operations to the full production level. U.S. domestic manufacturing plants

TABLE 4-7. CAPACITY UTILIZATION RATES FOR THE COMMERCIAL PRINTING INDUSTRY, FOURTH QUARTERS, 1989 AND 1990

	Full Production[a]	
Industry	1989	1990
Total Commercial Printing	81	81
Lithographic Printing	81	81
Gravure Printing	85	85
Other Commercial Printing	78	79

[a] The full production capacity utilization rates are rates of actual level of operations to the full production level.

Source: U.S Department of Commerce. Current Industrial Reports: Survey of Plant Capacity, 1990. Washington, DC, U.S. Government Printing Office. 1992. p. 5.

used an estimated 76 percent of their full production capacity for the fourth quarter of 1990 and 77 percent for the fourth quarter of 1989.[26] Commercial printing is considered a nondurable good and an advance processing industry. For the fourth quarter of 1990, total commercial printing operated at a one percent higher rate than all other U.S. nondurable goods industries and at a 6 percent higher rate than all other U.S. advance processing industries.

4.2.4 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 4-3 shows the distribution of gravure plants by average number of employees.[27] Figure 4-4 shows the distribution of flexography plants by average number of employees.[28] The flexographic printing plants tend to be larger than gravure plants.

Figure 4-3. Gravure printing facilities by number of employees, 1987.

Source: U.S. Department of Commerce. 1987 Census of Manufacturers. Industry Series: Commercial Printing and Manifold Business Forms. Washington, DC, U.S. Government Printing Office. Table 4.

Figure 4-4. 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.

4.2.5 Current Trends

Table 4-8 summarizes current openings and closings of plants in the printing industry.[29]

4.3 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).

TABLE 4-8. PLANT OPENINGS AND CLOSINGS: 1992-93

Company	Activity	
Alford Industries,	Closed:	Rochelle Park, NJ
American Business Products	Closed:	Santee, CA; San Antonio, TX (integration of two facilities making 45 into 43)
Arcata Graphics Co.	Closed:	Buffalo, NY; Clarkesville, TN; Nashville, TN (magazine division) to Quebecor
Banta Corp.	Opened:	Clarke Printing in Kansas City
Bowne & Co.,Inc.	Opened:	Hong Kong; Palo Alto, CA; Charlotte, NC; Mexico City
Clarke American	Opened: Closed:	Milwaukee, WI Mobile, AL
Courier Corp.	Opened:	Courier EPIC
Data Documents	Closed:	Los Angeles, CA
Duplex Products	Closed:	Jacksonville, FL
John H. Harland Co.	Closed:	9 Interchecks plants (out of 16 - kept 7)
Maclean Hunter Ltd.	Closed:	Check Gallery, Inc., Baltimore, MD
Mebane Packaging Corp.	Opened:	New 70,000-sq.ft. facility in Garner, NC
Merrill Corp.	Opened:	Printing facility in Union, NJ
Moore Business Forms	Closed:	5 foreign facilities
Quebecor Printing, Inc.	Opened:	Custom Direct, Cincinnati, OH
Queens Group, Inc.	Opened:	Stanley, NC

(continued) TABLE 4-8. PLANT OPENINGS AND CLOSINGS: 1992-93 (CONTINUED)

Company	Activity	
Queens Group, Inc.	Opened:	RRD Netherlands; Viewpoint Information Systems; RRD Documentation Services, Cumbernauld, Scotland; Partnerships: Advanced Communications (Thailand); RRD Pindar (UK); Desktop Data
R.R. Donnelley & Sons	Opened:	Charlotte, NC
Retail Graphics	Opened:	Fourth plant in West Bend, WI
Serigraph, Inc.	Closed:	Standard Gravure
Shea Communications	Opened:	Trading card plant in Aurora, IL
Solar Press, Inc.	Closed:	Hanford, CA plant
Standard Register	Opened:	Brampton, Ontario

Trans-Continental Printing, Inc.	Closed:	Albuquerque, NM; two plants consolidated into one in Salt Lake City, UT
Treasure Chest Advertising	Opened:	Lawrence, KS; Atlanta, GA; Newark, DE; Rolling Meadows, IL
UARCO, Inc.	Closed:	Don Mills, Ontario, CAN

Source: American Printer. 1993. The Foremost Ranking of Top Printing Companies, 100+. Vol. 211, No. 4. p. 74.

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 4-5, the chain of ownership may be as simple as one facility owned by

Figure 4-5. Chain of ownership.

one company or as complex as multiple facilities owned by subsidiary companies.

Potentially affected firms include entities that own plants which employ gravure or flexographic printing processes. The EPA survey indicates that in 1993 six companies owned the 27 publication rotogravure plants.[30] Furthermore sixty-four companies own the 107 packaging/product rotogravure plants EPA was able to identify in their survey.[31] The EPA survey of flexographic printers identified 500 companies.[32] Tables 4-9, 4-10, and 4-11 list the U.S. publication gravure, packaging/product gravure, and flexography companies identified by the EPA surveys.[33,34,35,36] All three tables present the total number of plants for each company that were identified in the EPA surveys, the total number of plants each company owns where available from other sources, and indicates the primary printing categories each company engages in.

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 which owned plants classified as gravure commercial printers in 1987.[37] The 304 includes both publication gravure and packaging/product gravure printers, and does not include companies which use the gravure printing process to decorate their manufactured products, which are classified in a different industry. Additional data on companies owning facilities that print tags, labels, corrugated boxes, and folding cartons using gravure and flexography may be obtained from Package Printing & Converting's "1993 TLMI Products Guide" (lists tag and label companies) and the Paperboard Group's Official Container Directory (lists corrugated box and folding box companies). Both sources indicate the type of printing process each company employs.

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4-10, 3 pages

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4.3.1 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.[a]

Each type has its own legal and financial characteristics that may influence how firms are affected by the regulatory alternatives. Table 4-12 provides information about the legal for of ownership of firms for commercial gravure printers (SIC 2754) and commercial printers, n.e.c. (SIC 2759), which includes flexographic printers.[38] The majority of commercial gravure printers and other, n.e.c. printers are single-facility corporations. Figure 4-6 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.[39,40]

4.3.1.1 Sole Proprietorship. A sole proprietorship consists of one individual in business for him/herself who contributes all of the equity capital, takes all of the risks, makes the decisions, takes the profits, or absorbs the losses. Behrens reports that sole proprietorships are the most common form of business.[41] The popularity of the sole proprietorship is in large part due to the simplicity of establishing this legal form of organization. For 1987, Internal Revenue Service (IRS) data indicate that nonfarm sole proprietorships represented almost 72 percent of U.S. businesses but accounted for only 6 percent of business receipts.[42] The 1987 Census of

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[a] Refer to Appendix A for more detail on each ownership type and corresponding advantages and disadvantages of each.

Manufactures reports,

TABLE 4-12. LEGAL FORM OF FIRM ORGANIZATION IN THE COMMERCIAL PRINTING INDUSTRY, 1987

Industry Segment/ Facility Ownership	Legal Form of Organization: Corporation	Sole Proprietorship	Partner-ships	Other and Unknown	Total
Gravure printing (2754)					
Single-facility firms	167	N/A	N/A	N/A	258
Multifacility firms	44	N/A	N/A	N/A	46
All gravure firms	211	42	21	30	304
Other printing (2759)					
Single-facility firms	5,701	N/A	N/A	N/A	10,256
Multifacility firms	342	N/A	N/A	N/A	352
All other printing firms	6,043	1,649	556	2,360	10,608

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

however, that approximately 14 percent of firms in the U.S. commercial gravure printing industry are sole proprietorships. For other n.e.c. printers about 16 percent of the firms are sole proprietorships. This type of business organization plays a relatively small role in these two commercial printing industries.

4.3.1.2 Partnerships. For 1987, IRS data on business tax returns indicate that partnerships represented only 9 percent of U.S. businesses and accounted for an even smaller percentage of business receipts--4 percent.[43] For 1987, the Census of Manufactures reports that only 21 of the 304 commercial gravure printing companies are partnerships--accounting for about 7 percent of all firms in the industry. Five percent of other n.e.c. commercial printing companies are organized as partnerships.

Figure 4-6. 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 Manufacturers. 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.

4.3.1.3 Corporations. According to IRS business tax returns for 1987, corporations represented only 19.7 percent of U.S. businesses but accounted for 90 percent of all business receipts.[44] For 1987, the Census of Manufactures reports that 213 of 304 firms listed under SIC code 2754 for the gravure commercial printing industry are corporations. For SIC 2759, commercial printers, n.e.c. 6,043 of 10,608 firms are corporations. Therefore, corporations represent 57.3 percent of the business entities involved in gravure and other, n.e.c. commercial printing.

4.3.2 Size Distribution

Firm size is likely to be a factor in the distribution of the regulatory action's financial impacts. Grouping the firms by size facilitates the analysis of small business impacts, as required by the Regulatory Flexibility Act (RFA) of 1982.

Firms are grouped into small and large categories using Small Business Association (SBA) general size standard definitions for SIC codes. These size standards are presented either by number of employees or by annual receipt levels, depending on the SIC code.

As presented in Table 4-13 the firms owning plants which have gravure or flexographic printing capabilities, and thus potentially affected by the regulation, 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 SIC's 26, 30, 32, and 34, as well industries under SIC's 26 and 30 that produce products with gravure or flexographic printing. The Small Business Administration size standards for all of these industries are based on the number of employees, and as Table 4-14 shows, businesses classified in most of these industries are considered small if they have less than 500 employees, otherwise they would be considered large.

TABLE 4-13. 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, nec	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, nec	500
2732	Book printing	500
2752	Commercial printing, lithographic	500
2754	Commercial printing, gravure	500
2759	Commercial printing, nec	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	Plastics bottles	500
3089	Plastics, n.e.c.	500
3221	Glass containers	750
3411	Metal cans	1,000

TABLE 4-14. NUMBER OF PLANTS OWNED, SALES, EMPLOYMENT AND TYPE OF OWNERSHIP FOR COMMERCIAL PRINTING FIRMS[a]

Company Name	Legal Form of Organization	Number of Plants Owned	Number of Employees	1993 Sales (10^6)	Sales per Employee (10^3)
Publication Gravure (6)					
Brown Printing Company	Private	7	3,100	410	132.3
R.R. Donnelley and Sons	Public	40	30,400	4,193	137.9
Quad/Graphics	Private	8	6,400	582	90.9
Quebecor Printing	Public	62	14,500	1,444	99.6
Ringier America Inc.	Private	10	4,890	610	124.7
World Color Press, Inc.	Private	13	6,219	838	134.7
Packaging/Product Gravure (60)					
Alcan Foil Products	Div. of Alcan Aluminum Corp.	NA	6,500	2,900	446.2
Alford Industries	Private	1	250	55	218.0
Allied Stamp Corporation	NA	NA	175	NA	NA
Alusuisse Flexible Packaging, Inc.	Private	3	470	125	266.0
American Fuji Seal, Inc.	NA	NA	175	NA	NA
American Greetings	NA	31	21,400	1,688	78.9
Amgraph Packaging, Inc.	Private	1	145	30	206.9
Avery Dennison	Public	NA	16,500	2,623	158.9
Borden, Inc.	Public	NA	46,000	7,143	155.3
Butler Printing & Laminating, Inc.	NA	NA	175	NA	NA
Cello-Foil Products, Inc.	Private	NA	250	70	280.0
Chiyoda America Inc.	Subsidiary	NA	115	20	173.9
Cleo, Inc.	Subsidiary of Gibson Greening, Inc.	NA	1,700	220	129.4
Congoleum Corporation	Private	NA	1,200	200	166.7
Constant Services, Inc.	NA	NA	50	NA	NA
CPS Corporation	Subsidiary of Fox Valley Corp.	NA	1,000	100	100.0

(continued)TABLE 4-14. NUMBER OF PLANTS OWNED, SALES, EMPLOYMENT AND TYPE OF OWNERSHIP FOR COMMERCIAL PRINTING FIRMS[a] (CONTINUED)

Company Name	Legal Form of Organization	Number of Plants Owned	Number of Employees	1993 Sales (10^6)	Sales per Employee (10^3)
Decor Gravure Corporation	Private	NA	150	23	153.3
Decorating Resources, Inc.	Subsidiary of Permenance Label Corp.	NA	120	5	41.7
Decorative Specialties International, Inc.	NA	NA	24,498	NA	NA
Dinagraphics	Subsidiary of Jefferson Sumfit Corp.	NA	100	20	
Dittler Brothers	Subsidiary	NA	550	85	154.5
Dopaco, Inc.	NA	NA	625	NA	NA
DRG Medical Packaging, Inc.	Subsidiary of Gothic, Inc.	NA	350	75	214.3
Engraph, Inc.	Public	12	1,531	235	174.1
Eskimo Pie Corporation	Public	NA	130	63	484.6
Federal Paper Board Co., Inc.	Public	NA	6,850	1,461	213.3
Fleming Packaging Corporation	Private	8	650	107	165.1
Fres-Co System USA, Inc.	Private	NA	210	13	61.9
GenCorp Inc.	Public	NA	13,900	1,937	139.4
Graphic Packaging Corporation	Subsidiary of ACX Tech, Inc.	NA	979	202	206.3
Gravure Carton & Label	NA	NA	15	NA	NA
Gravure Packaging, Inc.	NA	NA	175	NA	NA
Hallmark Cards	Private	6	21,500	3,100	144.2
Hargro Flexible Packaging	Private	6	800	120	150.0

International Label Company	Joint Venture	NA	300	40	133.3
J. W. Fergusson and Sons, Inc.	Private	2	280	42	150.0
James River Corporation	Public		38,000	4,728	124.4

(continued)TABLE 4-14. NUMBER OF PLANTS OWNED, SALES, EMPLOYMENT AND TYPE OF OWNERSHIP FOR COMMERCIAL PRINTING FIRMS[a] (CONTINUED)

Company Name	Legal Form of Organization	Number of Plants Owned	Number of Employees	1993 Sales (10^6)	Sales per Employee (10^3)
Jefferson Smurfit Corporation	Subsidiary of SIBV/MS Holdings, Inc.		18,100	2,940	162.4
JSC/CCA	Joint Venture	NA	>1,500	NA	NA
Koch Label Company, Inc.	Private	1	170	30	176.5
Lamotite, Inc.	NA	NA	>1,500	NA	NA
Lux Packaging Ltd.	Private	NA	300	40	133.3
Mannington Mills, Inc.	Private	NA	3,000	600	200.0
Mundet-Hermetite, Inc.	Private	NA	135	23	170.4
Newco Inc.	Private	NA	100	5	50.0
Package Service Company	Private	3	168	27	161.3
Paramount Packaging Corporation	NA	NA	875	NA	NA
Quick Roll Leaf Manufacturing Co.	Private	NA	50	8	160.0
Reynolds Metals Company	Public	NA	29,300	5,656	193.0
Riverwood International USA, Inc.	Subsidiary of Riverroad International Corp.	NA	8,500	1,000	117.6
Scientific Games, Inc.	Private	NA	500	120	240.0
Shamrock Corporation	NA	NA	50	NA	NA

Somerville Packaging Corp.	Division	NA	110	12	109.1
Stone Container Corporation	Public	NA	31,200	5,520	176.9
Technographics, Inc.	Private	NA	500	65	130.0
The C. W. Zumbiel Company	NA	NA	375	NA	NA
Union Camp Corporation	Public	NA	20,153	3,064	152.0
Vitex Packaging, Inc.	Private	NA	90	12	133.3
Waldorf Corporation	Private	NA	2,000	360	180.0
Wrico Packaging	NA	NA	>1,500	NA	NA

(continued)

TABLE 4-14. NUMBER OF PLANTS OWNED, SALES, EMPLOYMENT AND TYPE OF OWNERSHIP FOR COMMERCIAL PRINTING FIRMS[a] (CONTINUED)

[a]Includes all firms with gravure printing capacity for which data were available, but excludes firms with flexographic printing capacity including those that responded to EPA's survey due to lack of data.

NA = Not available.

Souces: EPA. Publication Gravure, Packaging/Product Gravure, and Flexography Printers Databases. 1993.

Printing Impressions. "The Who's Who in Printing, Industrion 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

Package Printing and Converting. The 1993 TLMI Products Guide. 1993. pp. 33-71.

Paperboard Packaging's Official Container Directory. Advanstar Communications, Inc. Vol. 81, No. 2. Fall. 1993. pp. 59-150.

Ward's Business Directory of U.S. Private and Public Companies. Washington, DC, Gale Research, Inc. 1994.

Table 4-14 lists the companies for which data are available that will potentially affected by the regulation to reduce HAP emissions from gravure and flexographic printers.[45] In addition to company name, Table 4-14 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 4-14 shows that the potentially affected firms ranges in size from less 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 as small. In fact, data from Ward's Business Directory indicates that almost 94 percent of firms in SIC 2759 (Commercial Printing, NEC) have less than 500 employees.[46]

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

- Facilities which 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 another.

4.3.3 Issues of Vertical and Horizontal Integration

The vertical aspects of a firm's size reflects 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. For example, 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 either or both of two 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.

4.3.4 Current Trends

Table 4-15 summarizes the ownership changes occurring in the printing industry during 1992 and 1993.[47] Major changes included during 1992 were Trans-Continental Printing, Inc.'s purchase of Southam's Canadian web printing operations valued at $105 million, the investment group First Printing's purchase of a majority interest in Holladay-Tyler valued at $60 million, R.R. Donnelley exercising its option to purchase Combined Communication Service with $60 million in sales, and Quebecor Printing, Inc. acquiring three plants from Arcata Graphics. These three plants generated $240 million in sales over the past year. During the first half of 1993, World Color Press acquired $177.3 million Alden Press, making it the third largest diversified commercial printer. In addition, R.R. Donnelley and Sons acquired two short-run magazine plants from Ringier America, Inc.[48]

TABLE 4-15. PRINTING INDUSTRY OWNERSHIP CHANGES: 1992-1993

Company	Acquisition (Sales Noted in Italics)
American Greetings Corp.	Custom Expressions, Inc.
Brown Printing Co.	CMP Printing, Thorofare, NJ
Cadmus Communications Corp.	Tuff Stuff Publishing Co.
Century Graphics Corp.	Rapid Press, Inc., Omaha, NE
Consolidated Graphics Inc.	Gulf Printing, Houston, TX
Deluxe Corp.	Nelco, Inc., Green Bay, WI
Engraph, Inc.	Polaris Packaging, Robbinsville, NJ
Gibson Greetings, Inc.	Gibson de Mexico
Graphic Industries, Inc.	Eastern Typesetting, Hartford, CT
John H. Harland Co.	Interchecks Corp. and Rocky Mountain Bank Note (1/1/93)
Maclean Hunter Ltd.	Southam Paragon Business Forms & Specialty Printing Group, CAN; Bedinghaus, U.S.; Templeton Studios Ltd., Toronto
Moore Business Forms, Inc.	Travelers Print Center
Quebecor Printing, Inc.	Arcata Graphics, San Jose, CA; NADCO, Hazelton, PA; Graphique-Couleur, LaSalle (Quebec); First Western Printing, Calgary, Alberta
R.R. Donnelley & Sons	Combined Communications Service; American Inline Graphics; Laboratorio Lito Color, S.A. de C.V. (Mexico); Professional Lithographers; Geosoft Corp.; INK International (Netherlands)
Reynolds & Reynolds Co.	Norick Automotive Forms, OK; Shumate, IN; Woodbury, Atlanta, GA
Sullivan Graphics, Inc.	Sold: Haddon Craftsman and Nicholstone Companies (no longer included in totals due to the acquisition of Sullivan by Morgan Stanley in April 1993)
Trans-Continental Printing, Inc.	Drummondville, Quebec, Candiac, Quebec; Ontario, BC; Vancouver, BC

Source: American Printer. 1993. The Foremost Ranking of Top Printing Companies, 100+. Vol. 211, No.4. p. 60.

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

2. Eldred, Nelson R. Package Printing. Plainview, NY, 1993. Jelmar Publishing Co., Inc. 1993. p. xvii.

3. Kline, James E. Paper and Paperboard Manufacturing and Converting Fundamentals. 2nd Edition. San Francisco, Miller Freeman Publications, Inc. 1991. p. 184.

4. Rauch Associates. The Rauch Guide to the U.S. Packaging Industry. Bridgewater, NJ, Rauch Associates. 1989. p. 12.

5. U.S. Department of Commerce. 1987 Census of Manufactures, Subject Series: Concentration Ratios in Manufacturing. Washington, DC, U.S. Government Printing Office. 1992. pp. 6-19.

6. Ref. 4.

7. Hyman, David N. Modern Microeconomics, Analysis and Applications. Homewood, IL, Richard D. Irwin, Inc. 1989. p. 459.

8. Ref. 1.

9. Gravure Association of America. Profile Survey of the U.S. Gravure Industry. New York, GAA. 1989. p. PRESS-12.

10. U.S. Department of Commerce. 1987 Census of Manufactures, Industry Series: Commercial Printing and Manifold Business Forms. Washington, DC, U.S. Government Printing Office. March 1990. p. 27B-14.

11. Ref. 1.

12. Ref. 1.

13. Ref. 9., pp. PRESS-12-34.

14. Ref. 9., p. PRESS-10.

15. Ref. 1.

16. Ref. 9., p. PRESS-15.

17. Ref. 13.

18. Paperboard Packaging. U.S. Gains Corrugating/Folding Carton Plants in 1993. Vol. 79, No. 2. February 1994. p. 31.

19. 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.

20. Ref. 1.

21. Ref. 19.

22. Ref. 1.

23. Ref. 1.

24. Ref. 18.

25. U.S. Department of Commerce. Current Industrial Reports: Survey of Plant Capacity, 1990. Washington, DC, U.S. Government Printing Office. 1992. p. 5.

26. Ref. 25., p. 1.

27. Ref. 10., Table 4.

28. Ref. 19.

29. American Printer. 1993. The Foremost Ranking of Top Printing Companies, 100+. Vol. 211, No. 4. p. 74.

30. Ref. 1.

31. EPA Gravure Packaging/Product plants database. 1993.

32. EPA Flexographic plants database. 1993.

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

34. EPA Publication Gravure, Packaging/Product Gravure, and Flexographic plants databases. 1993.

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

36. Ref. 29., pp. 59-74.

37. U.S. Department of Commerce. 1990. 1987 Census of Manufactures, Industry Series: Commercial Printing and Manifold Business Forms. Washington, DC, U.S. Government Printing Office. p. 27B-11.

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

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

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

41. Behrens, Robert H. Commercial Loan Officer's Handbook. Boston, Banker's Publishing Company. 1985.

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

43. Ref. 42.

44. Ref. 42.

45. EPA. Publication Gravure, Packaging/Product Gravure, and Flexographic plants databases. 1993; Printing Impressions. 1993. "The Who's Who in Printing, Industry 500." Vol. 36. No. 7 December. pp. 44-72; American Printer. 1993. The Foremost Ranking of Top Printing Companies, 100+. Vol. 211, No. 4. pp. 59-74; Package Printing and Converting. 1993. The TLMI Products Guide. pp. 33-71; Paperboard Packaging's Official Container Directory. 1993. Advanstar Communications, Inc. Vol. 81, No. 2. Fall. PP. 59-150; and Ward's Business Directory of U.S. Private and Public Companies. Gale Research, Inc. Washington, DC. 1994.

46. Ward's Business Directory of U.S. Private and Public Companies. Gale Research Inc. Washington, DC. 1994.

47. American Printer. 1993. The Foremost Ranking of Top Printing Companies, 100+. Vol. 211, No.4. p. 60.

48. American Printer. 1993. The Foremost Ranking of Top Printing Companies, 100+. Vol. 211, No.4. p. 60.

SECTION 5
MARKETS

Printed products are produced and consumed domestically as well as traded internationally. Therefore, domestic producers export some of these products to other countries, and foreign producers supply their printed products to U.S. markets. This section includes information on value trends from 1987 to 1991 for printing and printed products, where statistics are available. The data presented concentrates on publication, packaging, and other printed products.

5.1 PRODUCTION

This section describes the domestic and foreign production of products.

5.1.1 Domestic Production

Tables 5-1, 5-2, and 5-3 present U.S. Department of Commerce Census data for value of U.S. shipments for the major product classes relevant to printing or printed products from 1987 to 1991. Table 5-1 presents shipments for publication printing and printed publication products.[1] In 1991, the commercial printing segments (2752, 2754, 2759) had a total of $51.8 billion in shipments. Between 1987 to 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 5-2 presents value of shipments for packaging materials.[2,a] 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 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 5-3 presents value of shipments for various printed products.[3] These product categories in aggregate have grown steadily since 1987 with an average annual growth rate of 5.9 percent over this five-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 5-1, 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.

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[a] Shipments for commercially printed labels and wrappers are included in data in Table 5-1.

Figure 5-1. 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.

5.1.2 Foreign Production (Imports)

Table 5-4 presents the value of U.S. imports for printing and printed products for 1989 to 1991.[4] 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 publishing represents the largest share of imports, with $925 million in 1991.

Tables 5-5 and 5-6 provide U.S. imports by trading partners for five industry groups related to printing and publishing.[5] Data are presented for the entire printing and publishing industry as well as the commercial printing sector;

(Table 5-5).

broad final published products sectors; and the paper and allied products industry, which includes packaging materials and printed products. In 1990, the value of U.S. imports within SIC 27 was $1.9 billion with the European community being the U.S.'s largest trading partner accounting for 38.2 table 5-4, landscape, 1 page percent of total value of imports and Canada accounting for 19.3 percent. As expected for the commercial printing industry (SIC 275), Canada is the largest single country importer to the U.S. with 29.3 percent of total value of imports (Table 5-6), while the European community as a whole represents an even larger import share with 40.3 percent (Table 5-5).

5.2 CONSUMPTION

This section describes the domestic and foreign consumption of printed products.

5.2.1 Domestic Consumption

Table 5-7 presents U.S. domestic consumption data for products related to printing for 1989 to 1991.[6] These data represent the value of shipments for each product category (see Tables 5-1, 5-2, and 5-3) minus exports, plus imports (See Table 5-4). Total domestic consumption for these product categories reached $181.6 billion in 1991. This represents a 5 percent increase in growth over 1989. There was however a slight decrease in domestic consumption for these product categories between 1990 and 1991 (0.2 percent), largely due to the decline in consumption of newspapers, commercial printing, and corrugated boxes.

5.2.2 Foreign Consumption (Exports)

Table 5-4 presents the value of U.S. exports for printing and printed products for 1989 to 1991. The product categories listed represent printing and printed products for which data

are available. U.S. exports rose by 32 percent to reach $5.4

TABLE 5-7. VALUE OF DOMESTIC CONSUMPTION FOR PRODUCTS RELATED TO PRINTING, 1989-1991 (10^6)[a]

SIC Code	Product Description	Value of Domestic Consumption 1989	1990	1991
2711	Newspapers	32,524.5	32,841.9	31,872.7
2721	Periodicals	18,439.9	18,711.5	18,789.0
2731	Book Publishing	12,438.6	13,683.9	14,639.5
275	Commercial Printing	49,198.0	52,193.0	51,286.4
2652	Setup paperboard boxes	499.4	544.1	526.2
2653	Corrugated & solid fiber boxes	17,140.7	18,082.0	17,668.9
2655	Fiber cans, drums, and similar products	1,578.7	1,734.5	1,776.5
2656	Sanitary food containers	2,043.8	2,241.2	2,406.8
2657	Folding paperboard boxes	5,878.8	6,576.9	6,808.5
2672	Paper coated & laminated, n.e.c.	5,939.2	6,343.1	6,380.3
2673	Bags: plastics, laminated, coated	4,748.0	5,288.3	5,242.8
2674	Bags: uncoated paper, multiwall	2,601.8	2,663.0	2,641.3
2676	Sanitary paper products	11,913.4	13,438.2	13,647.5
2677	Envelopes	2,645.3	2,589.9	2,587.9
2678	Stationery products	1,172.3	1,139.0	1,176.5
2679	Converted paper products, n.e.c.	3,827.9	3,799.9	4,134.8
	TOTALS	172,590.3	181,870.4	181,585.6

[a]Domestic consumption is U.S. value of shipments minus exports plus imports.

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.

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

billion from 1990 to 1991. Book publishing represents the largest share of exports with $1.5 billion in 1991.

Tables 5-5 and 5-6 provide U.S. exports by trading partners for five industry groups related to printing and publishing. In 1990, the value of U.S. exports within SIC 27 was $3.1 billion with Canada and Mexico being the U.S.'s largest trading partner accounting for 50.9 percent of the total value of exports and the European community accounting for 19.3 percent. As expected for the commercial printing industry (SIC 275), Canada is the largest single country exporter to the U.S. with 27 percent of total value of exports (Table 5-6), while the European community as a whole represents a smaller export share with 22.8 percent (Table 5-5).

5.3 FUTURE PROJECTIONS

Table 5-8 presents a forecast of market trends in the U.S. printing industry for the years 1990 through 2000.[7] The table shows that growth in the industry is expected to be between 3.8 and 5.3 percent annually. Markets expected to 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.[8]

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.[9]

TABLE 5-8. 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.

1. U.S. Department of Commerce. 1991 Annual Survey of Manufactures. Value of Product Shipments. Washington, DC, U.S.G.P.O. 1992. Table 1. and U.S. Department of Commerce. 1987 Census of Manufactures. Industry Series: Commercial Printing and Manifold Business Forms. Washington, DC, U.S.G.P.O. 1990. Table 6a.

2. U.S. Department of Commerce. 1991 Annual Survey of Manufactures. Value of Product Shipments. Washington, DC, U.S.G.P.O. 1992. Table 1.

3. Ref. 2.

4. U.S. Department of Commerce. U.S. Industrial Outlook, 1992. Washington, DC, U.S.G.P.O. 1992. Chapters 10 and 25.

5. U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics. May 1992. Use Cluster Analysis of the Printing Industry. Washington, DC. Table 7. and U.S. Department of Commerce. U.S. Industrial Outlook, 1992. Washington, DC, U.S.G.P.O. 1992. p. 10-3.

6. U.S. Department of Commerce. U.S. Industrial Outlook, 1992. Washington, DC, U.S.G.P.O. 1992. Chapters 10 and 25. and U.S. Departement of Commerce. 1991 Annual Survey of Manufactures. Value of Product Shipments. Washington, DC, U.S.G.P.O. 1992. Table 1.

7. 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.

8. U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics. May 1992. Use Cluster Analysis of the Printing Industry. Washington, DC. p. 28.

9. Ref. 8., p. 26.

APPENDIX A
OWNERSHIP CHARACTERISTICS

This appendix contains a detailed characterization of the three types of ownership:

- sole partnerships,
- partnerships, and
- corporations.

The advantages and disadvantages are presented in table format.

A.1 SOLE PROPRIETORSHIPS

Legally, the individual and the proprietorship are the same entity. From a legal standpoint, personal and business debt are not distinguishable. From an accounting standpoint, however, the firm may have its own financial statements that reflect only the assets, liabilities, revenues, costs, and taxes of the firm, aside from those of the individual.

When a lender lends money to a proprietorship, the proprietor's signature obligates him or her personally of all of his/her assets. A lender's assessment of the likelihood of repayment based on the firm and the personal financial status of the borrower is considered legal and sound lending practice because they are legally one-and-the-same. Table A-1 highlights the advantages and disadvantages of this ownership type.

TABLE A-1. ADVANTAGES AND DISADVANTAGES OF THE SOLE PROPRIETORSHIP

Advantages	Disadvantages
Simplicity of organization	Owner's possible lack of ability and experience
Owner's freedom to make all decisions	Limited opportunity for employees
Owner's enjoyment of all profits	Difficulty in raising capital
Minimum legal restrictions	Limited life of the firm
Ease of discontinuance	Unlimited liability of proprietor
Tax advantage	

Note: A brief evaluation of these advantages and disadvantages is available in Steinhoff and Burgess (1989).

Source: Steinhoff, D., and J.F. Burgess. Small Business Management Fundamentals. 5th ed. New York, McGraw-Hill Book Company. 1989.

A.2 PARTNERSHIPS

A partnership is an association of two or more persons to operate a business. In the absence of a specific agreement, partnerships mean that each partner has an equal voice in management and an equal right to profits, regardless of the amount of capital each contributes. A partnership pays no federal income tax; all tax liabilities are passed through to the individuals and are reflected on individual tax returns. Each partner is fully liable for all debts and obligations of the partnership. Thus, many of the qualifications and complications present in analyses of proprietorships (e.g., capital availability) are present--in some sense magnified--in analyses of partnerships. Table A-2 lists the advantages and disadvantages of this ownership type.

TABLE A-2. ADVANTAGES AND DISADVANTAGES OF THE PARTNERSHIP

Advantages	Disadvantages
Ease of organization	Unlimited liability
Combined talents, judgement, and skills	Limited life
Larger capital available to the firm	Divided authority
Definite legal status of the firm	Danger of disagreement
Tax advantages	

Note: A brief evaluation of these advantages and disadvantages is available in Steinhoff and Burgess (1989).

Source: Steinhoff, D., and J.F. Burgess. Small Business Management Fundamentals. 5th Ed. New York, McGraw-Hill Book Company. 1989.

A.3 CORPORATIONS

Unlike proprietorships and partnerships, a corporation is a legal entity separate and apart from its owners or founders. Financial gains from profits and financial losses are borne by owners in proportion to their investment in the corporation. Analysis of credit availability to a corporation must recognize at least two features of corporations. First, they have the legal ability to raise needed funds by issuing new stock. Second, institutional lenders (banks) to corporations assess credit worthiness solely on the basis of the financial health of the corporation--not the financial health of its owners. A qualification of note is that lenders can require (as a loan condition) owners to agree to separate contracts obligating them personally to repay loans. Table A-3 highlights the advantages and disadvantages of this ownership type.

TABLE A-3. ADVANTAGES AND DISADVANTAGES OF THE CORPORATION

Advantages	Disadvantages
Limited liability to stockholders	Government regulation
Perpetual life of the firm	Expense of organization
Ease of transferring ownership	Capital stock tax
Ease of expansion	
Applicability for both large and small firms	

Note: A brief evaluation of these advantages and disadvantages is available in Steinhoff and Burgess (1989).

Source: Steinhoff, D., and J.F. Burgess. Small Business Management Fundamentals. 5th Ed. New York, McGraw-Hill Book Company. 1989.