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What is print? A Characterization of the printing industry in the United States

Printing Industry Center (CIAS)

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A Publication of the

Printing Industry Center at RIT

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Introduction

Print touches our lives constantly in the form of product packaging, books, newspapers, magazines, mail, or any of the wide variety of printed items we use every day. We consume it without even thinking about it. To treat printing as a stand-alone product, service, or process is impossible. It is a manufacturing industry in the strictest sense, but it is also a service industry. There are a number of other industries and services intertwined with printing, such as paper manufacturing, ink manufacturing, equipment manufacturing, print finishing, graphic design, marketing, distribution, mailing, and fulfillment services.

This report will briefly touch on these ancillary industries as needed, but is not an exhaustive discussion of the relationships (be they financial, historical, or physical) between all of these and the printing industry. Instead, this report is intended to be an introduction to printing and its many facets. References, an appendix on the history of the industry, and a suggested reading list have been provided for further study. You can find further information online at the Printing Industry Center's website: **print.rit.edu**.

Range of Products & Services

Printing as a method of production cannot be considered as a standalone process. It is linked to the other processes within the value chain of print media production. All of these processes are interdependent, and they often depend on each other to create added value and revenues, as shown in Figure 1.

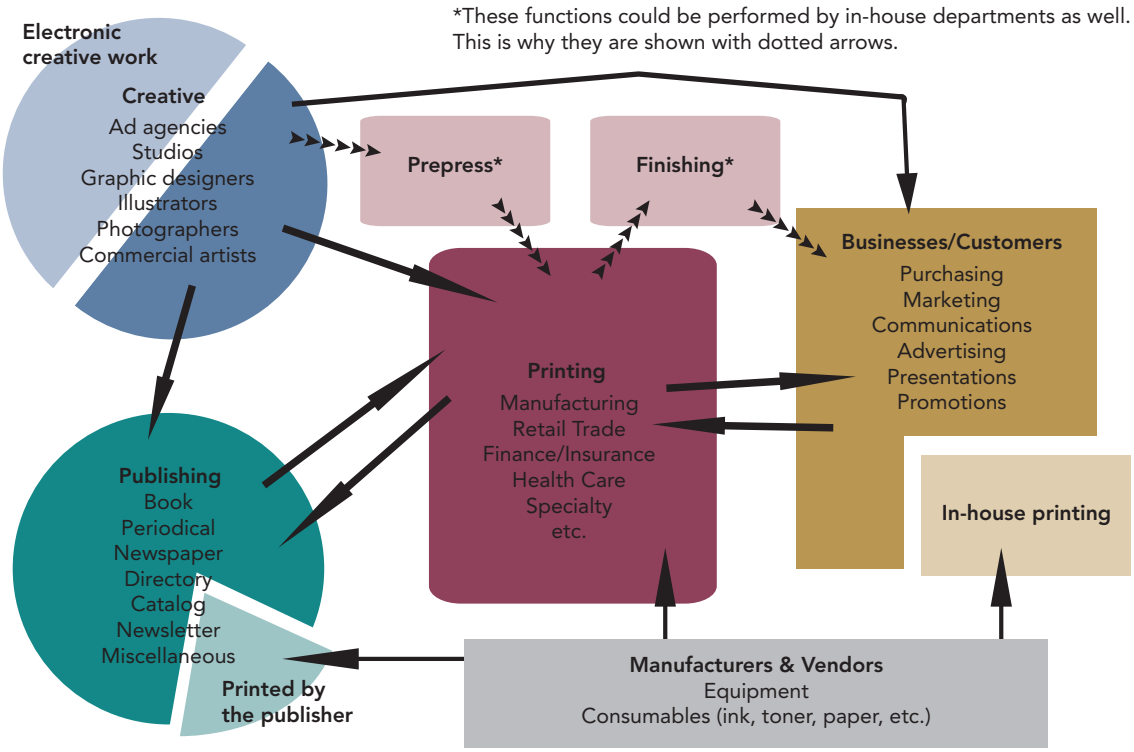

Figure 1. Interdependent value chain activities (Adapted from Romano, 2001.)

Printed products can be viewed in the same manner. These products are often linked to other goods and/or services, and may not be viewed as innately valuable to the final consumer. Oftentimes, the products that incorporate print as a prominent feature are characterized as the product of the printing industry even though the print production itself was only one stage in the process of producing the finished product. The various classes of printed goods and some examples from each category are shown in Figures 2 and 3.

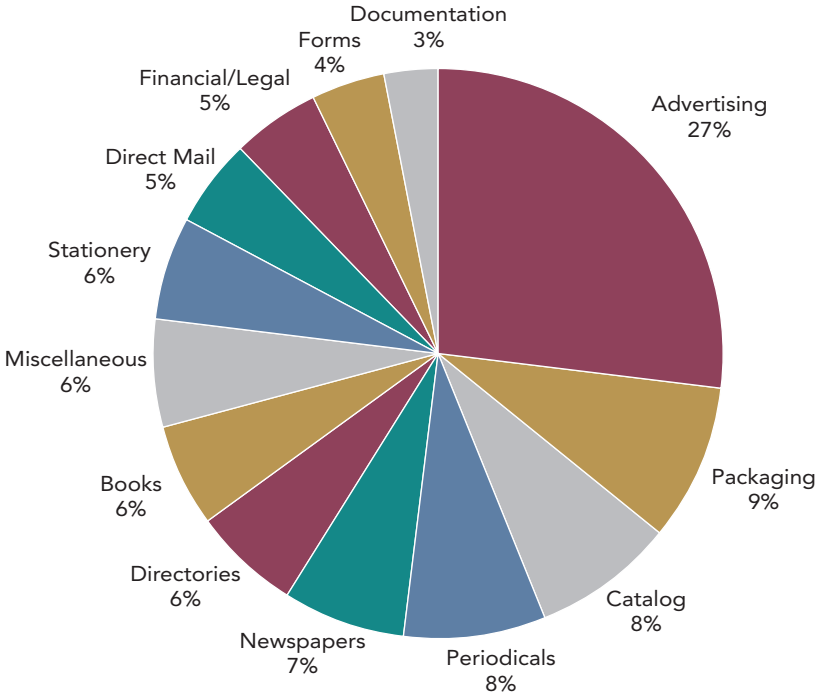

Figure 2. Categories of print products (Romano, 2007)

Books
- Soft cover
- Hard cover
- Specialty

Periodicals
- Magazines
- Journals
- Newsletters
- Reprint/Preprint
- Reply cards

Catalogs
- Consumer
- Business
- Other

Newspapers
- Daily
- Weekly
- Other

Directories
- White Pages
- Yellow Pages
- Parts/Price Lists
- Other

Direct Mail
- Postcards
- Self Mailers
- Booklets
- Envelope Mail
- Coupons

Promotional
- Flyers
- Brochures
- Booklets
- Circulars
- Ad Inserts

Technical Documentation
- Manuals
- Guides
- Tech Bulletins
- Instructions

Legal-Financial
- Annual/Quarterly Reports
- Transactional Statements
- Transactional Promotions
- Legal Reports
- IPOs
- Other

Packaging
- Cans, Bottles, Caps, Lids
- Labels, Tags
- Folding Cartons
- Flexible Packaging
- Bags, Multiwall Sacks, Pouches
- Corrugated Cartons
- Test Packaging

Electronic
- Circuitry, Boards
- RFID, MEMS
- LED/OLED Displays
- Bio-chemical Sensors
- Membrane Switches

Office Communications
- Reports
- Presentations
- Forms
- Other

Stationery
- Envelopes
- Business Cards
- Social Stationery

Display/Signage
- Signage
- Point-of-purchase (POP) Displays
- Fleet Graphics
- Posters
- Banners/Billboards
- Building/Vehicle Wraps
- Awnings
- Nameplates

Textiles
- Apparel
- Ties, Scarves
- Smart Clothing
- Wall Coverings
- Upholstered Furniture

Food/Medical
- Drug Delivery
- Food
- Cell Printing

Imagery
- Art Reproduction
- Photo Printing

Home/Office
- Shower Curtains
- Venetian Blinds
- Ceiling Tiles
- Floor Coverings

Manufacturing
- Components
- Wires & Cables
- 3-D Prototypes

Decoration/Coating
- Caskets
- Ceramics
- Foil/Metal
- Glass
- Leather

Security
- Cards
- Smart IDs
- Passports

Miscellaneous
- Greeting Cards
- Wrapping Paper
- Wall Paper, Pool Liners
- Calendars, Maps
- Playing Cards
- Currency, Stamps
- Smart Media/Audio Paper
- Flip Flops
- Binders, Notebooks
- Lottery Tickets
- CDs/DVDs, Buttons, Balls
- Toys, Games, Pens/Pencils
- Lenticular Imaging

Figure 3. Examples of print products (Adapted from Romano, 2007)

Measuring the Industry

There are many associations that produce annual and quarterly measurements of the printing industry, and this report should not be considered as definitive in regards to measuring the industry. Although many of these measures are similar, there are often variances in the results. This is generally dependent on what codes are used to define an industry segment, what types of segments are defined and measured, and how the numbers have been calculated.

The printing industry is hard to measure because of the problems that arise when one tries to define a "printing company." Today's printers may offer a variety of services beyond putting ink on paper, ranging from website design to marketing communication campaign management. For some, revenue from these services may outweigh the revenue they actually obtain from print, although print may have been their core business in the past. It also becomes difficult to effectively measure the printing industry when considering other companies whom offer printing or reproduction services such as office superstores (i.e. Staples, OfficeMax, Office Depot and the like). The revenues these companies obtain from the printing services they offer should still be counted within industry revenues, but it can be hard to differentiate which revenue is obtained from those services. The same is true for companies who offer ancillary services to print.

The change from SIC to NAICS codes in 1997 has also had an effect on industry measurements. Throughout the 1930s, printing and publishing activities were shown together. Under NAICS, book and newspaper publishing are now shown under the Information Sector, separated from print due to the changes in publishing that have led to a division of the processes. Additionally, publishing today may be in both print and electronic formats, which is primarily the management of information content as opposed to print manufacturing.

NAICS also changed the scope of classifications. Under SIC 27, there were nine classifications; under NAICS 323, there are twelve. NAICS is inclusive of all the previous classifications, and also includes some percentage of other classifications that are relevant, specifically, automotive and apparel trimmings (textile products) and greeting cards publishing. This allows for a better understanding of what print output is actually produced within the United States.

However, one classification that was and is not covered under either system is *secondary production*. This term refers to the fact that other industries will sometimes produce their own printed output rather than purchase it from the printing industry. The secondary production of commercial print by another industry is more likely to be left out of the tracking measures for the print industry when that industry has many of the same input requirements that are of importance to the commercial printing industry. Proxy measures can be used to estimate this output, but the estimate may not fully capture all of the printed output that is actually produced within the United States.

One of the organizations that measures and publishes printing industry data is PIA/GATF. The following table was published in the April 11, 2006 "Economic & Print Market Flash Report," and contains information on aggregate numbers for the seventeen market segments covered by PIA/GATF. This gives a good understanding as to the number of printing establishments, the number of workers employed, and the size of industry output (measured as the dollar value of shipments) in 2005 for the United States.

Table 1. Printing industry segment data (Davis, 2006. Reprinted with permission.)

Segment	Establishments	Employment	Shipments ($M)
Commercial Printing			
General Commercial Printing	17,527	356,397	$50,615.8
Quick Printing	5,883	45,870	$4,623.4
Magazine Printing	226	35,085	$6,014.8
Newspaper Printing	4,897	208,190	$35,915.0
Book Printing	295	51,963	$7,073.4
Financial, Legal Printing	137	11,273	$1,836.5
Screen Printing	1,030	23,711	$3,403.3
Thermography	224	6,809	$971.5
Total	30,219	739,298	$110,453.7
Form, Label, & Tag Printing			
Business Forms Printing	558	35,640	$4,629.4
Label, Wrapper Printing	709	32,620	$6,207.6
Tag, Ticket, Tape Printing	124	5,765	$924.9
Total	1,391	74,025	$11,761.9
Greeting Card Printing			
Total	39	3,632	$562.9
Specialty Printing			
Total	821	40,174	$6,261.5
Packaging Printing			
Total	1,436	137,756	$27,105.8
Trade Services			
Prepress Services	4,251	56,395	$6,798.5
Trade Binding	574	16,497	$1,315.5
Other Finishing Services	656	15,595	$1,216.6
Total	5,481	88,488	$9,330.6
TOTAL U.S. PRINTING	**39,387**	**1,083,373**	**$165,476.4**

As can be seen from this data, the printing industry produces approximately $165 billion dollars worth of goods and services each year. It employs over one million people in 39,387 establishments. However, this number shrank from 42,976 plants in 2004, indicating further consolidation and plant closings.

Eleven of the seventeen print markets had increased shipment values for 2005, which resulted in an overall increase of $4.4 billion (about 2.8%). The segments with decreased shipment values were financial and legal printing, business forms printing, greeting card printing, and all three trade services segments (prepress services, trade binding, and other finishing services). Overall employment declined by approximately 3,000 people, which is the smallest decline out of the past four years of declining employment. Only six market segments saw an increase in employment — newspaper printing, thermography, label and wrapper printing, tag, ticket, and tape printing, specialty printing, and packaging printing — which the rest saw a decrease in employment.

Current State

The printing industry is experiencing forces that have affected or begun to affect many mature industries within the United States. These trends include consolidation, decreased employment, rapid technological change, increased competition, geographic displacement, and increased buyer power. Each of these trends is discussed further below:

Consolidation

Before the beginning of the digital age, the industry was largely a collection of tens of thousands of small companies serving local markets. Today, the industry is increasingly dominated by a smaller number of larger companies serving broader geographic markets. Figure 4 below gives a visual description of this phenomenon. In ten years, the printing industry will likely consist of a handful of multinationals that account for most of the industry's global revenues, and a diverse selection of smaller companies that serve highly specialized vertical niches. In the case of the latter, we may not even think of them as part of the printing industry, but as unique business categories unto themselves.

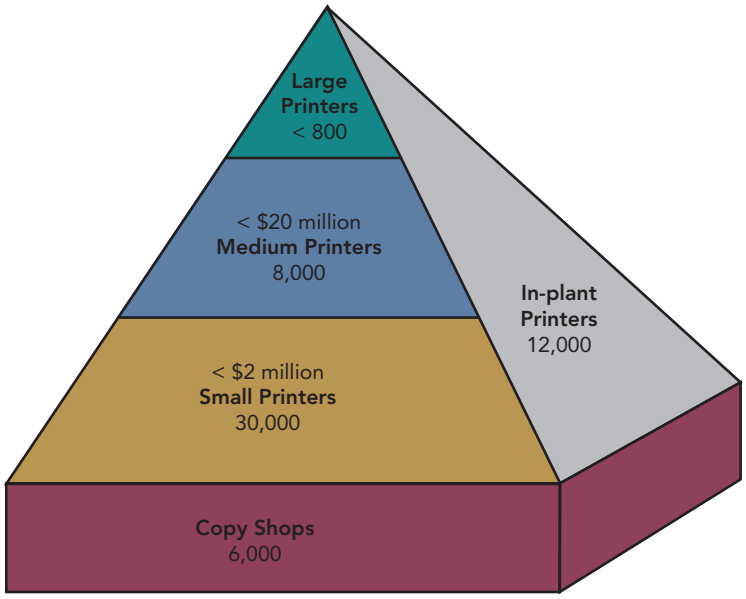

Figure 4. A pyramid of firms (Romano, 2007)

Decreased Employment

In 2000, the U.S. printing industry employed more than 1.2 million workers. Today, that number has decreased by almost 200,000. Most of the decreases in employment can be accounted for by the increasing amount of automation present on printing presses and other printing equipment that traditionally had to be run by hand.

Some of these decreases are also due to retirement. PIA/GATF estimates that approximately 60,000 workers are needed each year to replace retirees at the current levels of

industry employment. However, many companies have been having trouble finding qualified, trained workers to replace their retirees. One of the major discussion points among industry collaborators currently is the issue of decreased enrollment in printing programs at colleges and other institutions across the country. Now that graphic design and other computer-based fields of study have become more popular, many "graphic arts" programs at high schools have been shut down due to a lack of participation.

Printing employment has also decreased because of two other trends: consolidation and geographic displacement. Industry consolidation has resulted in fewer, larger companies who benefit from economies of scale, as the newer presses and equipment tend to need less people to run them overall. By consolidating two printing plants into one, printing companies can employ less people in one facility and still reach higher productivity than was previously possible with older technology. Geographic displacement (also called offshoring) has become more of an issue as printing companies in other countries increased their product quality and production standards. This causes some jobs to be sent overseas, even though the costs of shipping the finished pieces back to the U.S. can be prohibitively high in certain situations.

Rapid Technological Change

Changes in technology have occurred at all points of the printing process. New processes and types of equipment have emerged and replaced the prevalent technologies almost completely. (See Appendix A for more on the history of printing technologies.) Today's printer has multiple technologies available to use when creating an image, printing a job, and finishing a job.

Future changes in communication technology, reproduction technology, and display technology, in addition to the changing preferences of consumers, will all impact the printing industry. The question to be answered is how printers will respond to these changes. Looking back to the advent of digital printing, many printers held back from purchasing or fully implementing this type of technology within their organization. It remains to be seen whether or not printers will respond in the same way to new technologies, or if instead they will embrace new technologies in order to provide more value to their customers.

Increased Competition

Commercial printing used to be a specialized field, where printers were easily distinguishable from other types of businesses because of the equipment they used and the skills they possessed. With the technological advances that have impacted the industry, this is no longer the case. Today sign shops, photographic services, industrial printers, specialty printers, package printers, converters, newspapers, pre-media services, in-plant shops, quick printers, binders/mailers, and copy shops are all competing with "traditional" commercial printers for the same work.

Geographic Displacement (Offshoring)

Although offshoring is a concern for many U.S. manufacturing industries, research conducted on this topic has revealed that offshoring has not yet had as strong of an impact on the printing industry. Printing worldwide is estimated at $600 billion, and the U.S. holds about 28% of that total (Rothenberg, Tang, & Hira, 2007). However, the amount of print trade the U.S. conducts is miniscule in comparison, with a total export value of about $5.2 billion (3.15% of total U.S. print value) and an import value of $4.7 billion (2.85% of total U.S. print value). The total decrease in the trade balance surplus since 2000 has been about $500 million dollars, which is equivalent to a decrease of 0.3% in terms of current total U.S. print value (Rothenberg, Tang, and Hira, 2007). One exception to this trend is trade with China, where U.S. print imports have been increasing at approximately 26% a year, resulting in a trade deficit of about $380 million (Rothenberg, Tang, and Hira, 2007).

However, many printers view offshoring as a threat to their business. Although there has not been a severe change in the trade balance of print, there may be some harder to measure changes that justify this point of view. One such measure is the amount of print that is moving closer to the end destination, such as printing marketing materials in China that will be used in Asia-Pacific markets. This would not be accounted for in the trade balance because it does not represent an increase or decrease in imports or exports. Instead, it represents a lost revenue opportunity for U.S. printers who do not have a global reach. In the study by Rothenberg, Tang, and Hira (2007), they noted that 49% of their survey respondents reported losing a job to foreign competition. Of these, 34% reporting that lower cost was the determining factor, while 7.7% reported that the customer's work was moving overseas.

Overall, it seems that the real issue is that most U.S. printing companies do not have a global reach in terms of locations, customers, or suppliers. Now that the industry has been forced to look outside its own borders, perhaps such needed changes will occur before the impacts of offshoring increase.

Increased Buyer Power

The increased transparency of print purchasing, as made possible through the Internet, has given more power to print buyers. The ability to obtain quotes from multiple vendors at the same time has commoditized printing so that no printer can maintain margins above those of market prices. Additionally, the increased competition for customers has also given more power to buyers, as there are more companies looking to land the same job(s) within a market.

Worldwide communication has also made business models such as that of Vistaprint possible and profitable. Print buyers are willing to wait longer for their jobs if they think they are getting a better price. They are also willing to pay shipping costs, which allows the job to be printed in other cities, states, countries, or continents. This further

increases the power of buyers, as they now have more options for suppliers on a regional, national, and global scale.

Migration to Other Media

Today, print has more substitutes than ever before. The increasing utilization of the Internet as a medium of communication has decreased the amount of print being used for directories, publications like newspapers, and advertising.. Although industry shipment values are increasing, this does not necessarily reflect an increase in volume.. Newspapers and other "traditional" printed publications are now being offered in electronic formats. In some cases, new publications are only offered online, thereby sidestepping the production and delivery costs associated with traditional publications.

Books and catalogs are other categories of print where electronic substitution has become a viable option. More catalogs are now offered entirely online. Textbooks often exist in both digital and print formats, although many may migrate to online-only formats. E-books were supposed to be the wave of the future when the first prototypes appeared. Today, these have not become nearly as popular as promised, but new developments in display technologies may allow the creation of devices that are as flexible and portable as a paperback book.

Print must learn how to complement these other media. Marketing campaigns that are delivered via e-mail, text or SMS messages, PURLs, and other digital means can be enhanced by the use of print as a component at certain stage(s) of the process. Research continues to be conducted on the effectiveness of print as a marketing communication tool — see a summary in "The Case for Print Media Advertising in the Internet Age" (PICRM-2006-02) available at **print.rit.edu**. However, the question is what value does the printed form of the information provide over and above the content (which can be delivered electronically)? Printers will have to learn how to work closely with their customers to answer these questions so that the maximum impact of the printed product is achieved.

Challenges & Opportunities

The greatest challenge in the next decade for the large multinational printing companies will be to continue to improve the value of print so that customers will continue to favor its use. There are still significant opportunities to reduce costs in the manufacturing process. However, the industry is already experiencing diminishing returns on these efforts. Far greater opportunities lie in improving the probability that each printed piece reaches its intended mark and exerts its intended influence.

Today, a large percentage of printed products, whether distributed through retail channels, through the postal channel, or as newspaper inserts, are consigned to the landfill without ever having reached their intended audience. Reaching current and potential customers is an issue for all companies, everywhere. Print is one vehicle of communication, but there are many others that can be utilized as well. These competing media will likely drive down the volume of print that is produced in the future.

Future communications will continue to migrate to cross-media platforms, and the use of web-centric, integrated services will abound. The use of automation, distributed printing, and digital printing will continue to increase. Printers can offer more of these services, thereby increasing the value they provide their customers. It is likely that the printing industry will change from being viewed as a manufacturing-based industry to being viewed as a service industry. This paradigm shift is beginning to occur today.

Another important pathway to increasing the value of print to its users is improving its ease of use. Today, commercial print production and distribution services are still very difficult to buy. As a result, print users spend a lot of money on the buying process. Printing companies also spend a lot of money on the selling process. In the next decade much of this cost must be eliminated. Rapidly multiplying legions of potential print buyers now have at their fingertips powerful computers, intelligent graphic design tools, advanced database technologies, and high-speed Internet connections. They should be able to use these capabilities to purchase commercial print services over the Internet and connect with their audiences easily.

One final challenge is the aging of the industry's leaders and employees. As discussed previously, the printing industry's employment has decreased by almost 200,000 people over the past seven years. A certain percent of this decrease is due to retirees who were not replaced by new employees. Those employees were not replaced because of a lack of skilled, experienced press workers available for hire.

Overall, the printing industry is finding it difficult to persuade young people to pursue a career in printing. Many in the younger generation do not know about the opportunities that exist within the industry. Some of this is due to the connotation of "blue-collar" work, and some of it is due to a lack of education, training programs, and internships in local communities. Although scholarships abound for printing students, many of these

are awarded to design students and students in other fields of study related to graphic communications. Currently, the industry is seeking ways to change this trend, but it will be hard to overcome this obstacle without a combined effort that incorporates businesses, schools, and industry organizations.

Printing in 2012

A five-year forecast for the printing industry reveals the expectation of modest revenue growth at an average rate of 2 to 3% (Davis, 2007). However, there are many external factors that can change this prediction, as with any forecast dealing with economic change. One such factor is inflation, which impacts the real growth and increase in revenues that printers can expect to receive.

Digital printing and other ancillary services will grow at above-average rates, following the current trend (Davis, 2007). This is due to the fact that sales within each sector increasingly come from the use of these services.

Table 2. Five-year outlook data
(Adapted from Davis, 2007. Reprinted with permission.)

Category	Average Annual Rates of Change
Ink-on-paper print growth	1.0 - 1.5 %
Digital printing growth	3.5 - 4.0 %
Printer's ancillary services	3.0 - 3.5%
Market Sector	**Average Annual Change in Revenues**
Direct Marketing Printing	2.5 - 3.5 %
Labels/Wrappers Printing	2.0 - 3.0 %
Packaging	2.0 - 3.0 %
Catalog Printing	1.5 - 2.5 %
General Commercial/Quick Printing	1.5 - 2.0 %
Book Printing	1.0 - 2.0 %
Periodical/Magazine Printing	1.0 %
Directories Printing	< 1.0 %
Business Forms Printing*	(2.0) - (3.0) %

**Negative changes are shown in parentheses.*

These predicted changes will lead to overall industry shipments (based on 2005 figures) of approximately $1.9 - $2.03 billion in 2012. However, it is important to note that these figures only represent the value of printing shipments, and do not represent inherent increases or decreases in printing volumes.

Conclusion

Print will persist in the foreseeable future. As a medium of communication, as a tool for protecting goods, as an art form, it is both necessary and beloved. The history of print, of books, and of printed objects will continue to educate and intrigue new generations of learners. On the other hand, questions arise as to who will still teach them and whether or not the industry can continue to attract new talent.

There are many challenges that face the industry, both in the short- and long-term. These are shown in the trends that have affected and continue to affect the industry, in the changes of industry demographics, and in the continuous emergence of technologies. Print's long and illustrious history tells us that printing will remain. However, the form in which it will remain, the size of the industry, and the types of output that will be produced are all things that no one can precisely predict.

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Appendix A: History & Technologies

History

The printing industry arose around a set of technological inventions of Johannes Gutenberg in Germany in the middle of the fifteenth century. These included a casting process for producing individual metal types, a system for assembling these into page forms, and a press that enabled the forms to be used to produce multiple printed copies of the pages. Prior to this invention, most books and printed pieces were created or copied by hand. Gutenberg's invention made it possible to produce multiple copies of the same page, poster, or pamphlet more cost-effectively and in less time. Print became the sole medium of mass communication, until more than four hundred years later when the radio was patented by both Tesla and Marconi.

Letterpress remained the dominant printing process until the middle of the 20th century, when it was almost all but replaced by offset lithography. However, letterpress is still used today for niche applications, mostly in the packaging and label markets, as well as for specialty stationery items such as wedding invitations. Working handpresses similar to Gutenberg's original invention are on display at the Cary Collection within the Wallace Library at the Rochester Institute of Technology (**wally.rit.edu/cary/**).

New Technologies

Many technologies have had impacts on the printing industry. It is not possible to discuss them all in this report, so we will cover those that have been the most vital in bringing about change. An excellent publication for further learning is the research monograph titled "An Investigation Into Printing Industry Trends," published in October of 2004 by the Printing Industry Center (**print.rit.edu**).

The invention of the personal computer and the desktop printer made "desktop publishing" possible, and reduced the dependence of the user on mechanical printing processes for production of documents. Today, we can fill out forms online or in word processing software. Prior to computers, commercial printers printed forms on carbon paper and other substrates and sold them by the box to companies who had manual filing systems. The availability of computer technology has also resulted in many changes regarding the media segment of the printing industry, where the creation of plates was for many years a manual and time-intensive process using films and chemicals to lay out entire print jobs by hand. Today, computer-to-plate technologies are available that create custom tooling for the manufacturing process in an automated fashion, with the exception of digital printing.

The invention of digital printing and the introduction of the first high-speed production systems such as the Xerox DocuTech digital printer in 1990, has greatly impacted the

industry. The ability to send digital files to a production-quality device changed the way the world viewed printing. Short print runs, which previously were prohibitively expensive due to the set-up time needed for conventional print manufacturing, were now possible. Variable data printing (VDP) also became possible with the advent of database software that created new digital images each time the printing device was ready to make a new impression. Print became more accessible, less technical, and more transparent as a process.

With the commercial advent of the World Wide Web in 1995, many more advances became possible. The Internet became a competitor to print in many ways, but it also provided new opportunities that were not possible previously.

Web-to-print combines the ideas of soft proofing (seeing a print preview on the computer screen) and integration of the customer and manufacturing workflows. Distribute-and-print reflects the idea that one document can be distributed to various production facilities in order to be produced as close to the end consumer as possible. This can be accomplished at the same time in multiple locations around a region, a nation, or the globe so as to improve delivery time, delivery cost, and logistics. Print-on-demand reflects a desire for decreased waste (and a decrease of the associated costs of waste), as well as a desire for on-time production and delivery as needed (a reflection of the just-in-time philosophy of manufacturing pioneered by Toyota). Online ordering and worldwide communication and delivery capabilities have made this possible.

Emerging technologies range from e-paper, e-ink, and circuit printing to three-dimensional printing. All of these will impact the printing industry in the future, although it is impossible to truly predict to what extent the effects will be felt. As has been shown in recent history, companies that are willing to change with the times and offer technologies that provide real value to their customers are more likely to survive. However, not all technologies provide value to all customers. Not all customers can benefit from VDP or print-on-demand, although many of them can if they are educated as to the benefits for their specific application or business.

Printing Processes Today

Today, there are five categories of printing used commercially:

- Relief printing
- Gravure
- Lithography
- Screen printing
- Digital printing

Relief Printing

Relief printing is printing from a raised surface. There are two basic forms: *flexography* and *letterpress*. *Flexography* uses soft rubber-like printing plates and thin fluid ink to print on continuous rolls of paper or plastic substrates. This technology is especially suitable for packaging printing, and most of the flexible packaging materials you find in your local supermarket are printed this way. *Letterpress* uses raised metal type or plates in conjunction with thick, paste-like ink to create "relief" impressions on paper.

Gravure

Gravure originates from a long line of engraving printing technologies that began during the Renaissance, which are known as *copper engraving* or *intaglio* processes and were used for the reproduction of images. This process uses cylinders made of steel with a thin layer of copper electroplated on the surface. The copper layer is engraved on special computer-controlled engraving machines that cut millions of microscopic cells into the polished copper surface. Once mounted on a press, the cells are filled with ink from a pan held below the cylinder on the press. A sharp steel blade is scraped across the surface of the cylinder to remove ink from outside of the image area, and then the cylinder is impressed against a substrate to transfer the ink. Possible substrates include paper, packaging materials, simulated wood grains, vinyl floor coverings, wallpaper, and other materials used in the manufacture of decorated surfaces. Gravure is an expensive process due to the large cylinders and the cost of engraving, so it is generally used for extremely long print runs.

Lithography

Lithography literally means "stone writing." This process was invented by Alois Senefelder more than 200 years ago, who discovered that wetting the non-image areas of a smooth piece of limestone with water allowed him to control where the oil-based ink remained. Today, the most common process is called *offset lithography*, and although the basic principle of "oil and water don't mix" remains the same, the process is accomplished through the use of flexible metal or plastic plates that are rolled across a *blanket* roll (a soft smooth rubberized cylinder). The plate transfers the inked image to the blanket, and the blanket is then used to transfer the ink to the final substrate. The major benefit of the blanket is that it permits the use of right-reading plates, which initially was beneficial for proofreading purposes.

Screen Printing

Screen printing is a form of stencil printing where the stencil is supported by a fabric, plastic, or metal screen mesh through which the ink is pushed onto the print medium. The process was traditionally called "silk screening" because silk fabric was used as a support for the stencils. Today's screen printing presses use screens made of synthetic fabrics or metal, and the screens can be either flat or cylindrical. One of the differentiating characteristics of this process is its ability to apply an extremely thick layer

of material to a surface. Since other printing processes cannot supply this capability, screen printing units are sometimes integrated into flexographic or electrophotographic presses, where they are used to apply thick layers of varnish, ink, or adhesives.

Digital Printing

There are only two fundamental ways to form an image digitally: with a computer-controlled energy source (light or electric current) or with a computer-controlled device that selectively applies ink directly to a surface. Energy-writing digital printing processes include *electrophotography* (also known as *xerography*), *electrography*, *thermal printing*, and *laser ablation*. Material-writing digital printing processes include *thermal transfer* and *inkjet*. Each of these technologies is briefly described below:

- ***Electrophotography*** – Uses computer-controlled lasers or LEDs to create an electrically charged image on a photoconductive imaging surface. Oppositely charged ink or toner is then attracted to the image and sticks to the photoconductor, where it is transferred to a substrate and then fused with heat.
- ***Electrography*** – Uses dielectric materials to hold and transfer an image. Most suitable for use in large outdoor displays, as it lacks the precision of laser technologies.
- ***Thermal printing*** – Uses computer-controlled arrays of heating elements to selectively apply heat to a surface to cause a chemical change that yields a visible image. Often used in fax machines and receipt and barcode printers.
- ***Laser ablation*** – Uses powerful lasers to selectively burn (ablate) material from a surface. Most often used to image printing plates for lithography, flexography, or gravure.
- ***Thermal transfer*** – Uses computer-controlled arrays of heating elements to selectively apply heat to a surface to physically transfer colored materials from a ribbon to a receiver, such as in dye sublimation photo printers.
- ***Inkjet*** – Uses a print head with hundreds or thousands of microscopic nozzles that can all be controlled independently. Each nozzle is supplied by an ink chamber that can be made to eject the ink mechanically when commanded to do so by the computer. Various kinds of inkjet printing devices exist, which are called *drop-on-demand*, *piezo*, *continuous*, and *bubble jet*.

Inks

Color is not treated the same in printing as it is in other methods of reproduction, such as painting. When reproducing images using a printing process, most processes use separate plates for each of the four colors that are imposed over each other to create an image. The four colors are **Cyan**, **Magenta**, **Yellow**, and **blacK** (otherwise known as **CMYK**). These colors are most often laid down in dots, but the specific shape of the dot depends on the printing process used and on the type of screening used to create the

plate. When multiple colors are printed in dots close to each other, your eye blurs them together and creates a new color, which is the essential reason as to why printing works.

Each of the processes discussed previously uses a different kind of ink to produce a printed piece. Letterpress uses thick, pasty inks similar in texture to oil paint. Flexography uses thinner, more fluid inks. Gravure uses inks with high levels of solvent, which are more easily transferred from cell to paper at the high speeds used in this process. Lithography uses oil-based inks that are more fluid than letterpress but thicker than flexographic inks. Screen printing uses thick inks, although many of these are polymer-based depending on the substrate to be imaged. Digital printing has two main types of "ink" used: inkjet inks, which are primarily dye-based and fluid (although new formulations are emerging which are based on pigments), and toner technologies, which use plastics and pigments to create a vehicle that sticks to paper via electrostatic attraction and is then fused (heated to a point where it melts and binds to the paper).

Printing is called a subtractive process due to the subtractive properties of CMYK (and other) inks. Subtraction occurs when light bounces off of a colored area on a page – all of the other colors of light within the spectrum are absorbed (subtracted), and the color reflected back to your eye is the color of the ink. In printing, CMYK are the four basic inks used to create other colors, but specific inks can be mixed to match a precise color. These inks are called *spot colors*. The most-used standards for creating spot colors are the swatches and specifications published by Pantone, which is why these colors are sometimes referred to as "Pantone colors." Spot colors are often used for matching colors in corporate logos or other color-specific graphics.

Substrates

The inks used and mechanical qualities of each printing process determine what substrate(s) can be used for printing. These range from papers of multiple varieties and thicknesses (coated, uncoated, glossy, textured, recycled, coated on one or both sides, etc.) to plastics and films of varying caliper and chemical compositions. However, there is one major difference between processes and presses that should be noted. This is the difference between printing on rolls of substrates (otherwise known as *webs*) and printing on previously cut sheets of substrates. *Web* presses vary in size (the width of the press generally determines the width of the web that can be printed), and can run at higher speeds than *sheet-fed* presses. This is due to the mechanical accoutrements needed to pass sheets from one part of the press to another. Webs can be run from spool to spool after the initial setup.

Appendix B: Suggested Reading

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