MEETING THE CHALLENGE:
U.S. INDUSTRY FACES THE 21ST CENTURY

THE CHEMICAL INDUSTRY

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Foreword

For more than a decade, there has been widespread and increasing concern over the ability of the United States to achieve sustained economic growth and long-term prosperity. Since 1980, successive Congresses and Presidents, in a bipartisan response, have introduced a wide range of programs and policies directed toward improving U.S. competitiveness. Such policies — whether focused on building a 21st-century infrastructure, stimulating technological innovation and commercialization, improving the business climate for investment and growth, emphasizing opportunities for education and training, or promoting trade — start with assumptions, often implicit, about the competitive position of U.S. industry.

The Office of Technology Policy commissioned the series, "Meeting the Challenge: U.S. Industry Faces the 21st Century," in order to solicit the view of different segments of the private sector concerning what policymakers should know about them — their strengths and weaknesses, opportunities and obstacles. Drawing principally from the experience and insight of the private sector, some 150 experts from over 30 organizations in industry, academia, and government have contributed to the drafting and review of the series. These studies provide a framework for government policy that explicitly reflects the concerns and perspectives of U.S. industry.

The subject of the first report in this series is the Chemical Industry. It was prepared under the auspices of the Chemical Manufacturers Association and was broadly reviewed within the industry. It discusses (1) the structure of the chemical industry; (2) the forces currently shaping the industry; (3) anticipated industry evolution over the next five to ten years; and (4) the major factors affecting the chemical industry's competitiveness. While there is a rich literature concerning the industry, this is the first collective effort by its members to describe its competitive status and the first time that so many different aspects of its posture have been treated together.

Several important insights emerge from this effort. First, it is clear that as the domestic and other developed markets mature, the chemical industry will find its greatest opportunities for growth in developing countries. While this outward focus will involve exporting, it will also make overseas investment increasingly important to the industry's profit base.

Second, to remain competitive in this global industry, chemical manufacturers must maintain a technological edge. Thus, the industry must continue to invest heavily in research and development.

Third, while most of the decisions that ultimately determine growth and profitability fall to individual firms, government policies will directly affect the U.S. chemical industry in several areas, including:

- lowering of trade barriers;
- access to, and protection for, investments in developing countries;
- protection of intellectual property; and
- maintenance of a climate conducive to innovation, including a strong U.S. R&D base.

The views expressed are those of the authors and reviewers, and not necessarily those of the Department of Commerce.

Graham R. Mitchell
Assistant Secretary of Commerce for Technology Policy

ACKNOWLEDGMENTS

As a part of the fact-finding process leading to the publication of this report, the Chemical Manufacturers Association (CMA) organized a roundtable discussion with representatives of the chemical industry. This discussion was held on July 25, 1995, in New York City.

The roundtable was chaired jointly by Commerce and CMA.

The cochairs were:

Mary L. Good, *Under Secretary of Commerce for Technology*
Allen J. Lenz, *Director of Economic Analysis, CMA*

The industry representatives in attendance were:

Harvey E. Bale, Jr., Ph.D., *Senior Vice President, International, PhRMA*
David J. Deutsch, *Chemical Bank*
Dr. J. Michael Fitzpatrick, *Vice President and Director, Corporation Research, Rohm and Haas Company*
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Frederick M. Peterson, *President, Probe Economics*
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Ronald M. Whitfield, *Vice President, Charles River Associates, Inc.*
Andrew Wood, *Deputy Editor, Chemical Week*

In addition, the following individuals generously contributed their knowledge and insights in the preparation of the report, under the leadership of Dr. Lenz:

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Ronald M. Whitfield, *Charles River Associates, Inc.*
Andrew Wood, *Chemical Week*

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Executive Summary

The Chemical Industry Today

The U.S. chemical industry is vital to the U.S. economy. It produces 1.9 percent of U.S. gross domestic product (GDP). It is the nation's number one exporter. It supplies more than $1 out of every $10 of U.S. exports and consistently runs large international trade surpluses. It is a high-tech, research and development (R&D) oriented industry that is awarded about one out of every eight U.S. patents. It employs over one million people at wages well above the U.S. manufacturing average, and it produces over 70,000 different products.

Most importantly, chemicals is a "keystone" industry — one critical to the global competitiveness of other U.S. industries. Because so many modern products depend on chemicals, the international competitiveness of other U.S. industries requires a high-tech, globally competitive U.S. chemical industry that can supply new products at prices that give U.S. producers an edge.

Globalization

Critical to the future competitiveness of the U.S. chemical industry will be its ability to maintain its technological edge. To do so it must continue and increase already high levels of investment in R&D and new plants and equipment (P&E). But in a seeming anomaly, maintaining the competitiveness of U.S.-based R&D and production will require that rising amounts — and rising portions — of U.S. chemical industry P&E investment go to foreign countries.

As the chemical markets throughout the developed world mature, developing countries offer the greatest growth opportunities for U.S. chemical companies. Foreign markets can be served either by exports or by investments in production facilities in these markets. Exports from the U.S. are likely to expand, but increased foreign investments will be vital to continued U.S. competitiveness in three key ways:

(1) Many important markets cannot be served adequately or competitively solely by exporting from the United States. To compete successfully in many foreign markets, companies often must now produce in those markets, a trend that is likely to increase.

(2) Producing some products in a foreign market opens the door to exporting other products to that market and so actually expands export opportunities.

(3) Ultimately, foreign production and sales expand total sales and profits, and hence, the base against which R&D and other fixed costs of U.S.-based companies can be amortized.

The tougher global competition that lies ahead need not signal either the demise or decline of U.S.-based chemicals R&D and production or a slippage in the U.S. industry's exports and trade surpluses.

Rather, a shift in the locus of chemical manufacturing may be the inevitable result of rising living standards and rapidly growing production and consumption of goods in many developing countries. Individual multinational companies will configure the amount and location of their production to global market conditions. In a world of increasing capital mobility, investment capital will flow to those locations that offer the most attractive investment opportunities. Continued globalization and expanding foreign demand offer many opportunities, but diversification of production and expanding global supplies signal a tougher, more competitive world for the U.S. chemical industry.

Internal and External Factors Affecting Competitiveness

Meeting the rising R&D and P&E investment needs of the future will require a chemical industry that is profitable and attractive to investors. While the industry's profitability will be determined primarily by individual company decisions, government decisions that influence the environment in which U.S. producers compete will also be increasingly critical to the industry's continued growth and competitiveness.

Individual companies' decisions, or internal factors, include growth strategies, costs of production, and the amounts, strategies, and locations of both P&E and R&D investments. External factors that affect the industry include:

- U.S. economic and trade policies;
- changing international political and economic conditions;
- export and investment access to foreign markets;

- global protection for intellectual property; and
- U.S. regulatory policies.

This report seeks to identify the most important of the many interacting factors that will determine the future competitiveness of U.S.-based chemicals R&D and production. To that end, it describes the contributions of the U.S. chemical industry to the U.S. economy, the structure and competitiveness of the industry, the key determinants of its current strength, and the factors most likely to determine its future performance.

I. Industry Condition

Structure and Characteristics of the Industry

The U.S. chemical industry is a vital element of the U.S. economy.[1] The chemical industry is:

- a "keystone" or enabling industry, critical to the global competitiveness of other U.S. industries;
- huge, high-tech, and dynamic;
- a large employer;
- a global industry; and
- capital-intensive and environmentally committed.

A Keystone Industry

The chemical industry is defined by Standard Industry Code (SIC) 28, Chemicals and Allied Products. Chemicals, as defined by SIC 28, is a broad, complex industry that produces over 70,000 different products.[2] These products range from the chemicals first derived from the initial processing of organic or inorganic raw materials — chemicals such as benzene, toluene, and chlorine that are vital to other production — to finished consumer products such as medicines, soap, and toothpaste that are seldom associated with the chemical industry. Production is thus very diverse. In volume terms, however, most of the industry's outputs are basic chemicals little known to consumers. For the most part, its

[1] For the purposes of this report, unless otherwise noted, the "U.S. chemical industry" refers to U.S.-based chemical research and development (R&D) and U.S.-based production of chemicals. Thus, all the R&D and production facilities located in the United States, regardless of the nationality of their ownership, are part of the U.S. chemical industry. The interests of U.S.-based R&D and production may differ from the interests of individual multinational companies that have foreign investments. The basic goal of multinational companies is maximizing global profits, not maximizing their contribution to the U.S. economy or the economy of any particular nation. But this report's focus on U.S.-based R&D and production is consistent with an evaluation of how U.S. policies affect the industry's contributions to the U.S. economy and living standards and to the nation's competitiveness in world markets.

[2] Unless otherwise noted, aggregate data cited in this report cover all of SIC 28.

The chemical industry's manufacturing processes extend far beyond the making of basic industrial chemicals.

products are used by other chemical producers to make other chemicals or by other industries to make or grow things that serve society — products ranging from apples and autos to zippers and zithers. Nevertheless, much of the public is unaware of the vital role of the chemical industry in everyday life and modern products.

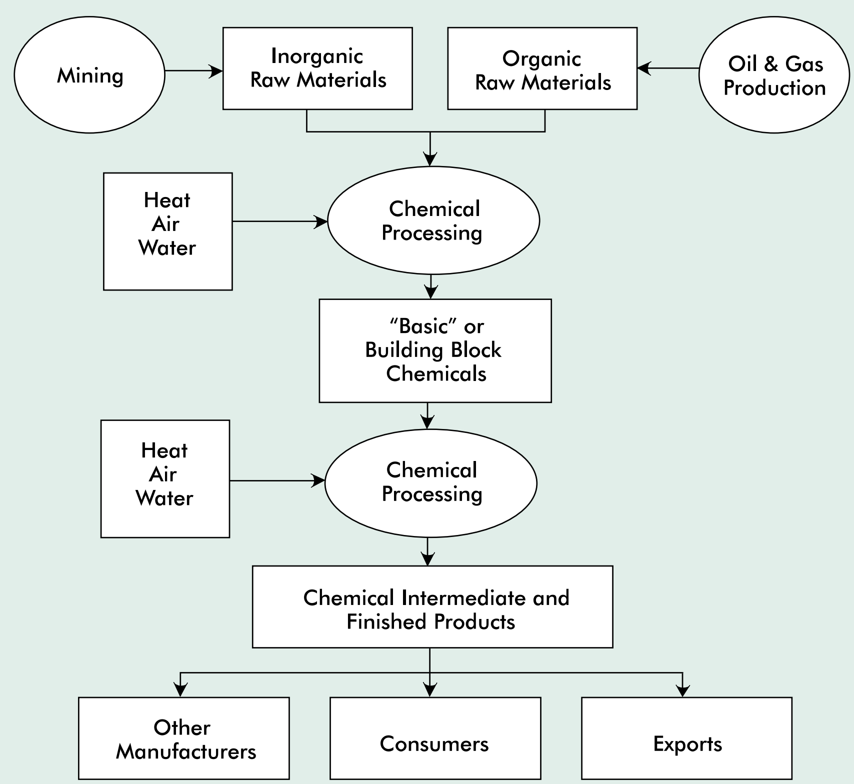
The many different products and processes of the chemical industry make a concise but meaningful description difficult. In essence, however, at the base of the chemical industry are companies that combine organic and inorganic materials from the earth with heat, air, and water to make chemicals that, in turn, are essential to products used in everyday life in modern economies (Figure 1). Box 1 outlines the major components of the industry.

The production of basic industrial chemicals falls into two broad categories, organic and inorganic chemicals. Organic chemicals production begins with raw materials containing hydrocarbons such as oil, natural gas, and coal. Inorganic chemicals do not contain carbon but are made from the air and from minerals taken from the earth, such as salt.

The chemical industry's manufacturing processes, however, extend far beyond the making of basic industrial chemicals. One useful way to describe the industry is vertically — by the layers or sequences of production it embraces. As noted above, some chemical companies are involved in the initial transformation of inorganic and organic raw materials into basic industrial or "building block" chemicals (for example, chlorine, benzene, ethylene, propylene, xylene, toluene, butadiene, methane, and butylene). Other chemical companies use these basic or "commodity" chemicals to make more highly refined "intermediate" chemicals that are essential inputs to everyday consumer products made by other industries — products such as glass, paper, steel, etc. Another group of chemical companies may take these intermediate chemicals and, through combinations and further processing, make "specialty" chemicals — such as water treatment chemicals — and other products, such as paints, fertilizers, plastics, artificial fibers, etc.

The immediate economic interests of firms at different "layers" of the production process may sometimes conflict. For example, an oversupply of production that leads to depressed prices for some basic chemicals would be bad news for the producing companies but could be good news for other chemical companies that must use basic chemicals in producing their own, more highly refined products.

Figure 1. What Is Chemistry?



The industry can also be defined in rough terms by product groups. Approached this way, the chemical industry is made up of a number of subindustries, such as basic petrochemicals, basic inorganic chemicals, plastics, man-made fibers, industrial gases, fertilizers and agricultural chemicals, and pharmaceuticals. The Bureau of Labor Statistics maintains employment data for the industry in an eight-way breakout: industrial inorganic chemicals; plastics materials and synthetics; drugs; soap, cleaners, and toilet goods; paints and allied products; industrial organic chemicals; agricultural chemicals; and miscellaneous chemical products.

None of these descriptions alone adequately conveys the industry's complexity or the relationships of chemical production and consumption within the industry. But noting the tiers or "layers" of production, it should be recognized that for many chemical producers, other chemical companies are their best customers. That is, a large portion of the

A large portion of the industry's shipments goes to other chemical companies for further refinement into other chemical products.

Box 1. Major Components of the U.S. Chemical Industry

The U.S. chemicals and allied products industry consists of some 9,125 corporations whose primary business is the development, manufacturing, and marketing of industrial chemicals, pharmaceuticals, and other chemical products.

The industrial chemicals segment (SICs 281, 282, and 286) of the industry consists of some 1,725 corporations whose primary business is the manufacturing and marketing of alkalis and chlorine, inorganic pigments, industrial gases, and other industrial inorganic chemicals; plastic resins, synthetic rubber, and man-made fibers; and petrochemicals and other industrial organic chemicals.

The pharmaceuticals segment (SIC 283) consists of some 1,225 corporations whose primary business is the development, manufacturing and marketing of medicinal chemicals and botanicals; in vitro and other diagnostic substances to diagnose or monitor the state of human or veterinary health; bacterial and virus vaccines, toxoids, serums, plasmas, and other biological products for human and veterinary health; and vitamins and other pharmaceutical preparations for both human and veterinary use.

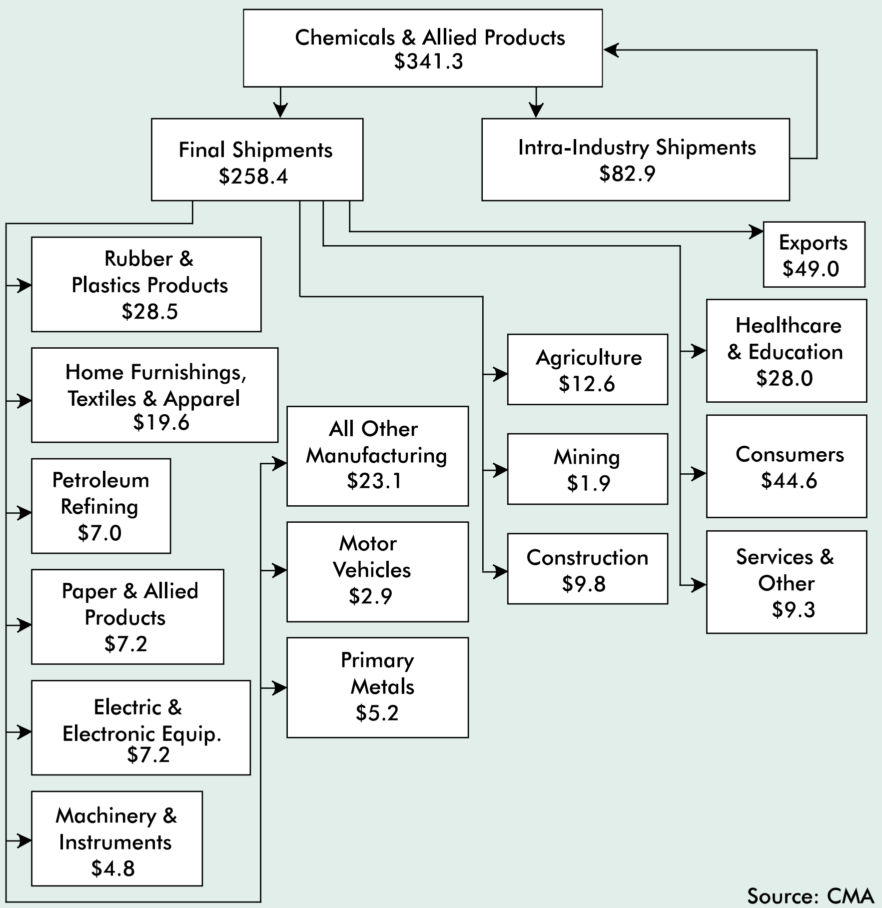
Other chemical products (SICs 284, 285, 287, and 289) consist of some 6,175 corporations whose primary business is the manufacturing and marketing of soaps and detergents; surfactants; specialty cleaning, polishing, and sanitary preparations; perfumes, cosmetics, and other toilet preparations; paints, varnishes, enamels, and other allied products; fertilizers, pesticides, and other agricultural chemicals; and adhesives and sealants, explosives, printing ink, and other specialty chemicals and chemical preparations.

industry's shipments goes to other chemical companies for further refinement into other chemical products. And another large portion — almost half of the industry's total output — goes to other manufacturing industries to enable production of other manufactured goods (Figure 2).

The chemical industry supports and makes possible millions of jobs in other industries.

The chemical industry is an enabling industry, a supplier to virtually every other industry. In fact, the food, clothing, construction, health care, and transportation industries are dependent on chemical industry inputs (Figures 3A and 3B). Every automobile, for example, contains about $2,200 of chemical processing and products. Thus the chemical industry supports and makes possible millions of jobs in other industries — beyond the million-plus jobs it generates directly — by supplying the products and technologies that enable other U.S. industries to perform their services, make their products, and develop new ones.

Figure 2. U.S. Chemical Industry Flow Chart, 1994



Developing countries invariably give high priority to building their own chemical industries because they recognize the keystone nature of this industry in modern economies. This emphasis on chemicals in the development plans of industrializing countries has significant implications for the U.S. chemical industry.

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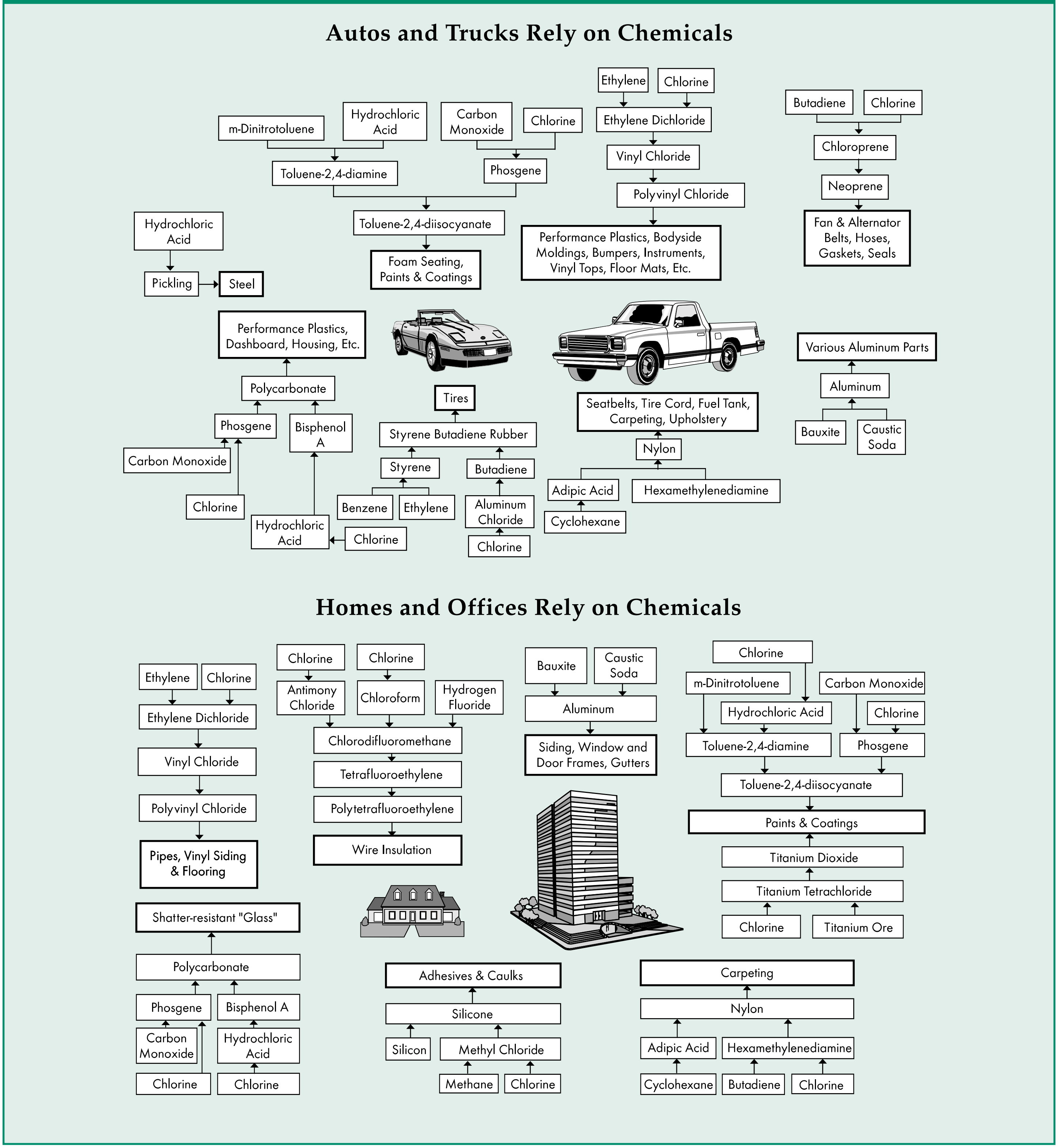
Despite its keystone importance to manufacturing, the contributions of the chemical industry to the economy are often not apparent to the general public, probably because most chemical companies are not directly involved in the production of consumer goods.

It should also be noted that most chemical companies do not fit neatly into just one of the tiers or product groups described above. Some large

Figure 3A. Role of Chemicals in Everyday Products



companies produce many — if not most — of the full range of chemical products. Some may produce not only basic chemicals, intermediates, and specialty chemicals but consumer products as well. Most companies, however, produce only a relatively narrow range of products.

This layering of production, the diversity of products, and the differing product orientations of individual companies complicate the collection and interpretation of data about the chemical industry. For purposes of this report, however, the chemical industry is generally described in data presented for three subsectors: industrial chemicals, pharmaceuticals, and other chemical products.

Huge, High-Tech, and Dynamic

The U.S. chemical industry is the world's largest. Production by plants in the U.S. provides about 24 percent of world chemical production (Figure 4). Japan is the second-largest producer — about 16.6 percent of the world total — followed by Germany and France with 7.9 and 5.2 percent, respectively, of total world output. U.S. chemical industry shipments of more than 70,000 different products reached $341 billion in 1994. On a value-added basis the industry provides about 1.9 percent of U.S. gross domestic product (GDP).

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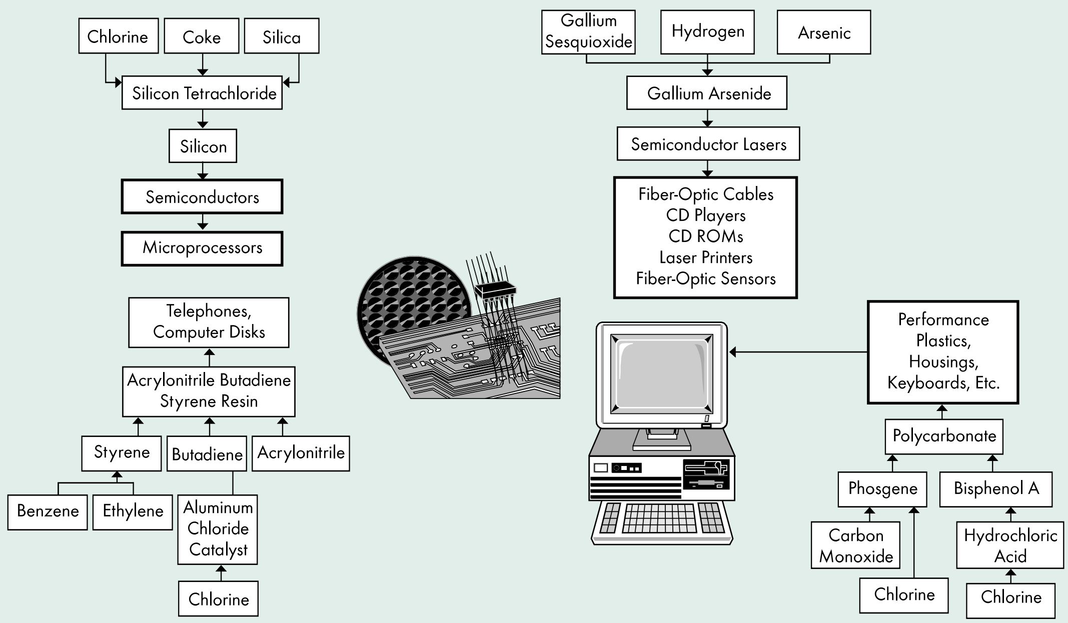
The huge size of the U.S. market and U.S. chemical production dictates that major foreign companies need a U.S. presence. This motivates large amounts of foreign investment in the U.S. chemical industry and adds to U.S. production, technology, and the international competitiveness of U.S.-based research and development (R&D) and production.

Chemicals is a very dynamic industry, with large expenditures for R&D providing a constant flow of new products and processes. The U.S. chemical industry is R&D-intensive, employing over 89,000 R&D chemists, engineers, and technicians in the constant search for innovations. The role of chemistry in modern life is ubiquitous and growing. Before World War I, only 3 patents of every 100 issued by the U.S. Patent Office were in the chemicals field. In the 1980s, chemical patents accounted for about 15 percent of each year's total.

The chemicals industry is the nation's top industry R&D spender — an estimated $18 billion in 1994 (Figure 5). Chemical industry R&D spending has been growing rapidly, increasing from 3.7 percent of sales in 1983 to 5.0 percent in 1994. Over half of the industry's R&D spending is by the pharmaceutical sector of the industry. But the continuing search for new materials, agricultural chemicals, adhesives, sealants, coatings and preservatives, and a variety of chemicals to meet environmental and

Figure 3B. Role of Chemicals in Everyday Products

Electronics Rely on Chemicals



Agriculture and Food Production Rely on Chemicals

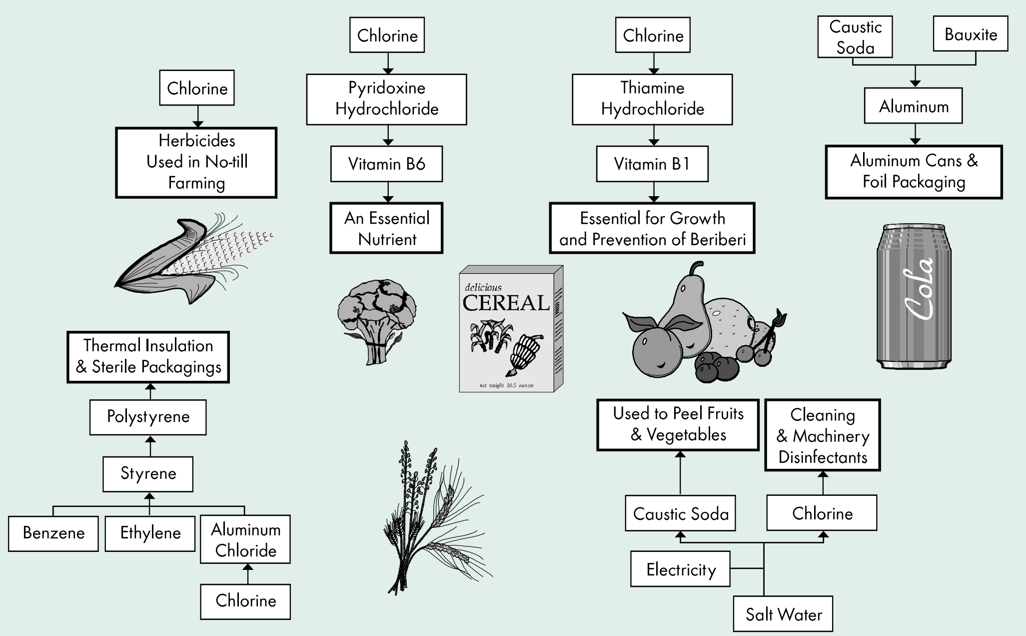
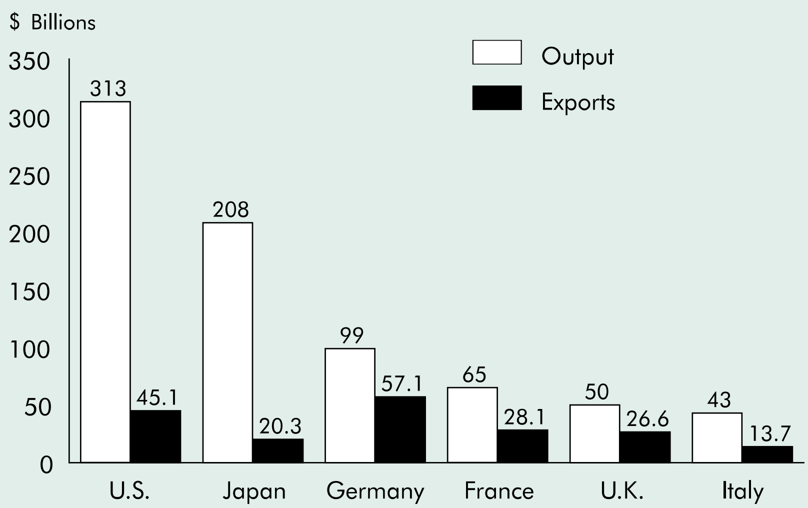


Figure 4. Total Output and Exports of Major Chemical Producing Countries, 1993



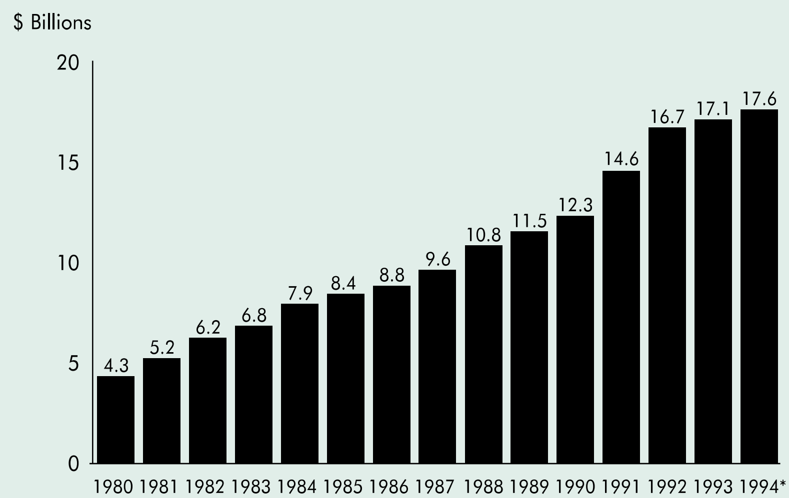
other needs motivates heavy R&D spending by other sectors of the industry as well.

Chemical industry R&D has traditionally been funded almost solely by the industry. Although the U.S. government has funded about one-fourth of the R&D performed by U.S. manufacturing, less than 2 percent of chemical industry research is U.S. government sponsored. However, the U.S. government has made important historical investments in basic chemical research at universities, which have helped to educate the chemists and chemical engineers employed by the industry. For example, in 1992, the U.S. government funded $0.316 billion in basic and applied chemical research (approximately 4.2 percent of industry's spending that year). The basic research thus funded, mainly at universities, was equivalent to 14 percent of the basic research funded by industry that year.

The U.S. government has made important historical investments in basic chemical research at universities.

Federally funded research has been particularly important in the health care field, where programs such as the Human Genome project have benefited both the pharmaceutical and biotechnology industries. In 1992, U.S. government funding for basic biological and medical science research was $0.005 billion compared to $1.2 billion in basic research funded by industry. During 1992, federal funding for applied research in this area totaled $4.0 billion in contrast to industry funding of $3.3 billion. While much larger sums are spent by industry in the develop-

Figure 5. U.S. Chemical Industry Research and Development Spending



Source: National Science Foundation *Estimate

The U.S. government has made a seminal contribution to the development of basic knowledge and to education of scientific and technical personnel.

ment of new products ($4.25 billion), the U.S. government has made a seminal contribution to the development of basic knowledge and to education of scientific and technical personnel in these areas.

Over 1 Million U.S. Jobs

The chemical industry directly employs a large number of workers. Industry employment has been quite stable and the industry's employees are well-paid. Employment in 1994 averaged 1.054 million, about 5 percent below the peak 1981 level. Over the same 1981–94 period, industry output increased by 44.8 percent, indicating productivity gains of about 3.3 percent annually. The 5 percent decline in total chemical industry employment from 1981 levels was modest compared to the 10.4 percent drop for total manufacturing sector employment. This difference mirrors the chemical industry's strong international trade performance compared to manufacturing as a whole.

About 8.5 percent of chemical industry employees are R&D scientists and engineers. Another 53 percent are production workers who earn about one-third more than the manufacturing average and who experience injury and illness rates about one-half the manufacturing average.

Although total chemical industry employment has been quite stable, there has been significant restructuring within the industry. In the 1980s, competition forced the closing of a number of inefficient and obsolete plants and the modernizing of production processes. Also, many companies during the 1980s put more emphasis on specialty chemicals, expecting them to yield higher profit margins than basic industrial chemicals.

Although total chemical industry employment has been quite stable, there has been significant restructuring within the industry.

The economic downturn of the early 1990s and a continuing increase in global competition have brought additional changes. Many companies have "downsized," often significantly reducing their nonproduction workers. The sectoral composition of employment within the industry has also changed. Of eight industry segments, six have lower employment than in 1981. But "Soap, Cleaners, and Toilet Goods" employment increased by 4.4 percent to 152,400, and pharmaceuticals employment increased by 33.0 percent to 264,600. Only 22,100 of the pharmaceuticals employment increase was in production workers, probably signaling increases in the number of persons devoted to R&D and to compliance with regulations.

A Global Industry

The chemical industry is perhaps the nation's most global major manufacturing industry. Globalization is manifested in worldwide diversification of production, high levels of foreign investment, rapidly rising levels of foreign trade, and increasingly intense competition for U.S. and foreign markets. Chemical markets around the world are now sufficiently integrated that world supply-demand relationships determine world prices for many basic products that can readily be transported across oceans and over great distances.

Many developing countries are pursuing export-led growth strategies that rely on industrializing — on building their own manufacturing industries. Industrializing countries want their own chemical production capabilities to support their other manufacturing industries, to build their own technology bases, and to obtain the value added by the production process. At the same time, well-established producers in many countries are motivated to invest in foreign markets — particularly in developing countries — as a means to continued growth and international competitiveness. Large U.S. companies have investments in production facilities around the world, and foreign companies have similar investments in the U.S. and other countries.

The end-1994 book value of U.S. direct investments in foreign chemical companies was $51.6 billion. The comparable value of foreign companies' investments in the U.S. chemical industry was $67.3 billion. But these data do not fully convey the globalization of business activity. U.S. chemical companies in 1992 controlled assets of $194 billion in foreign countries; foreign companies controlled assets of $162 billion in the United States (Figure 6). U.S.-owned companies in foreign countries employed 740,000 persons and generated $186 billion of sales; foreign companies employed 515,000 persons in the United States and generated sales of $123 billion. Some U.S. companies derive half or more of their total revenues and profits from foreign operations. For the 171 U.S. parent chemical companies as a whole, however, $8.6 billion — 35 percent — of the $24.7 billion of 1992 profits came from their foreign affiliates.

New chemical production sites include some countries that have the competitive advantage of low-cost energy. Energy costs are important because hydrocarbons — oil, natural gas, coal — are used both for raw materials (termed "feedstocks" by the industry) and to power the production process. Countries that do not have access to low-cost energy often provide aid to their new producers by various forms of government assistance and subsidies.

As a result of globalization, the number of chemicals whose prices are set by global supply-demand relationships is likely to increase steadily.

Capital Intensive

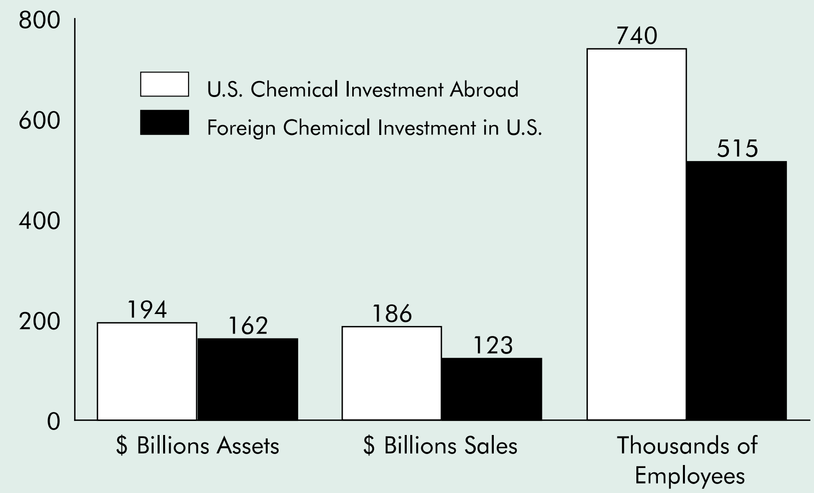
There are about 12,085 chemical production establishments in the United States. Total chemical company assets at the end of 1994 were about $442 billion, 14.6 percent of the manufacturing total. Shareholder's equity was about $160 billion.

A continuing flow of new investment in plant and equipment and R&D is necessary to increase U.S. production, to meet changing environmental standards, and to improve productivity in the never-ending struggle to maintain U.S. competitiveness.

Chemicals is a capital-intensive industry, with large economies of scale in production. This is particularly true for the producers of basic industrial chemicals. For the chemical industry as a whole, companies with assets under $25 million account for less than 3 percent of total industry assets. Invested capital is around $148,200 per employee, about twice the manufacturing average.

Large accumulated stocks of physical capital and the advanced technologies created by earlier research are critical factors in the U.S. industry's international competitiveness and its ability to pay high wages. But a continuing flow of new investment in plant and equipment and R&D is necessary to increase U.S. production, to meet changing environmental standards, and to improve productivity in the never-ending struggle to

Figure 6. Globalization of the Chemical Industry



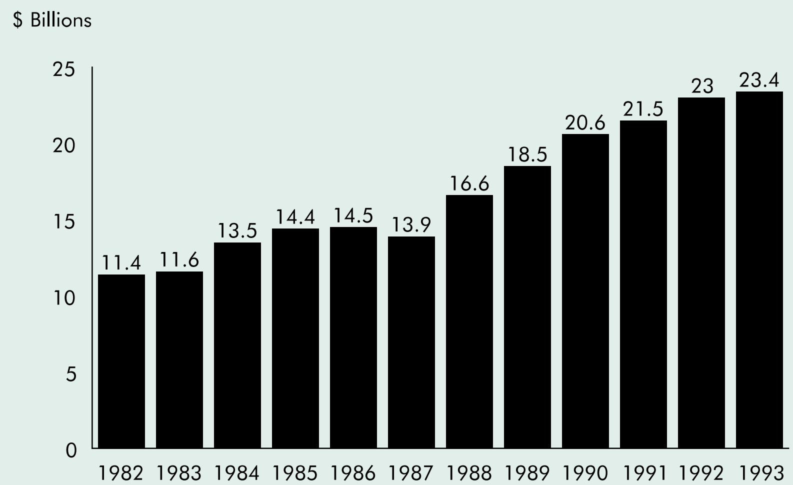
maintain U.S. competitiveness. New plant and equipment investment reached $23.4 billion in 1994, double the 1983 total (Figure 7).

Environmentally Committed

The chemical industry is one of the nation's most regulated industries. It is subject to numerous environmental regulations as well as the voluntary obligations imposed by the industry's Responsible Care® program — its environmental, health, and safety improvement initiative. Sixteen major federal statutes, as well as numerous state laws, impose significant compliance and reporting requirements on the industry (see Box 2). The costs of meeting mandated and self-imposed environmental requirements are large and continue to grow. Indeed, about one-sixth of new P&E investment is for environmental improvement purposes rather than to improve productivity or increase output.

According to U.S. government data the chemical industry spent $5.4 billion in 1993 operating costs to meet government requirements for pollution abatement and control, up from $2.8 billion in the six years from 1987. The bulk of these costs — $4.1 billion in 1993 — was borne by the manufacturers of industrial chemicals who convert raw materials such as oil, coal, and natural gas to basic chemicals for industrial uses. These pollution control costs have been rising faster than sales. U.S. government-measured pollution abatement and control costs for industrial

Figure 7. U.S. Chemical Industry Plant and Equipment Spending



Source: Bureau of the Census

The 1995 chemical industry labor costs of preparation of toxic release inventory (TRI) reporting will be about $132 million.

chemical producers rose from 1.9 cents per dollar of sales in 1983 to 3.3 cents in 1993.

These data, however, reflect only a fraction of total industry environmental costs. The data cited above essentially capture only operating costs (including depreciation) of equipment intended to reduce the generation of air pollutants, water pollutants, or solid/contained wastes. Not included are the costs of cleanup of areas designated as hazardous waste sites under the Superfund law and the large personnel costs involved in environmental compliance and reporting. For example, using EPA estimates of the number of reports, labor hours, and labor costs, the 1995 chemical industry labor costs of preparation of toxic release inventory (TRI) reporting — just one of many required reports — will be about $132 million.

Also not included in pollution abatement and control costs as measured by government data are the substantial costs of the voluntary commitment by the chemical industry's major producers to continuous improvement in performance in accordance with ten guiding principles and six performance codes set out in the Responsible Care® initiative (see Box 3). The Responsible Care® initiative, which originated in Canada, is interna-

Box 2. Major Health, Safety, and Environmental Legislation

Toxic Substances Control Act (TSCA) of 1976 gives the Environmental Protection Agency (EPA) comprehensive authority to regulate any chemical substance whose manufacture, processing, distribution in commerce, use, or disposal may present an unreasonable risk of injury to health or the environment.

Clean Air Act (CAA) was first passed in 1955 as the Air Pollution Control, Research and Technical Assistance Act and amended in 1963 to become the CAA. A more significant statute was passed in 1970 and amended in 1977 and 1990. It provides EPA authority to regulate air pollutants from a wide variety of sources including automobiles, electric power plants, chemical plants, and other industrial sources.

Clean Water Act (CWA) was first enacted in 1948 as the Federal Water Pollution Control Act. Subsequent extensive amendments defined the statute to be known as the CWA in 1972; it was further amended in 1977 and 1987. The CWA provides EPA authority to regulate effluents from sewage treatment works, chemical plants, and other industry sources into U.S. waterways. EPA has recently undertaken control efforts in non-point source pollution as well.

Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA) provide the basic legal framework for the Federal "Superfund" program to clean up abandoned hazardous waste sites.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) provides EPA authority to register and assess the risks of agricultural pesticides, industrial biocides, and other nonagricultural pesticides. It was first enacted in 1947 and last amended in 1988.

Federal Food, Drug and Cosmetics Act (FDCA) provides the Food and Drug Administration (FDA) authority to regulate the manufacturing of drugs and pharmaceuticals and the use of packaging and additives in food and cosmetics.

Emergency Planning and Community Right-to-Know Act of 1986, also known as SARA Title III, mandates state and community development of emergency preparedness plans and also establishes an annual manufacturing-sector emissions reporting program.

Resource Conservation and Recovery Act (RCRA) of 1976 provides EPA with authority to establish standards and regulations for handling and disposing of solid and hazardous wastes.

Occupational Safety and Health Act (OSHA) provides the Department of Labor authority to set comprehensive workplace safety and health standards, including permissible exposures to chemicals in the workplace, and authority to conduct inspections and issue citations for violations of safety and health regulations.

Safe Drinking Water Act, enacted in 1974 and amended in 1977 and again in 1986, establishes standards for public drinking water supplies.

Box 2. ***Continued***

Hazardous Materials Transportation Act (HMTA) provides the Department of Transportation the authority to regulate the packaging and movement of hazardous materials.

Chemical Diversion and Trafficking Act (CDTA) of 1988 is designed to prevent the diversion of chemicals to illegal drug producers.

Pollution Prevention Act of 1990 makes it the national policy of the United States to reduce or eliminate the generation of waste at the source whenever feasible and directs the EPA to undertake a multimedia program of information collection, technology transfer, and financial assistance to the states to implement this policy and to promote the use of source reduction techniques.

Flammable Fabrics Act, enacted in 1970 and last amended in 1983, gives the Consumer Product Safety Commission the authority to set flammability standards for fabrics that protect against an unreasonable risk of the occurrence of a fire.

Poison Packaging Prevention Act of 1953, and last amended in 1990, provides the Consumer Product Safety Commission authority to set standards for the special packaging of any household product to protect children from a hazard.

Consumer Product Safety Act, enabled in 1972 created the Consumer Product Safety Commission, and gives the Commission authority to issue mandatory safety standards, ban hazardous products, investigate safety of products, and use other forms of corrective action.

State Regulations. State governments are increasingly active in the environmental and safety areas.

tional in scope. It is now being implemented in 38 countries and is growing rapidly. It commands attention and resources from every part of the chemical production process, requiring substantial investment by those companies that have embraced its requirements.

Commitment to the U.S. Chemical Manufacturers Association Responsible Care® program is a condition of membership in the Association, whose 186 member companies provide 90 percent of the U.S. production of industrial chemicals. Partner memberships include some 23 additional companies and 19 associations.

The extensive, goal-oriented health, safety, and environmental performance improvement efforts of the Responsible Care® initiative have proven to be an effective, efficient way to achieve advances. Responsible Care® participants believe a key to the strength of this approach is that it

Box 3. Responsible Care® Initiative

In 1988, the Chemical Manufacturers Association (CMA) launched Responsible Care® to respond to public concerns about the safe management of chemicals. Through Responsible Care®, more than 200 member and Partner companies are committed to continuously improving their health, safety, and environmental performance in a manner that is responsive to public concerns.

Responsible Care® covers the entire life cycle of the chemical process, from initial research through recycling and disposal. CMA's members account for 90% of the productive capacity for basic chemicals in the United States, so the initiative has an impact on chemical operations around the country. And through the Responsible Care® Partnership Program, members from all levels of the chain of commerce are committed to continuously improving their health, safety, and environmental performance.

The key to Responsible Care® is industry's commitment to continuously improve health, safety, and environmental performance by fully implementing the six Responsible Care® Codes of Management Practices. The six Codes promote continuous improvement by focusing on management practices in all areas of chemical operations. CMA member and Partner companies must make good faith efforts to attain the goals of the six Codes: Community Awareness and Emergency Response (CAER), Pollution Prevention, Process Safety, Distribution, Employee Health and Safety, and Product Stewardship.

Like continuous improvement, openness and dialogue with the public are vital to the success of the initiative. Through the National Public Advisory Panel, the public is directly involved in helping to shape the Responsible Care® initiative. The National Public Advisory Panel acts as a sounding board for public concerns and is made up of a cross section of environmental, health, and safety thought leaders. Members and Partners also respond to public concerns more directly by engaging in a dialogue with their local communities through Community Advisory Panels around the country. These local panels, established in the communities near chemical sites, provide a valuable means of establishing a dialogue with the public.

The Guiding Principles of Responsible Care® outline the philosophy of the initiative. Member and Partner companies pledge to manage their businesses according to these principles:

- To recognize and respond to community concerns about chemicals and our operations.
- To develop and produce chemicals that can be manufactured, transported, used, and disposed of safely.
- To make health, safety, and environmental considerations a priority in our planning for all existing and new products and processes.
- To report promptly to officials, employees, customers, and the public, information on chemical-related health or environmental hazards and to recommend protective measures.

Box 3. ***Continued***

- To counsel customers on the safe use, transportation, and disposal of chemical products.
- To operate our plant and facilities in a manner that protects the environment and the health and safety of our employees and the public.
- To extend knowledge by conducting or supporting research on the health, safety, and environmental effects of our products, processes, and waste materials.
- To work with others to resolve problems created by past handling and disposal of hazardous substances.
- To participate with government and others in creating responsible laws, regulations, and standards to safeguard the community, workplace, and environment.
- To promote the principles and practices of Responsible Care® by sharing experiences and offering assistance to others who produce, handle, use, transport, or dispose of chemicals.

allows flexibility in how improvements are achieved and that the program offers a viable, more efficient alternative to the "command and control" regulations that governments have traditionally relied upon.

Position in World Markets and Trade Performance

Trade Performance and Competition

Chemical industry exports have consistently provided more than $1 out of every $10 of U.S. goods exports in recent years.

International trade is rapidly growing in importance to the U.S. chemical industry, and the industry's trade performance is becoming a more important indicator of its competitiveness. Trade data show that the chemical industry is the nation's biggest exporter and one of the most internationally competitive. Indeed, chemical industry exports have consistently provided more than $1 out of every $10 of U.S. goods exports in recent years. Exports of chemicals and related products reached $51.5 billion in 1994, substantially topping second-ranking total U.S. agricultural exports of $46 billion. Exports in 1995 will approach — and possibly top — $60 billion. Chemicals trade has also consistently provided substantial U.S. surpluses, $18.4 billion in 1994 and a cumulative total of $140 billion over the 10-year period 1985–94 (Figure 8).

Trade's growing importance to the chemical industry is evident from the fact that exports rose from 10.5 percent of total industry shipments in 1983 to 15.1 percent in 1994 (Figure 9).

U.S. chemical imports have also risen relative to U.S. production — from 5.7 percent of industry shipments in 1983 to 9.9 percent in 1994. Although the U.S. industry is increasingly dependent on trade, it is much less so than the chemical industries of several other major producer nations. Including its shipments to other European Union countries, Germany in 1993 exported 58 percent of its total chemical output, the United Kingdom, 53 percent, and France, 43.2 percent. On the other hand, Japan's chemical industry — the world's second largest — exported less than 10 percent of its output.

Although the U.S. industry is increasingly dependent on trade, it is much less so than the chemical industries of several other major producer nations.

The large role of chemicals in U.S. trade and the increasing importance of trade to the U.S. chemical industry parallels the role and growth of chemicals in world trade. World trade in chemicals and allied products was $312 billion in 1992, about 9.1 percent of total world goods trade and 12.9 percent of total world manufactures trade. World chemical trade has grown much more rapidly than world chemical production, increasing by 153 percent over the 1981 to 1992 period, compared to a growth of only 66 percent in world chemical production.

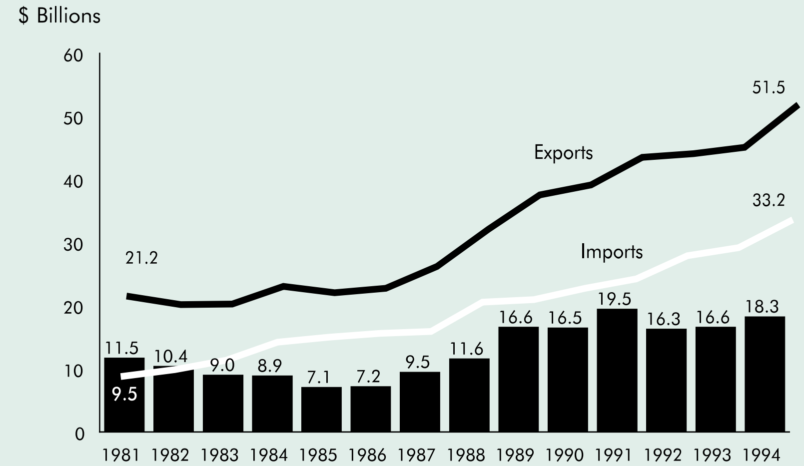
The U.S. plays a large role in world chemical trade, but not so large as Germany. In 1992 — the latest data available — the United States had a 14.0 percent share of world chemical exports. Germany had a larger share — 17.2 percent (Figure 10). However, over half — about 53 percent — of Germany's total chemical exports went to other European Union countries.

The 14.0 percent U.S. share of 1992 world chemical exports is down substantially from the 18.6 percent share of 1981 (Figure 11). In a world where many developing countries are becoming producers, a declining U.S. share of world output and trade is probably inevitable. But although the U.S. share of world chemical exports declined over the 1981–92 period, its share of world imports rose from 7.7 percent to 8.9 percent. As a result, the margin of U.S. export shares over import shares narrowed from 10.9 percentage points in 1981 to 5.1 percent in 1992, indicating a relative decline in the competitive position of U.S.-based chemical production in international markets.

In a world where many developing countries are becoming producers, a declining U.S. share of world output and trade is probably inevitable.

Germany's export and import shares have remained relatively more stable. Its share of world exports was 17.8 percent in 1981 and 17.2 percent in 1992. Its share of world imports increased by only one percentage point, from 9.7 percent in 1981 to 10.7 percent in 1992. Moreover, more often than not, since the beginning of the 1980s German trade surpluses have topped those of the United States. But market shares and trade balances

Figure 8. U.S. Chemical Trade, 1981–1994



Source: Bureau of the Census

The international competitiveness position of U.S.-based R&D and chemical production today is probably stronger than that of the other major chemical producer nations.

As part of their efforts to industrialize, developing nations will strive to build their own production capabilities.

are not complete measures of the domestic industry's strength and its longer term international competitiveness. Other critically important factors include the profitability of domestic operations, the amounts and profitability of foreign investments, rates of return, and amounts and trends of new investment in plant and equipment and R&D.

By most standards the international competitiveness position of U.S.-based R&D and chemical production today is probably stronger than that of the other major chemical producer nations — the several major European producer countries, Japan, and Canada. But these countries are not the only competitors for world markets, and indeed, they may not be the fiercest competitors in the years ahead. Like the United States, the major European producer countries and Japan and Canada have become mature markets for chemicals. Growth in domestic demand for chemicals in these mature markets will probably increase at only about the same pace as their GDP growth, which is likely to be modest compared to the growth rates of several developing countries. Increasingly, faster-growth developing countries and regions are likely to provide the largest future opportunities for sales gains.

These new markets will offer expanding opportunities for exports of chemicals and direct investments by established producers. But as part of their efforts to industrialize, developing nations will strive to build their own production capabilities. Some of this new production will be used to

Figure 9. U.S. Chemical Trade Shares of Total Shipments

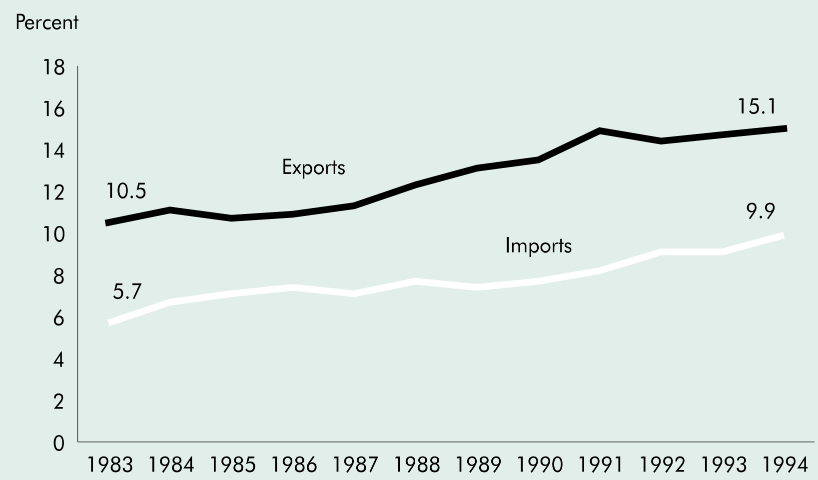
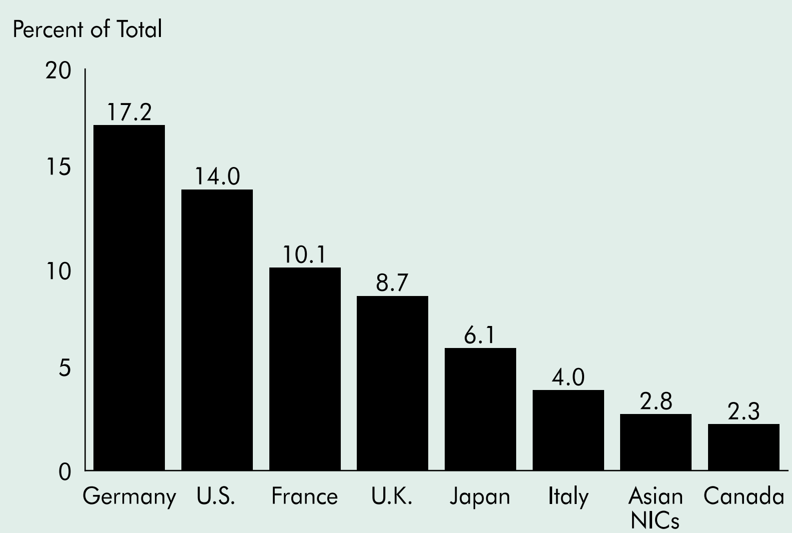


Figure 10. World Chemical Export Shares, 1992



reduce their import needs. But some of it will be exported, increasing the level of competition in global markets. To cite one example, from 1981 to 1992, the Asian newly industrializing countries (NICs) (Taiwan, Hong Kong, Singapore, and South Korea) share of world imports increased from 4.3 to 7.9 percent. But over the same period their share of world exports rose from 0.6 percent to 2.8 percent. Continuing new investment in these countries indicates their production capacity and their share of world export markets will continue to grow, and they may soon become net exporters in many chemical products, if not net exporters in their total chemical trade.

Trade Composition by Product

U.S. implementation of the Harmonized System of trade data provides the finest level of detail available for trade information. Applying the nomenclature of this system, the United States in 1994 exported 1,054 different chemical and related product items and imported 1,700 chemical items. In fact, however, a relatively few items account for the major portion of U.S. chemicals trade. For example, the top 100 chemical exports alone accounted for 58.3 percent of total exports; the top 100 imports accounted for 49.4 percent of the import total.

U.S. chemical trade continues to include substantial portions of basic industrial chemicals such as styrene, vinyl chloride, and disodium carbonate. Overall, the composition of the trade among major product categories has been relatively stable but is, nevertheless, undergoing some changes. Exports of organic chemicals, for example, were 24.7 percent of total 1994 exports, down only modestly from a 26.7 percent share in 1983 (Figure 12). Mirroring a change in world trade composition, however, inorganic chemicals declined from 14.9 percent of the 1983 total to 7.9 percent in 1994.

Plastics are also a large component in the U.S. trade. Together, primary and non-primary plastics make up 24.3 percent of 1994 U.S. exports, up from the 20.0 percent share of 1983.

The United States typically achieves trade surpluses in each of the nine categories identified by Standard International Trade Classification codes.

The pharmaceuticals segment of the industry is somewhat less export-oriented than the rest of the chemical industry. Pharmaceuticals exports were only about 11.8 percent of that segment's sales in 1994 compared to 15.1 percent for the industry as a whole. Pharmaceuticals are thus a relatively modest portion of U.S. chemical trade, 11.1 percent of U.S. exports in 1983, 11.8 percent in 1994. The pharmaceuticals share of U.S. chemical imports, however, increased from 7.4 percent in 1983 to 14.7 percent in 1994.

Trade in oils and perfumes has been fast-growing but remains a modest portion of the whole — 6.9 percent of exports and 5.5 percent of imports.

Figure 11. U.S. Share of World Chemical Exports and Imports

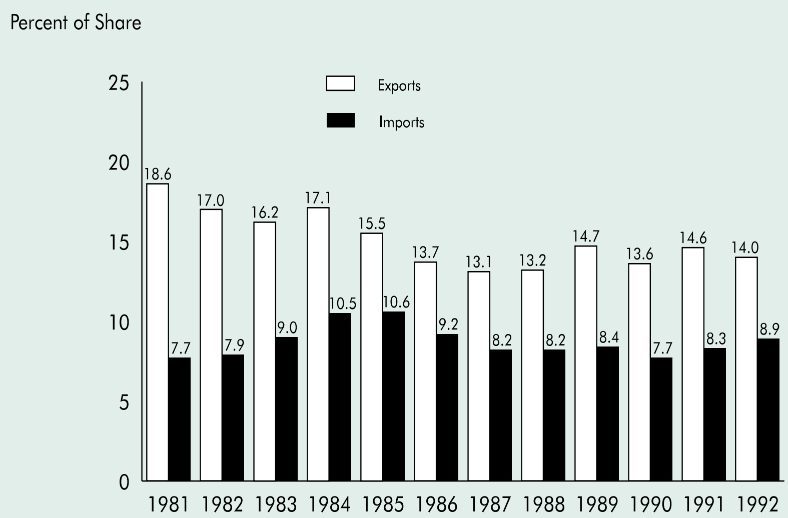
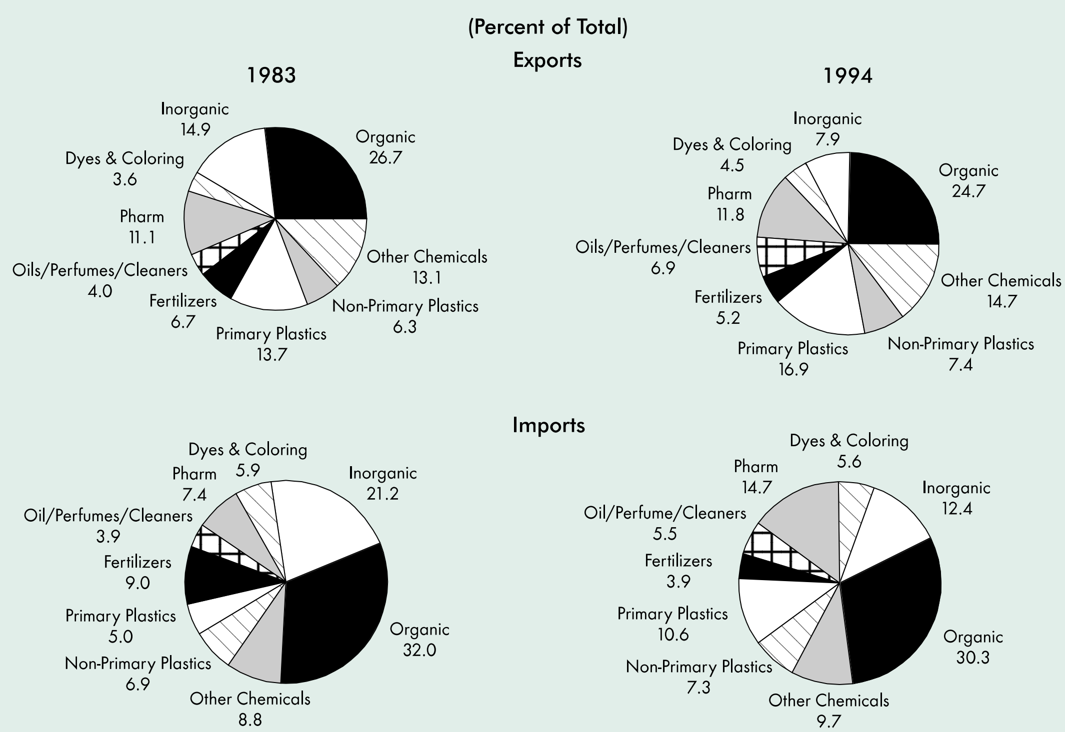


Figure 12. Product Composition of U.S. Chemical Industry



The United States typically achieves trade surpluses in each of the nine categories identified by Standard International Trade Classification (SITC) codes. In 1994, however, a small inorganic chemicals deficit was the first in that category in many years. In contrast, however, the relatively modest dyeing and coloring material trade has moved in the last 10 years from consistent small deficits to small but increasing surpluses, $574 million in 1994.

Geographic Composition of Trade

The geographic distribution of U.S. chemical trade has also been relatively stable, though changes mirroring those in world trade patterns and changes relating to trade agreements have been occurring. The major portion of U.S. chemical trade continues to be with other developed countries — Western Europe, Canada, Japan, and Australia. In 1994, for example, 58.8 percent of U.S. exports went to developed countries, down only modestly from 60.7 percent in 1983. Disaggregation of the data, however, shows an increasing importance of first-ranking Canada — from 12.9 percent of U.S. exports in 1983 to 17.2 percent in 1994 — and a decline in the importance of second-ranking Japan, from 13.0 percent to 9.5 percent. The Asian NICs and Mexico were important contributors to the increase of the developing countries' share of U.S. exports, which moved from 35.6 percent in 1983 to 37.9 percent in 1994 (Figure 13).

U.S. imports (Figure 13) are even more dominated by the developed countries, although their share of imports declined from 83.4 percent in 1983 to 79.8 percent in 1994. Western Europe supplied 25.3 percent of 1994 U.S. imports, Canada 20.1 percent, and Japan 12.6 percent. Among developing countries, the Asian NICs increased their share of U.S. imports, as did a small group of countries — China and countries of the former Soviet Union — not included in the "developing country" classification.

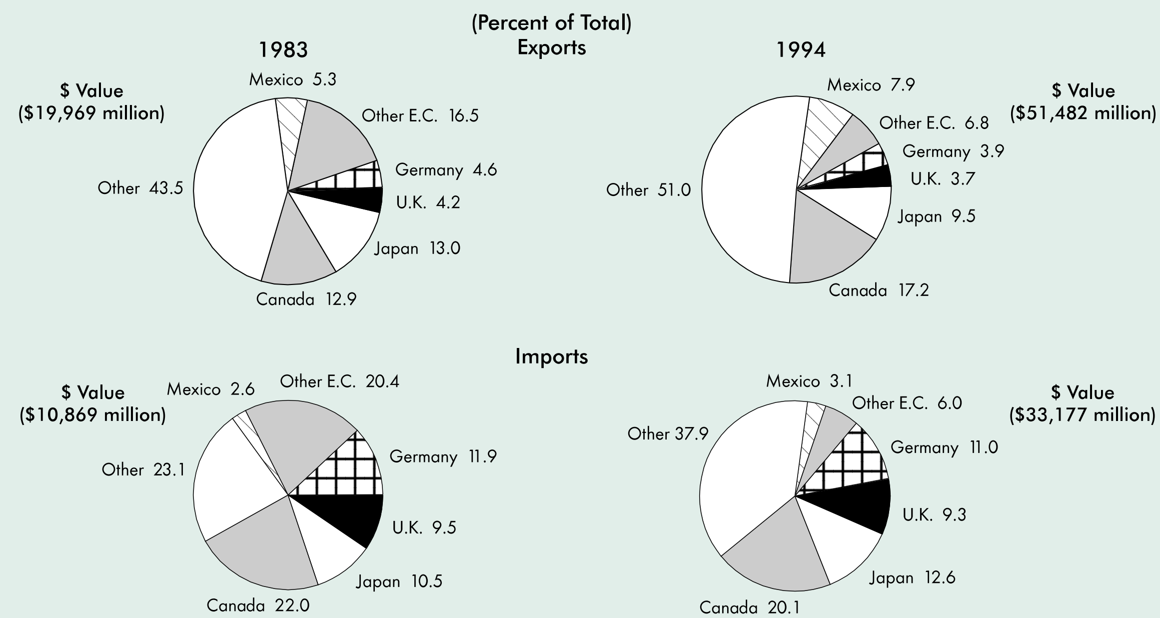
Although the major portion of U.S. chemical trade is with developed countries, U.S. trade surpluses come increasingly from trade with the developing countries.

Although the major portion of U.S. chemical trade is with developed countries — 59 percent of 1994 U.S. exports, 80 percent of imports — U.S. trade surpluses come increasingly from trade with the developing countries. In 1994 the U.S. surplus on trade with the developed countries was only $3.6 billion, while the surplus on the much smaller trade with developing countries was $14.2 billion.

Foreign Investment Performance

Foreign investments play a critical and positive role in the competitiveness and viability of the U.S. chemical industry, both through the returns from foreign production and sales and through expanded U.S. exports.

Figure 13. Geographic Composition of U.S. Chemical Trade

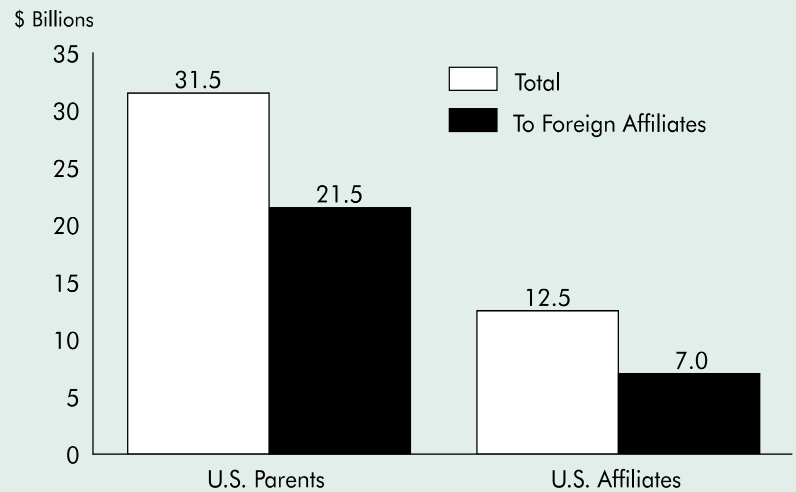


Foreign investments play a critical and positive role in the competitiveness and viability of the U.S. chemical industry.

As competition for markets becomes tougher, R&D to produce new products and processes becomes a more important competitive factor. But to be affordable, fast-growing R&D costs must be amortized over enlarging sales that often can be realized only by selling beyond the United States and into global markets. Exporting is one way to tap global markets. But production and transportation costs, the need for prompt delivery, foreign needs for tailor-made products, the service requirements that many chemicals pose, and myriad other factors often make it impossible to compete successfully in significant foreign markets solely by exporting from the United States. Often, to be competitive in an important foreign market, companies must produce in that market. But once U.S. chemical companies invest in foreign affiliate production facilities, those foreign affiliate companies provide natural channels for exports from the United States.

Direct investments in the United States by foreign companies and direct investments abroad by U.S. chemical companies have generated a substantial trade between U.S. parent companies and their foreign affiliates and between U.S. affiliates and their foreign parents. U.S. government data show that in 1992, U.S. chemical companies with foreign investments exported $31.5 billion of merchandise; $21.5 billion of that — 68 percent

Figure 14. 1992 Exports of Multinational Chemical Companies in the U.S.



Both U.S. parent chemical companies and the U.S. affiliates of foreign companies generate U.S. trade surpluses on their foreign trade.

of the total — went to their foreign affiliates (Figure 14). Also, of $12.5 billion of 1992 exports by U.S. affiliates of foreign chemical company parents, $7.0 billion — 56 percent of the total — went to foreign parents and affiliates.

The effects of foreign investment on U.S. imports are even more dramatic. U.S. parent chemical companies imported $15.2 billion of goods in 1992 (Figure 15). Of that, $10.1 billion — 66 percent — came from their foreign affiliates. The U.S. affiliates of foreign companies imported $11.8 billion, $9.4 billion of that from foreign parents and affiliates. Nevertheless, both U.S. parent chemical companies and the U.S. affiliates of foreign companies generate U.S. trade surpluses on their foreign trade.

Chemical industry contributions to U.S. trade accounts and the role of foreign investments in the industry's performance are not limited to goods exports and surpluses. The profits of foreign affiliates, service charges levied by U.S. parents on their foreign affiliates, and the licensing of U.S. technology (mostly to foreign affiliates) are classified as "services exports" in U.S. international accounts. These exports total about $9 billion annually. Imports of similar services from foreign countries (mostly by the U.S. affiliates of foreign companies) typically total

Figure 15. 1992 Imports of Multinational Chemical Companies in the U.S.

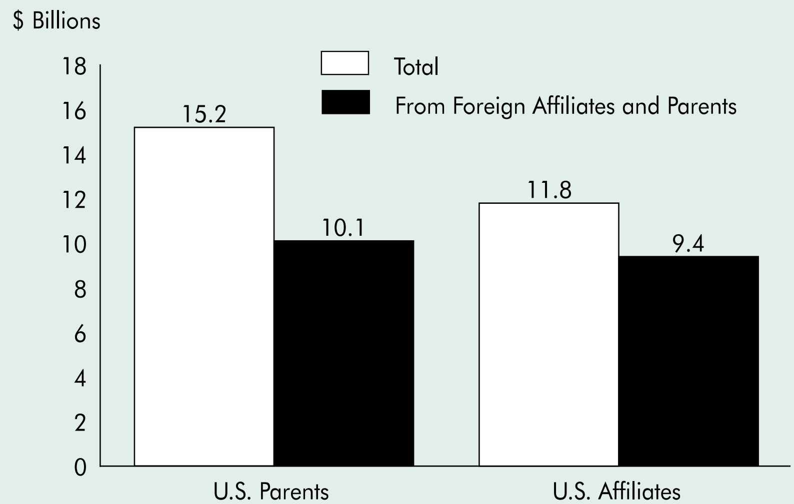
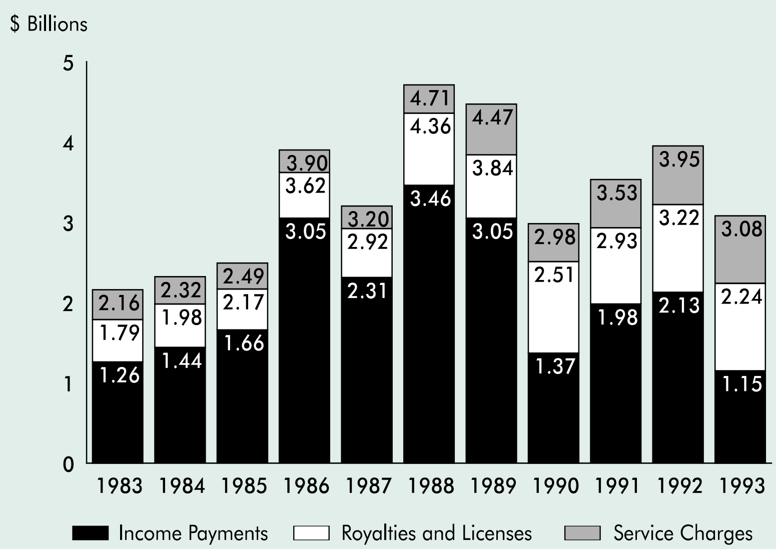


Figure 16. Net Income from Chemical Industry Direct Investment



Foreign investments are a very important factor in the U.S. chemical industry's strong international competitive position.

about $6 to $7 billion, leaving the United States with an annual chemical industry "services" trade balance of some $2 to $4 billion (Figure 16).

Foreign direct investments thus not only add to parent company sales and profits, but in addition, foreign plants typically become markets for inputs from U.S.-based production and channels for sales of products not made in the foreign plant. Clearly, foreign investments are a very important factor in the U.S. chemical industry's strong international competitive position. The U.S. chemical industry gained advantage by investing abroad early. The large growth in foreign investment in the U.S. chemical industry has been more recent (Figure 17). As a result, although the 1994 book value of foreign investment in the U.S. ($67.3 billion) now exceeds the book value of U.S. chemical investments abroad ($51.6 billion), the real worth and the earning power of the U.S. investments abroad still exceeds that of foreign investment in the United States. But the more important question, discussed later in this paper, is whether the recent pace of the U.S. industry's investment abroad and the investments in the years ahead will be adequate to maintain the longer term competitiveness of U.S.-based R&D and production.

Economic Performance and Financial Position

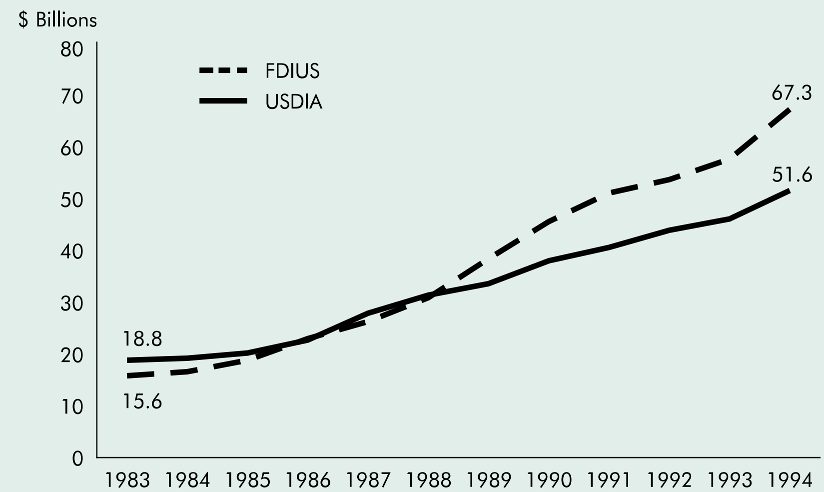
The U.S. chemical industry consists of some 9,125 corporations whose primary business is the development, manufacturing, and marketing of chemicals. U.S. government financial data disaggregates the industry into three segments: industrial chemicals, pharmaceuticals, and other chemical products. The industrial chemicals and other chemical products segments of the industry are often similar in economic and financial performance, but the pharmaceuticals (drugs) industry often differs in profits, rates of return, and other important measures (Table 1).

Revenues and Assets

Chemical industry revenues have grown rapidly, rising from $201 billion in 1983 to almost $357 billion in 1994, a 77 percent increase (Table 1). A rising portion of this revenue stream, however, appears to be going to pharmaceuticals companies. The pharmaceuticals share rose from 14.4 percent in 1983 to 25.2 percent in 1994.

Total industry assets over the same period increased from $187.6 billion to almost $464 billion (Table 1), with the pharmaceuticals share growing from 17.6 percent in 1983 to 29.5 percent in 1994.

Figure 17. Continuing Globalization through Direct Investment



Net fixed capital (total fixed capital less accumulated depreciation and amortization) increased from $78.3 billion in 1983 to $156.2 billion in 1994. As of 1994, 55.1 percent of net fixed capital was in industrial chemicals, 20.0 percent in pharmaceuticals, and 24.9 percent in other chemical products.

According to the U.S. Commerce Department's Bureau of Economic Analysis, the average age of the industry's net capital stock in 1994 was 5.34 years, down modestly from the 1987 high of 5.87 years but well above the 1977 low of 4.55 years.

The debt-to-equity ratios of the chemical industry doubled from 1983 to 1994, rising from 0.93 to 1.85 (Table 1). Over the same period the ratio for manufacturing as a whole rose from 1.04 to 1.67. The ratio for the industrial chemicals sector (2.12) is significantly higher than those of pharmaceuticals (1.63) and other chemical products (1.73).

Investment Trends

Investments in R&D and new plant and equipment are critical to the industry's competitiveness. Industry R&D funding rose from $6.8 billion in 1983 to an estimated $18 billion in 1994, a 165 percent increase. The pharmaceuticals sector accounts for a rising portion of the total, 57.4 percent in 1994.

Table 1. Chemical Industry Revenue and Assets

Revenues (In millions of dollars)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Total	201,319	209,627	202,804	205,778	225,200	261,616	278,300	287,457	297,841	315,534	325,074	356,876
Industrial	94,698	98,078	79,292	81,400	96,548	115,394	111,391	112,088	113,310	122,545	122,667	140,480
Pharmaceuticals	29,088	30,900	35,124	37,768	42,903	46,205	51,251	58,993	67,147	73,645	82,012	90,106
Other	77,533	80,649	88,388	86,610	86,749	100,017	115,658	116,376	117,384	119,344	120,394	126,291

Total Assets (In millions of dollars)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Total	187,572	193,089	205,339	217,166	244,446	277,582	293,317	325,370	357,665	385,374	418,285	463,973
Industrial	92,162	93,612	88,854	90,986	109,927	122,966	120,760	136,015	161,484	176,333	184,345	197,090
Pharmaceuticals	32,947	35,509	40,295	48,621	53,208	55,894	62,206	73,223	80,219	91,947	112,049	136,857
Other	62,464	63,970	76,190	79,560	81,311	98,724	110,353	116,132	115,963	117,094	121,891	129,846

Net Fixed Capital (In millions of dollars)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Total	78,227	77,281	77,166	77,547	82,766	92,835	100,219	114,586	129,785	141,857	147,292	156,150
Industrial	44,251	43,905	39,004	38,777	43,402	47,729	46,606	56,396	68,607	78,109	80,512	86,071
Pharmaceuticals	9,639	10,711	12,092	12,845	14,266	15,772	17,671	20,309	24,088	26,566	29,288	31,215
Other	24,387	22,666	26,072	25,926	25,099	29,334	35,943	37,881	37,390	37,182	37,493	38,864

Debt to Equity Ratio

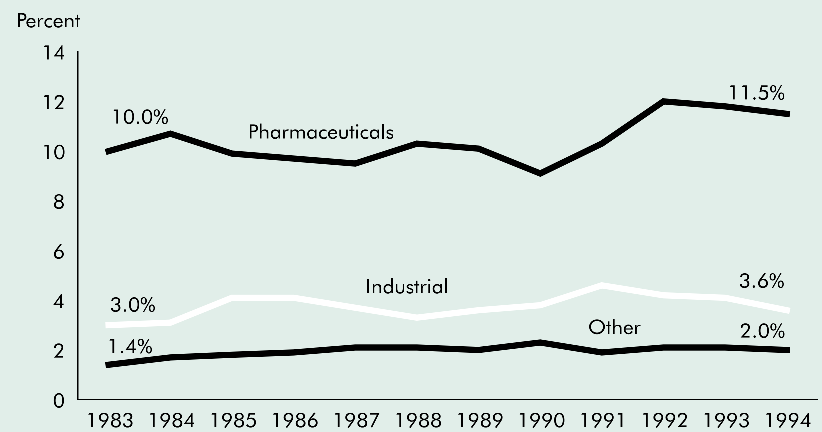
	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Total	0.93	0.92	1.05	1.15	1.29	1.30	1.30	1.35	1.39	1.58	1.74	1.85
Industrial	1.04	1.01	1.18	1.19	1.42	1.38	1.21	1.35	1.51	2.03	2.04	2.12
Pharmaceuticals	0.70	0.72	0.77	1.04	1.24	1.18	1.03	1.02	0.99	1.07	1.30	1.63
Other	0.92	0.93	1.07	1.19	1.15	1.28	1.60	1.63	1.58	1.51	1.81	1.73

Chemical industry R&D spending is higher relative to sales than in most industries, reaching 5.3 percent in 1993 before declining modestly relative to 1994's very strong sales gains. R&D has grown relative to sales in all three segments but is highest in the pharmaceuticals segment, averaging 10.4 percent over the 1983–94 period (Figure 18).

Capital equipment expenditures have also been increasing rapidly, reaching an estimated $25.6 billion in 1994. Capital spending, however, continues to be dominated by industrial chemicals, with 1994 expenditures of $13.9 billion, 54 percent of the total.

Capital spending is also a higher portion of total revenues for industrial chemicals than for the other two segments. For the 1983–94 period, industrial chemicals capital expenditures averaged 9.1 percent of rev-

Figure 18. R&D Percent of Sales



enues compared to 6.2 percent for pharmaceuticals and 3.1 percent for other chemical products (Table 2).

Profits

As is often the case with capital-intensive manufacturing industries, chemical industry profits fluctuate markedly with the business cycle, rising when demand, capacity utilization, and prices increase, declining rather sharply when demand, prices, and capacity utilization fall. These tendencies apply primarily to industrial and other chemical products, however. Pharmaceuticals profit performance has been consistently strong in recent years, much less affected by business cycles and global competition (Table 3). Rather, consistent growth in the demand for pharmaceutical products is closely correlated with increasing health care expenditures that accompany rising incomes and living standards.

Pharmaceuticals profit performance has been consistently strong in recent years, much less affected by business cycles and global competition.

Chemical industry profits hit a new high of $30.4 billion in 1994, 17.3 percent of the manufacturing sector total, a portion close to the 17.0 percent 1983–94 average. Pharmaceuticals profits were $13.2 billion, a new record and 43.5 percent of the industry total — well above the 39.9 percent average contribution for 1983–94. Industrial chemicals profits were $8.4 billion in 1994, the best performance since 1989 but well below the $10.2 billion record high of 1988. Industrial chemicals profits were 27.8 percent of the 1994 industry total, somewhat below the 30.7 average for the 1983–94 period. The other chemical products segment also set a

Table 2. Capital Equipment Investment Trends

Capital Equipment (In millions of dollars)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Total	9,154	9,825	10,852	10,179	11,890	14,558	18,849	19,350	24,188	24,585	23,902	25,633
Industrial	5,635	5,552	6,221	5,861	6,956	8,860	11,828	12,960	15,373	13,748	13,057	13,860
Pharmaceuticals	1,539	1,842	1,946	1,713	2,387	2,759	3,345	2,902	4,033	5,842	5,977	6,438
Other	1,980	2,431	2,685	2,604	2,547	2,939	3,676	3,488	4,782	4,995	4,868	5,335

Capital Equipment as a Percent of Sales

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Average 1983–94
Total	11.7	4.7	5.4	4.9	5.3	5.6	6.8	6.7	8.1	7.8	7.4	7.2	6.8
Industrial	6.0	5.7	7.8	7.2	7.3	7.7	10.6	11.6	13.6	11.2	10.6	9.9	9.1
Pharmaceuticals	5.3	6.0	5.5	4.5	5.6	8.1	6.5	4.9	6.0	7.9	7.3	7.1	6.2
Other	1.4	1.7	3.0	3.0	2.9	2.9	3.2	3.0	4.1	4.2	4.0	4.2	3.1

Table 3. After-Tax Profits

Income After Taxes (In millions of dollars)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Total	11,643	13,883	9,541	12,901	16,559	23,661	24,523	23,418	19,997	12,996	15,550	30,412
Industrial	3,517	5,309	1,741	4,920	7,150	10,243	9,320	7,842	4,744	–2,582	4,218	8,458
Pharmaceuticals	3,856	4,112	3,456	5,504	4,411	7,378	7,744	9,336	10,198	9,482	10,199	13,229
Other	4,720	4,462	4,344	2,477	4,999	6,029	7,458	6,240	5,055	6,096	1,133	8,724

Percent of Total

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Average 1983–1994
Industrial	30.2	38.2	18.2	38.1	43.2	43.3	38.0	33.5	23.7	–19.9	27.1	27.8	28.3
Pharmaceuticals	33.1	29.6	36.2	42.7	26.6	31.2	31.6	39.9	51.0	73.0	65.6	43.5	42.8
Other	36.7	32.1	45.5	19.2	30.2	26.5	30.4	26.6	25.3	46.9	7.3	28.7	28.9

new profit record, $8.7 billion, 28.8 percent of the 1994 industry total, compared to the 29.4 percent average for the 1983–94 period.

Rates of Return

There are also significant differences among the three industry segments in some key indicators of longer term performance. For example, the

Table 4. Rates of Return

Profit of Sales (Percent)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Average 1983–1994
Total	5.8	6.6	4.7	6.3	7.4	9.0	8.8	8.1	6.7	4.1	4.8	8.5	6.7
Industrial	3.7	5.4	2.2	6.0	7.5	8.9	8.4	7.0	4.2	–2.1	3.4	6.0	5.1
Pharmaceuticals	13.3	13.3	9.8	14.6	10.3	16.0	15.1	15.8	15.2	12.9	12.4	14.7	13.6
Other	5.5	5.5	4.9	2.9	5.8	6.0	6.4	5.4	4.3	5.1	0.9	6.9	5.0

Return on Assets (Percent)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Average 1983–1994
Total	6.2	7.2	4.6	5.9	6.8	8.5	8.4	7.2	5.6	3.4	3.7	6.6	6.2
Industrial	3.8	5.7	2.0	5.4	6.5	8.3	7.7	5.8	2.9	–1.5	2.3	4.3	4.4
Pharmaceuticals	11.7	11.6	8.6	11.8	8.3	13.2	12.4	12.8	12.7	10.3	9.1	9.7	11.0
Other	6.8	7.0	5.7	3.1	6.1	6.1	6.8	5.4	4.4	5.2	0.9	6.7	5.4

Return on Equity (Percent)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Average 1983–1994
Total	12.0	13.8	9.5	12.8	15.5	19.6	19.2	16.9	13.4	8.7	10.2	18.7	14.2
Industrial	7.8	11.4	4.3	11.8	15.8	19.8	17.0	13.6	7.4	–4.4	7.0	13.4	10.4
Pharmaceuticals	19.9	19.9	15.2	24.1	18.6	28.8	25.3	25.8	25.4	21.4	20.9	25.4	22.5
Other	13.1	13.5	11.8	6.8	13.2	13.9	17.6	14.1	11.2	13.0	2.6	18.4	12.4

1983–94 average return on revenues for the industry as a whole was 6.7 percent, compared to a 3.9 percent return for manufacturing as a whole. But within the chemical industry, the return on revenues was 5.1 percent for industrial chemicals and 5.0 percent for other chemical products, but 13.6 percent for pharmaceuticals. Similarly, the return on assets for 1983–94 was 4.4 percent for industrial chemicals and 5.4 percent for other chemical products, but 11.0 percent for pharmaceuticals. The average return on equity for the twelve-year period was 10.4 percent for industrial chemicals, 12.4 percent for other chemical products, and 22.5 percent for pharmaceuticals (Table 4).

The high rates of return enjoyed by pharmaceuticals companies have allowed high levels of new investment, particularly in R&D. This investment has, in turn, increased the pace of new product introductions, increased sales, and helped to make the U.S. pharmaceutical industry a world leader.

The high rates of return enjoyed by pharmaceuticals companies have allowed high levels of new investment, particularly in R&D.

A key question is whether the long-term returns for industrial chemicals and for other chemical products are sufficiently high to merit the new investment in both U.S.-based and foreign production facilities necessary to motivate and fund their international competitiveness needs.

Rates of return have not only been much lower for the other segments of the industry, but may also be more vulnerable to competition. Arguably, rates of return for the industrial chemicals group may be falling, perhaps at least in part because environmental compliance costs in that segment have been rising relative to sales. Over the longer 14-year period 1981 to 1994, the pharmaceutical group's return on equity (ROE) fluctuated between 15.2 percent and 28.8 percent, and the 1994 ROE of 25.4 percent was not far below the 1988 high of 28.8 percent. ROE for other chemical products companies over the same 14-year period ranged from 2.6 percent to a 1994 record of 18.4 percent.

The industrial chemicals ROE, however, ranged from the –4.4 percent low of 1992 to the 1988 high of 19.8 percent. For the cyclical industrial chemicals segment, 1994 was a very good year — one of the best in recent history. The U.S. economy was strong and growth rates in much of the global economy were good. As a result, demand for several basic chemicals was strong and prices were firm, though not at record levels. Indeed, 1994 may well represent the peak — or near-peak — of the current cycle and a match of favorable conditions unlikely to be sustained for long. Yet, industrial chemicals profits did not rise to new highs, and the 13.4 percent return on equity for 1994 was well below the levels of other recent cycle peaks. This may be a signal that if global competition continues to intensify, it will be difficult to sustain industrial chemical ROE around the 10.4 percent 1981–94 average, let alone to raise it.

Thus, a key question is whether the long-term returns for industrial chemicals and for other chemical products are sufficiently high to merit the new investment in both U.S.-based and foreign production facilities necessary to motivate and fund their international competitiveness needs. Unfortunately, when global investment requirements are considered, investment capital needs for industrial chemicals and other chemical products segments of the industry are likely to be much larger than those needed by the less capital-intensive pharmaceuticals companies. Construction of some industrial chemical production facilities may require investments of hundreds of millions of dollars, but new pharmaceutical production facilities are typically much less costly. Direct investments in foreign markets by the pharmaceutical industry will thus typically require relatively less capital than investments by the more capital-intensive industrial chemicals and other chemical product companies.

II. Forces Shaping the Industry

Many factors shape the international competitiveness of U.S.-based chemical production. A well-developed research and production infrastructure, access to competitively priced energy, and a variety of other factors discussed below currently allow the United States to be a low-cost production base for many chemicals. But in a fast-changing world these strengths are not immutable. Central to maintaining competitiveness are continued high and growing levels of R&D to develop new products and processes, and high levels of P&E spending to implement the new technologies and make the new products. In turn, however, high levels of R&D and growing P&E spending are in the longer term dependent on high and growing revenues and profits. The amounts and locations of investments in R&D and P&E respond to the signals provided by profits and rates of return. Profits and rates of return inadequate to motivate needed investments in R&D and P&E would ultimately jeopardize the longer term competitiveness of U.S.-based production.

Central to maintaining competitiveness are continued high and growing levels of R&D to develop new products and processes, and high levels of P&E spending to implement the new technologies and make the new products.

Profitability of the industry will be shaped by many forces, including the existing infrastructure and competitive advantages, U.S. access to foreign markets, the U.S. and world economic climates, and the resulting global chemical supply-demand relationships. Clearly, however, as the number of global suppliers increases, competition gets tougher. U.S. government regulatory and other policies that directly affect the chemical industry's U.S. costs of production and its profitability will become much more important in determining the industry's international competitiveness than in earlier years when the U.S. industry and producers in a few other countries were dominant in world markets.

Infrastructure and Sources of Current Strengths

The strong current international competitive position of the U.S. chemical industry stems from many factors, including the following:

The U.S. chemicals market is the world's largest. Although foreign trade is growing in importance, most of U.S. chemical production — about 85 percent of the total — still goes to U.S. markets. U.S. chemical producers thus are still less susceptible to foreign economic fluctuations, currency exchange rates, and the trade policies of other countries than are producers in most other countries.

Foreign investments provide critical access to foreign markets via exports from U.S. parent companies to their foreign affiliates.

The U.S. is the world's largest chemical producer country. The world's largest chemical market provides economies of scale for production of large volumes of a wide range of chemical products.

Investment in R&D and P&E is large. Large domestic markets, foreign markets accessed by direct investments, and a strong international trade competitive position over several decades have led to sustained high levels of R&D and P&E spending and development of an efficient U.S. research and production infrastructure that will be difficult for new foreign competitors to match.

Energy — a vital input to chemical production — is generally competitively priced in U.S. markets. Energy — for both feedstocks and power — is vital to chemical production. Chemical industry energy consumption is about 7 percent of the U.S. total.

An excellent port and internal transportation system effectively moves both energy inputs and industry products. This transportation system — including pipelines, inland waterways, railroads, and trucking — facilitates efficient production and distribution and the competitiveness of U.S.-based production in both domestic and foreign markets.

Large, well-established foreign direct investments are a major competitive asset. Direct investments abroad provide additional sales against which rising R&D and other costs can be amortized. The profits from foreign operations, license fees, and other charges levied on their foreign affiliates add to the strength of U.S. parent companies. Moreover, foreign investments also provide critical access to foreign markets via exports from U.S. parent companies to their foreign affiliates. At the same time, the large U.S. market attracts significant amounts of foreign investment and foreign technologies that also help to keep U.S. production competitive.

The dollar exchange rate provides a current but perhaps only temporary advantage. The dollar at mid-1995 was weak against the German mark and the Japanese yen. Given the linkages of the mark to other European currencies and the importance of the yen in Asian markets, the dollar was thus weak against the currencies of the majority of major chemical-producing nations. This provides U.S. producers with new advantages in the markets of major producer countries and in third country markets as well. In the longer term, however, neither industry competitive advantage nor increased U.S. living standards can be achieved by currency depreciation. A stronger dollar is desirable from the standpoint of members of the economy, and at least some near-term dollar recovery from mid-1995 levels vis-a-vis the Japanese yen and the German mark is seen as likely.

Chemicals has benefited enormously from the research done in U.S. universities and from the skills imparted to graduates of chemistry that do the R&D in individual companies.

The educational and business environment has helped to shape the industry's dynamism. Many intangible factors that will be difficult for other producer countries to replicate have contributed to the growth and advanced state of the U.S. chemical industry. A science-based industry, chemicals has benefited enormously from the research done in U.S. universities and from the skills imparted to graduates of chemistry that do the R&D in individual companies. Moreover, the United States is widely considered to have outstanding chemical engineers who can implement and bring into production the discoveries of laboratory scientists.

For example, U.S. chemical engineers and U.S. chemical engineering construction companies, widely judged to be among the best in the world, have been critical factors in the rapid development and global leadership of the U.S. petrochemical industry.

In addition, the U.S. business environment in several instances has been favorable, allowing the U.S. industry to develop its comparative advantages. For example, the United States is generally seen as now providing more favorable conditions for the growth of biotechnologies than some European countries. And, in earlier decades, the rapid growth of the auto and chemical industries was mutually reinforcing. The auto industry's rapid growth stimulated the demand for many basic chemicals and many new chemical products, and in turn, new chemical products promoted the advance of auto technology and stimulated increasing demand for autos. The interaction between the two industries continues today. Also important, the United States remains a dynamic society, generally open to new discoveries and products, an attitude that facilitates the growth and progress of science-based industries.

The factors noted above and other strengths typically make U.S. chemical companies both innovative and relatively low-cost producers of many products in today's world economy. But a growing number of new producers, such as Saudi Arabia and some other producers in energy-rich countries, may now have lower costs than U.S. producers. And, in a fast-changing world, existing U.S. competitive advantages could erode over time, perhaps more rapidly than they accrued.

In a global market the supply-demand imbalances in some basic industrial chemicals need only be relatively small to have significant effects on global prices and hence, on profits.

Global Supply-Demand Relationships

Countries that are industrializing aspire to have their own chemical industries. The role that chemicals play in enabling other manufacturing (and the value added by this role) makes the development of a chemical industry a critical step in the industrialization process. These characteristics have made the chemical industry highly globally dispersed; this dispersal can be expected to increase as more countries develop indigenous chemical production capabilities.

As has been noted above, the pharmaceutical portion of the chemical industry is more R&D-intensive and less capital-intensive than the other two segments. Moreover, pharmaceutical sales and profits are less susceptible to business cycles, tending to expand with the growth of living standards and health care in individual countries. And product differentiation and patent protection provide some insulation from business cycles and supply-demand mismatches. But the profits of the more capital-intensive industrial chemicals and other chemical products companies are sensitive to changes in prices and volumes. Their profitability has long been strongly affected by supply-demand imbalances resulting from mismatches in investment patterns and business cycles.

Industrial chemical companies have long lived with a boom-bust cycle, but in earlier years the domestic economy's business cycle was more dominant in determining their profitability than it is today. In earlier years prices were set primarily by the balance between U.S. supplies and U.S. demands. But in today's global economy, global supply-demand balances set prices for many chemicals. Moreover, in a global market the supply-demand imbalances in some basic industrial chemicals need only be relatively small to have significant effects on global prices and hence, on profits. Thus, a relatively modest global supply shortfall can produce sharp price and profit increases. But a similarly modest oversupply can significantly depress prices and profits in a global marketplace.

Thus, in an era where industry prices — and profits — are more and more set by global forces, the relationship between the global supply of chemicals and global demand will be an increasingly important determinant of the long-term profitability and competitiveness of U.S.-based R&D and production of industrial chemicals and other chemical products. This globalization of supply-demand relationships significantly complicates company investment, marketing, and competitiveness strategies — strategies that now must consider both global and national supply-demand trends.

Forecasting national supply-demand relationships is itself difficult and uncertain. But projecting global supply-demand relationships is fraught with so many uncertainties that the forecasts must be seen as highly uncertain at best. Forecasts of the supply side of the equation are tenuous. Plants announced as scheduled to be built may not be built, or construction schedules may be stretched out. On the other hand, continuous improvements and debottlenecking not reflected in supply projections can significantly raise the capacity of existing plants. And plants said to be scheduled for shutdown may instead continue to operate. As the number of suppliers increases, difficulties in forecasting and adapting to supply growth will increase.

Projections of global demand levels are also highly uncertain. The demand for chemicals fluctuates with and is amplified by the business cycle. Business cycles and resulting chemical needs of developed countries with established historical relationships of chemical demand to GDP growth ratios are difficult enough to forecast. But the chemical needs of rapidly industrializing countries highly dependent on exports for their economic growth are even more difficult to forecast. Moreover, in a number of developing countries where the growth in demand for chemicals will be high relative to economic growth rates, market assessments will be complicated by political volatility and/or the economic problems and difficulties inherent in the transition to a market-based economy.

Such volatility in developing countries may result in rather wide fluctuations in their economic growth rates and, hence, even wider fluctuations in their consumption of chemicals. As developing countries represent an increasing share of world output and consumption, global demand may thus not only become even more difficult to forecast but may also be subject to wider fluctuations.

Whether an increasingly integrated and more industrialized world economy will tend to aggravate or mitigate the effects of business cycles on a capital-intensive chemical industry with global production remains to be seen. In an environment of "rolling" business cycles — where different economies tend to be in different phases of the business cycle — fluctuations in the demand for chemicals would be smoothed by the offsetting effects of expansion in some economies concurrent with slow growth or contractions in others. But to the extent that the growing interconnection of economies resulting from increasing international flows of trade and capital brings more unison in business cycles, the effects on demand fluctuations will be aggravated.

Forecasts of global supply-demand relationships are thus problematic. But it may be rationally argued that the world supply of many basic industrial chemicals will — from the standpoint of producers — too often tend toward oversupply in the years ahead. Every developing country wants to build its own chemical industry. Other things being equal, more suppliers generally means tougher competition and a tendency toward overcapacity. If so, as the number of producers grows, the tendencies toward global oversupply will increase, and competition will intensify. Perhaps aggravating this tendency, developing countries intent on building their own chemical industries may not be guided solely by supply-demand relationships and short-term rates of return on investment but instead may be tempted to continue to increase their domestic production and to protect it from foreign competition.

In an ever more competitive global economy, a persisting global oversupply of basic chemicals could perhaps undermine the U.S. industry's profits for several years, and average rates of return could decline. Without strong profits and adequate rates of return, high levels of R&D and P&E investments at home and abroad may be difficult to maintain.

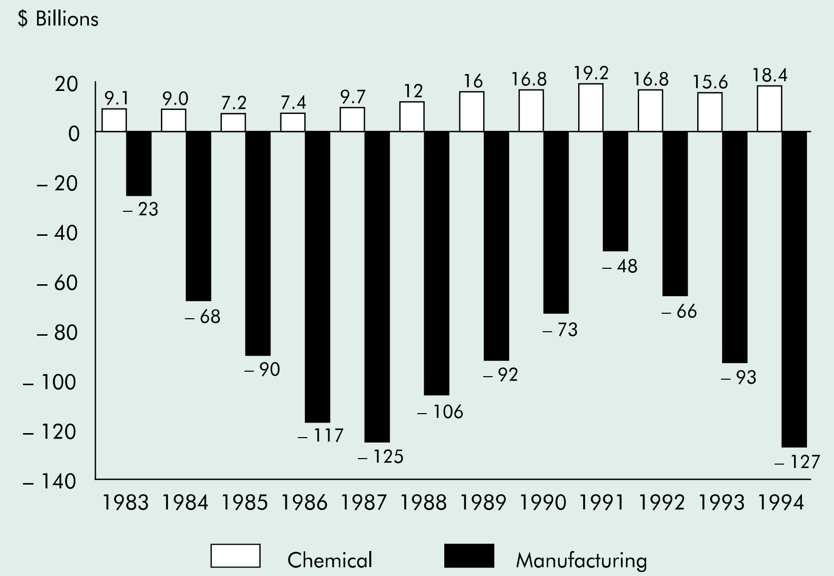
U.S. Economic Performance

The single most important factor in the U.S. chemical industry's output and profitability remains the state of the U.S. economy.

As noted above, the U.S. chemical industry's profits and its international competitiveness are substantially affected not just by U.S. economic performance but also by global supply-demand relationships that are set by trends and events in the world economy. Even so, the U.S. market for chemicals remains the world's largest, and, notwithstanding the growing importance of foreign markets, almost 85 percent of 1994 U.S. output was sold to U.S. customers. The single most important factor in the U.S. chemical industry's output and profitability therefore remains the state of the U.S. economy. Fluctuations in economic growth rates particularly affect the industrial and other chemical products segments, but all of the chemical industry has a vital stake in the long-term performance of the U.S. economy.

In addition, excepting pharmaceuticals, the chemical industry has a particular interest in the overall trade performance of its largest domestic customer. Other U.S. manufacturing industries provide the largest single market for U.S. chemicals, purchasing almost half of the chemical industry's total output. But taken as a whole, the international competitiveness of U.S. manufacturing has not been strong since the early 1980s. The last U.S. manufactures trade surplus was in 1981. Excluding the

Figure 19. U.S. Chemical and Manufacturing Trade, 1983–1994

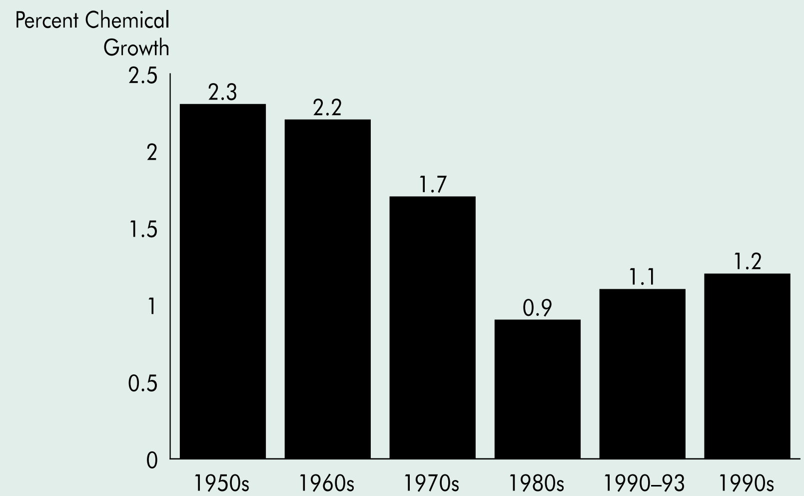


chemical industry surplus, the 1994 U.S. manufactures trade deficit was $145 billion, about 2.1 percent of U.S. GDP. The cumulative manufactures trade deficit for the twelve years from 1983 through 1994 was $1.15 trillion despite cumulative chemicals trade surpluses that totaled $157 billion (Figure 19). Had the U.S. achieved balance in its manufactures trade in recent years, the U.S. production of manufactured goods — and the manufacturing sector's consumption of U.S.-produced chemicals — would have been markedly higher. In a real sense then, large U.S. manufactures trade deficits represent significant sales losses to U.S. chemical producers.

According to widely accepted economic theory, the continuing large U.S. goods trade deficits manifest a low U.S. savings rate that in turn generates a need to import capital to finance government deficits and private sector investment. But major private savings rate changes are likely to be achieved only from significant and difficult-to-achieve changes in tax laws and/or from equally difficult major reductions in government deficits. Thus, large U.S. manufactures trade deficits, with their implicit losses to U.S. chemical production, will likely continue for some time.

The slowdown in chemicals demand growth relative to U.S. GDP growth in large measure reflects the growing share of "service" industries that are less chemical intensive, a trend unlikely to change.

Figure 20. Production Growth in U.S. Chemical Industry Production for Each 1 Percent GDP Growth



Notwithstanding continuing trade deficits, the near-term outlook for the U.S. economy appears good. But cyclical downturns and their effects on the U.S. demand for chemicals cannot be ruled out. Also, the sustainable long-term noninflationary growth rate of the U.S. economy is generally considered to be, at best, in the 2.5 to 3.0 percent range, well below the growth rates expected for a number of developing countries.

Moreover, the U.S. market for chemicals has matured and will not likely exhibit the rapid growth typical of earlier decades. During the 1960s each 1 percent of growth in U.S. GDP resulted in about 2.2 percent of U.S. chemical industry output growth. In the 1970s it was 1.7 percent. During the 1990s each 1 percent of GDP growth will likely generate about a 1.2 percent increase in U.S. chemicals output (Figure 20).

Why the diminishing chemicals-to-GDP growth relationship? Manufacturing and construction are two of the U.S. chemical industry's largest customers. The slowdown in chemicals demand growth relative to U.S. GDP growth in large measure reflects these industries' diminished shares of U.S. GDP and the growing share of "service" industries that are less chemical intensive, a trend unlikely to change. The discovery of major new chemical industry products or new uses for existing products could, of course, increase the ratio of chemicals output growth to U.S.

GDP growth. Significant increases in the ratio appear unlikely in the foreseeable future, however.

Faced with a maturing domestic market, several chemical companies sought increased growth and profitability during the 1980s by diversification — often by acquiring companies that would broaden their product lines. That strategy now appears to have been generally unsuccessful. Indeed, the recent trend has been toward divesting operations "outside the core competencies" of a company.

Continued growth in size and profits typically requires expansion into global markets, particularly fast-growing developing country markets.

"Restructuring" and "re-engineering" and various other terms cover continuing efforts to increase efficiency, productivity, and profits. But in a world of rapid communications and fast technology transfer, efficiency gains and product improvements from new technologies can soon be copied by competitors. And, to the extent that efficiency gains involve more or less arbitrary non-production personnel cuts, they cannot be continued indefinitely. Continued growth in size and profits, therefore, typically requires expansion into global markets, particularly fast-growing developing country markets.

World Economic Performance

Concurrent with maturing of the domestic market is the rapid growth in many developing country markets and the resultant growth in world chemical trade. Exports in 1994 were a record 15.1 percent of the chemical industry's shipments, and the exports portion will likely continue to increase. Moreover, increasing foreign production and competitive strengths are reflected in a growing foreign penetration of the U.S. market, with imports reaching a record 9.7 percent of U.S. shipments in 1994.

These factors and the major portion of the U.S. industry's sales and earnings that accrue from foreign investments point to a growing reliance on foreign markets for chemical industry growth and profitability. As noted earlier, profits of the capital-intensive industrial and other chemical products parts of the industry are strongly affected by capacity utilization rates and product prices. Strong global economic performance will be required to increase the global demand for chemicals in parallel with the expected growth of supplies. Slow global growth or a global recession, however, may let supply significantly outrun demand, putting pressure on profits. The future profitability of the U.S. chemical industry will thus be increasingly dependent on foreign economic growth and the resulting increases in demand for chemicals.

There will, of course, be major differences in the demand growth rates of individual countries. Just as the demand for chemicals has matured in the United States, so has it matured in other developed countries. While demand and production will continue to increase in the United States, Japan, the European Union, and other developed countries, growth there will be slower than in many developing countries in Latin America and Asia. Increasingly, a number of countries in those two regions will likely provide the most rapid growth in both export and investment opportunities.

These actual and projected demand growth differences are shaping the global marketing and investment strategies and decisions of both U.S. chemical companies and companies in other major producer countries. Investment decisions have always been difficult and uncertain in the chemical industry; they are likely to be even more so in the future.

Access to Foreign Markets and Protection of Intellectual Property

As noted earlier, the current strong foreign investment position is one of the major competitive strengths of the U.S. industry. Foreign investments not only add significantly to parent company income through foreign sales but also increase the parent company's exports from the United States. Looking ahead, foreign markets will become ever more important to U.S. chemical producers, both for exports and as locations for investments in production facilities.

The growing importance of foreign markets — particularly those in developing countries — underscores the importance of U.S. efforts to improve access for U.S. goods exports and direct investments in foreign markets. Completion of the GATT Uruguay round and the North American Free Trade Agreement provided major new opportunities for the chemical industry. But full implementation of these agreements will take several years and, even then, many barriers to U.S. trade and investment and to the protection of intellectual property will remain. This is particularly the case in a number of developing countries, some of which are fast becoming major chemical producers. Continued progress in opening access to exports and direct investments in these new markets is essential to the future strength and international competitiveness of the U.S. chemical industry.

Also particularly important is the protection of intellectual property — the honoring of patents and copyrights by foreign producers. While this protection is important to all of the science-based chemical industry, it is particularly critical to the highly R&D-intensive pharmaceuticals industry, whose high product development costs must often be recouped by global sales over extended time periods.

Government Policies

Setting aside the near-term effects of business cycles, existing strengths make the longer term outlook for U.S.-based chemicals production generally positive, perhaps as good as for any major U.S. manufacturing industry. Indeed, at this point in time U.S.-based chemical R&D and production is generally competitive with that of the other major producer countries. However, there will be many new competitors in the years ahead. Indeed, the greatest competitive threats may well come from production in countries that are not major producers today.

In large measure the industry's future will be determined by management's ability to anticipate and adapt to change.

Whatever may happen globally, the strengths and competitive advantages of the U.S. chemical industry are many and will not fade quickly. But in a fast-changing global economy, neither are they permanent or immutable. In large measure the industry's future will be determined by management's ability to anticipate and adapt to change. The industry's ability to achieve optimal allocations of investment capital between U.S. and foreign investments, to maintain high levels of productive R&D, and to meet changing global conditions with new products and processes that are competitively priced will clearly be critical.

But in growing measure, the competitive position of the industry will also be determined by a wide range of U.S. government policies. As previously noted, improved access to foreign markets, including protection of intellectual property, is a necessary condition to future U.S. chemical industry international competitiveness. But it is not a sufficient condition. In a world of intensifying competition, improved access is of little value if U.S.-based production and the products of U.S. research are not price competitive in both U.S. and foreign markets. U.S. economic and regulatory policies can and do significantly affect the costs and the rewards of U.S.-based R&D and production. Indeed, as globalization of the industry continues, the effects and importance of U.S. government policies will become more and more important. In earlier decades, when U.S. producers were often dominant, the effects of U.S. economic policies usually did not significantly affect U.S. international competitiveness. Cost increases could, for the most part, simply be passed on to buyers. In this earlier era, the industry's costs in large measure often determined its prices.

But in a new, increasingly competitive world economy, U.S. producers will be markedly less able to pass on cost increases that may result from domestic economic and regulatory policies — cost increases that competitors do not have to bear. Now, it has been said, prices often determine costs. That is, to remain competitive and to maintain performance levels that satisfy stockholders, costs may have to be cut to levels set by market conditions. But cost-cutting has its limits and some cost cutting — for example, reducing investments in R&D and new P&E — though good for short-term profits, may be bad for longer term competitiveness. In this new era, U.S. economic policymaking must recognize that U.S. manufacturing is no longer invincible — or even dominant — in world markets and is no longer able to shrug off the effects of U.S. policies. Today, the U.S. economy and the U.S. home market are much less insulated from foreign competition than before.

U.S. policymaking does not always recognize that many U.S. industries now compete in a world economy and that U.S. consumers draw from global suppliers. For example, the implementation of U.S. antitrust laws may discriminate in favor of foreign companies. Much of the foreign investment in the U.S. chemical industry that has taken place has been via acquisitions of existing U.S. assets by foreign companies. Many of these acquisitions might have been completed by U.S. companies but for antitrust laws designed to prevent unacceptable "concentration" of the domestic industry in the hands of fewer U.S. companies.

In a global economy, however, the unintended consequence of such restrictions may be to increase the global market power of foreign firms and the degree of concentration in global markets. It is certainly not clear in today's global economy that this kind of antitrust enforcement benefits U.S. consumers.

Environmental improvement regulatory measures have become ever more costly. The costs of further improvements will often be even higher and the benefits less certain. Greater environmental quality gains can be made at lower costs to members of our society, while maintaining the competitiveness of U.S. industry, by the consistent use of risk assessments, risk prioritization, and cost-benefit analyses. These techniques can be used to determine the societal costs and benefits of proposed regulatory measures and to identify the largest gains that can be had from the best use of our society's limited resources.

Many chemical companies are now truly global. Many chemicals are globally traded, and a growing number of firms operate around the world and purchase globally. Investment capital will flow to the most favorable production and distribution sites. Government economic and social policies directly shape a country's environment for production.

The profits and rates of return of industries that are capital-intensive, R&D-intensive, subject to high degrees of government regulation, and exposed to global competition are particularly vulnerable to the effects of government economic and regulatory policies. Few U.S. industries meet this description more perfectly than the chemical industry.

III. Competing in a Dynamic World Economy

The decade ahead is likely to be one of rapid changes for the chemical industry. Some trends affecting the industry seem evident and basic. But unanticipated political and economic events can wreak havoc with the accuracy of visions of the future. Forecasts of the competitiveness environment five to fifteen years hence are admittedly highly imperfect. Nevertheless, in an ever-changing world, several key factors in addition to the performance of the U.S. economy and the world economy will almost certainly have important effects on the U.S. chemical industry. These include the continuing advance of technology, environmental costs and product restrictions, the availability of energy, and continuing changes in the international geography of the consumption and production of chemicals. In turn, these factors will shape the amounts of new investment and the balance between domestic and foreign investments by the U.S. chemical industry.

The Advance of Technology

R&D will become an even more important factor in determining the competitive strengths of individual companies than it is today.

As the accumulated body of knowledge and technology increases, the pace of technological change is also expected to speed up. New information technologies and global competitive pressures will likely drive a more rapid rate of product and process innovations. In addition, pressures to conquer diseases and improve health, create new processes that reduce emissions, produce environmentally friendly products, and reduce production costs will almost certainly continue to grow. Given these health and environmental concerns and global competitive forces, R&D will become an even more important factor in determining the competitive strengths of individual companies than it is today.

Product and process advances will continue in every area of chemistry, with particularly rapid change in biotechnologies and the creation of new materials to be expected.

Advances in basic science in the fields of chemistry, biotechnology, and material technology will continue to be the foundation for growth in the chemical industry. The decade ahead will see new products and processes arising from the intersection of chemical sciences, biology, and physics, and integration with the enabling technologies of measurement and computation. The industry will use advanced process science and engineering to accelerate the commercialization of new technologies and radically improve existing ones.

Chemical Science, and specifically chemical synthesis, will focus on unique molecules and the improvement of chemistry and processes presently used in the industry. The existing chemistries and processes will be made more environmentally friendly and efficient. Catalysis will continue to be a major driver for new routes to new and exciting molecules, and new processes. The new or unique molecules will broaden the functionality of available chemicals and materials, enabling a more rapid rate of product and process innovation.

Biotechnology will expand in its practical use in industry. Biocatalysts, produced from enzymes, will provide routes to higher performance products. Biochemical Engineering will advance in parallel with technology. Efficient processes to convert biomass or purpose-grown feedstock crops into useful products will develop. The process will be cost effective for producing chemicals such as unique oils and polymers.

Material Science will also experience significant technology advances. Predication of material properties from the molecular level through the macroscopic level will lead to new synthesis techniques that will allow the manipulation of material structures with enhanced products properties. Enhanced performance materials structures will result in categories such as smart materials, higher temperature materials, biocompatible systems, and additives for polymers with reduced toxicity.

Process Science and Engineering will provide technology advancements resulting in reduced cycle times for product and process commercialization, more economic and environmentally friendly processes and products, supply chain integration and operations, agile manufacturing and delivery capability, integration of process units into common control and operating schemes, and process technology in reactors, separations, and other operating units.

Both Basic Science and Process Science and Engineering are supported by significant advances in enabling technology of Chemical Measurements and Computational Technology.

Advances in chemical measurements will allow more in-depth understanding that supports developments in chemistry, biotechnology, material science, and process science and engineering. Advances in this area will result in more precision, accuracy, and sensitivity. Measurements that were sophisticated a few years ago will be robust enough to be used routinely in a manufacturing setting with high reliability.

Advances in information and computational technology, with emphasis on integrated and transactionally current information systems will enhance operational effectiveness across the supply chains of the chemical industry. It will enable the rapid development of new products and processes through integration, modeling, and simulation. Computational technology will be advanced for use in areas such as fluid dynamics, molecular science, process modeling and optimization, and supply chain simulation. Data sharing and collaboration will occur across geographic locations.

Basic science, coupled with process science and engineering, will provide the chemical industry with its innovative growth. The enabling technology of measurements and information/computation will play a lead role in making it happen.

Quantum jumps in these and other technologies that would create whole new ranges of products and major increases in the demand for basic

Whether by quantum advances or via a continuing series of smaller discoveries, strong R&D performances have long been an important means by which the U.S. chemical industry has achieved both growth rates above those of the U.S. economy as a whole and strong international competitiveness.

chemicals — advances comparable to the discovery of plastics — are possible but not evident at this time.

But whether by quantum advances or via a continuing series of smaller discoveries, strong R&D performances have long been an important means by which the U.S. chemical industry has achieved both growth rates above those of the U.S. economy as a whole and strong international competitiveness. R&D will continue to be a key factor in determining the industry's future. There are, however, significant differences in R&D spending trends within the industry. Pharmaceuticals R&D spending now accounts for over half (57 percent) of the chemical industry's R&D spending, which totaled $18.0 billion in 1994 (Table 5). Pharmaceuticals R&D reached $10.3 billion in 1994, nearly five times the 1981 level of $2.1 billion, advancing at a growth rate far exceeding the pace of inflation. Over the 1981–94 period pharmaceuticals R&D has ranged from 8.1 cents per sales dollar in 1981 to a high of 12.0 percent in 1992 and a 1994 rate of 11.5 percent.[3]

The dominance of pharmaceuticals in chemical industry R&D is quite new. The industrial chemicals segment outspent pharmaceuticals in R&D in earlier years. But by 1983 rapid pharmaceuticals increases put it in the lead, and the margin has since continued to widen. R&D spending for industrial chemicals rose from $2.4 billion in 1981 to $5.1 billion in 1994, a 113 percent gain. Even so, it was only 28 percent of the industry total, down dramatically from the 46.0 percent share of 1981. Notwithstanding its share decline, industrial chemicals R&D spending has increased relative to sales revenues — from 2.5 percent in 1981 to 4.6 percent in 1991 and 3.6 percent in 1994.

High R&D investment has produced remarkable product advances that have benefited society and has been a major factor in the pharmaceutical industry's strong profit performance.

R&D spending by the other chemical products group is relatively small, 14 percent of the industry total. Relative to sales, however, its R&D spending has risen from 1.1 percent in 1981 to 2.0 percent in 1994.

The fast growth in pharmaceuticals R&D is part of "a virtuous circle." High R&D spending has both contributed to, and been facilitated by, strong profit performance. High R&D investment has produced remarkable product advances that have benefited society and has been a major factor in the pharmaceutical industry's strong profit performance. In

[3] In a more narrowly defined sample, the 1994 annual survey of research-based pharmaceutical companies conducted by the Pharmaceutical Research and Manufacturers of America (PhRMA) reports that U.S. pharmaceutical research and development expenditures were an estimated 19.2 percent of domestic U.S. pharmaceutical sales plus exports for its member companies.

Table 5. Research and Development

Research and Development (R&D) Expenditures (In millions of dollars)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Total Chemicals & Allied Products	5,204	6,197	6,792	7,736	8,310	8,664	9,445	10,573	11,383	12,276	14,439	16,421	17,176	17,999
Industrial Chemicals	2,393	2,810	2,828	3,057	3,281	3,374	3,531	3,763	3,960	4,272	5,225	5,152	5,004	5,105
Pharmaceuticals	2,064	2,473	2,896	3,310	3,481	3,657	4,095	4,743	5,164	5,366	6,947	8,822	9,653	10,326
Other Chemical & Allied Products	747	914	1,068	1,369	1,548	1,633	1,819	2,067	2,259	2,638	2,267	2,447	2,519	2,568

R&D Expenditures Relative to Revenues (Percent)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Average
Total Chemicals & Allied Products	2.8	3.3	3.4	3.7	4.1	4.2	4.2	4.0	4.1	4.3	4.8	5.2	5.3	5.0	4.5
Industrial Chemicals	2.5	3.2	3.0	3.1	4.1	4.1	3.7	3.3	3.6	3.8	4.6	4.2	4.1	3.6	3.9
Pharmaceuticals	8.1	9.2	10.0	10.7	9.9	9.7	9.5	10.3	10.1	9.1	10.3	12.0	11.8	11.5	10.4
Other Chemical Products	1.1	1.3	1.4	1.7	1.8	1.9	2.1	2.1	2.0	2.3	1.9	2.1	2.1	2.0	2.0

Source: National Science Foundation, CMA Estimates

turn, strong profit performance has motivated further increases in its R&D spending. The U.S. pharmaceutical industry leads the world in the discovery, development, production, and sales of medicinal drugs and is responsible for about one-half of all new patented drugs reaching the global market since 1970. The U.S. also holds a commanding lead in innovation in biotechnology medicines, surpassing both Japan and the European Union in the number of biotechnology patents and marketed products.[4]

Many of the resulting new pharmaceutical products have proven to be highly cost-effective for society in improving human health. The lives of an estimated 670,000 patients with coronary heart disease in the U.S. were saved over the last two decades with the assistance of new cardio-vascular medicines. Pharmaceuticals also helped to prevent nearly

[4] Redwood, Heinz. *Price Regulation and Pharmaceutical Research*. (Suffolk, England: Oldwicks Press). 1993.

From a societal viewpoint, market forces alone are unlikely to produce optimum levels of R&D.

500,000 stroke deaths and as many as 6 million nonfatal strokes in the U.S. over this same period.[5] At the same time, outpatient prescription drugs as a percentage of national health expenditures declined from 7.4 percent in 1970 to 5.5 percent in 1993.[6]

This virtuous circle of expanding R&D leading to health and cost-effectiveness advances will likely continue until broken by a reduction in profits and rates of return from R&D that causes a slowdown or reversal in the growth of R&D spending.

Such a reduction in rates of return on R&D could occur through the natural working of market forces if spending rises to the point where the pace of new discoveries simply does not merit further increases in spending. This could happen in a situation where more and more spending is applied to projects with smaller and smaller potential returns until the incremental additions to R&D costs begin to match or exceed the resulting increases in profits. But the growth of R&D spending can also be slowed — or even reversed — by government policies that reduce or limit profits and rates of return from R&D. Indeed, there is ample evidence to indicate that the caps placed on pharmaceutical prices by several European governments have lowered returns and markedly slowed R&D and the pace of new discoveries in several European Union countries that formerly had strong pharmaceutical industries.[7]

Research in the industrial chemicals sector also provides breakthroughs in a very wide range of products and processes that benefit society. Indeed, many advances in the formulation of new materials emanating from basic chemical research have been critical to the progress of medical science. But the profit payoffs to individual industrial chemical companies have not been as large, perhaps because the advances typically make small, incremental contributions to other products rather than providing new breakthrough, patentable finished products for delivery directly to the public. In any event, faced with more intensive global competition and lower levels of profits and rates of return, industrial chemical pro-

[5] Brown, Ruth E. and Luce, Bryan R. *The Value of Pharmaceuticals: A Study of Selected Conditions to Measure the Contribution of Pharmaceuticals to Health Status*. (Battelle Medical Technology and Policy Research Center, Washington, D.C.). March 1990.

[6] Health Care Financing Administration. Office of the Actuary, 1995.

[7] U.S. International Trade Commission. *Global Competitiveness of U.S. Advanced-Technology Manufacturing Industries: Pharmaceuticals.* (Report to the Committee of Finance, U.S. Senate, on Investigation No. 332-302 Under Section 332(g) of the Tariff Act of 1930). September 1991.

ducers have not expanded their R&D at rates comparable to pharmaceutical industry growth.

It is widely accepted that the returns to society from R&D are generally greater than the private returns to those who perform it. From a societal viewpoint, market forces alone are therefore unlikely to produce optimum levels of R&D. If this is so, R&D should be generally encouraged by governments, not discouraged. There is, however, no practical way to determine optimum levels of R&D or how government incentives might reach such an optimum.

There are some signs that a longer term slowing of both the growth in industrial chemical R&D spending and changes in research strategies may well occur.

Unfortunately, there are some signs that a longer term slowing of both the growth in industrial chemical R&D spending and changes in research strategies may well occur. For example, development research may be seen to offer quicker, more certain payoffs than basic research. In periods of tough competition and lean profits, companies may put more emphasis on product development expected to yield quick payoffs. This increase is typically at the expense of reduced attention to basic research that is not related to immediate customer needs and is not expected to produce profits in the near term.

There is evidence that such a move away from basic research may already be occurring. According to a 1994 CMA survey, its member companies (mostly industrial chemical producers) in 1995 planned to spend some 74.5 percent of their R&D budgets in "development," up from the 71.4 percent programmed for 1994 in the 1993 survey. Should this trend continue to develop, the short-term effects on profitability and competitiveness could be positive, but at the expense of foregone major fundamental breakthroughs and longer term profit and competitiveness gains.

In addition, there is concern that adapting to mounting environmental and product substitution regulatory requirements drains off financial and human R&D resources from other more productive uses. This could particularly affect the industrial chemical sector and contribute to a decline in international competitiveness.

Environmental Costs and Product Restrictions

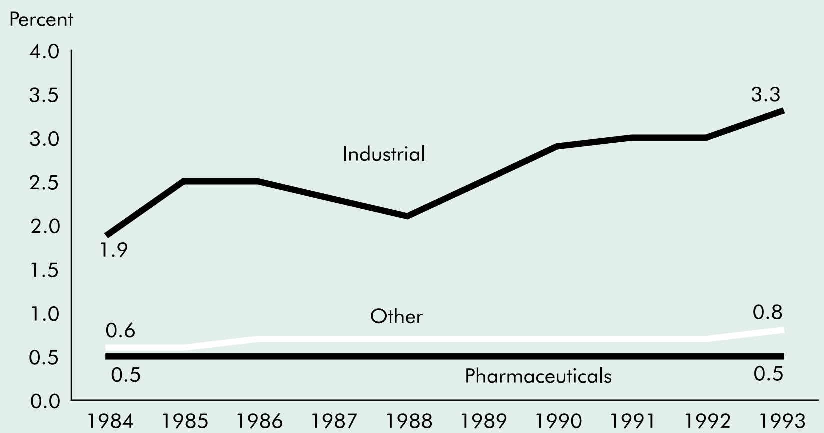
A large, productive R&D establishment is a key component in the long-term competitiveness of the U.S. chemical industry. But successful R&D programs alone are not enough. U.S.-based chemical production must be cost competitive. Rising environmental costs pose a threat to the competitiveness of U.S. chemical production, particularly for the industrial chemicals segment. Pollution abatement and control operating costs — only a fraction of total environmental costs — have risen dramatically in recent years and have become a significant drain on profits and rates of return. Industrial chemical companies' pollution abatement and control costs rose from 1.9 cents per sales dollar in 1984 to 3.3 cents in 1993 (Figure 21). For the years 1989–93, total pollution abatement and control costs for industrial chemicals companies of $14.3 billion slightly exceeded their $14.2 billion total after-tax profits.

Although the rising costs of environmental controls may not yet have caused major plant shutdowns, environmental costs have been a key factor in displacing the production of some chemicals — including a number of dyes and organic chemicals used in dye manufacturing — exclusively to non-U.S. locations.

Completing the implementation of existing regulations — examples include the Clean Air Act Amendments of 1990 and corrective actions under the Resource Conservation and Recovery Act — is likely to push these pollution abatement and control costs still higher and lead to other product migrations. In addition, the increasing difficulty and costs of obtaining permits and satisfying myriad litigants and interest groups may divert resources from new investments in U.S.-based production and increase the portion of total investment moving to foreign locations. New regulations would add to these burdens.

Proposals to ban or reduce the use of "toxic" chemicals embrace hundreds of chemicals, including both basic organic and inorganic chemicals essential to chemical processes. Advocates presume that "toxic" chemicals can be made unnecessary — and hence eliminated — by the substitution of benign, nontoxic chemicals into products and chemical processes. But in fact, substitutions are often chemically impossible — examples include the basic chemicals derived from crude oil and natural gas — or are not economically viable.

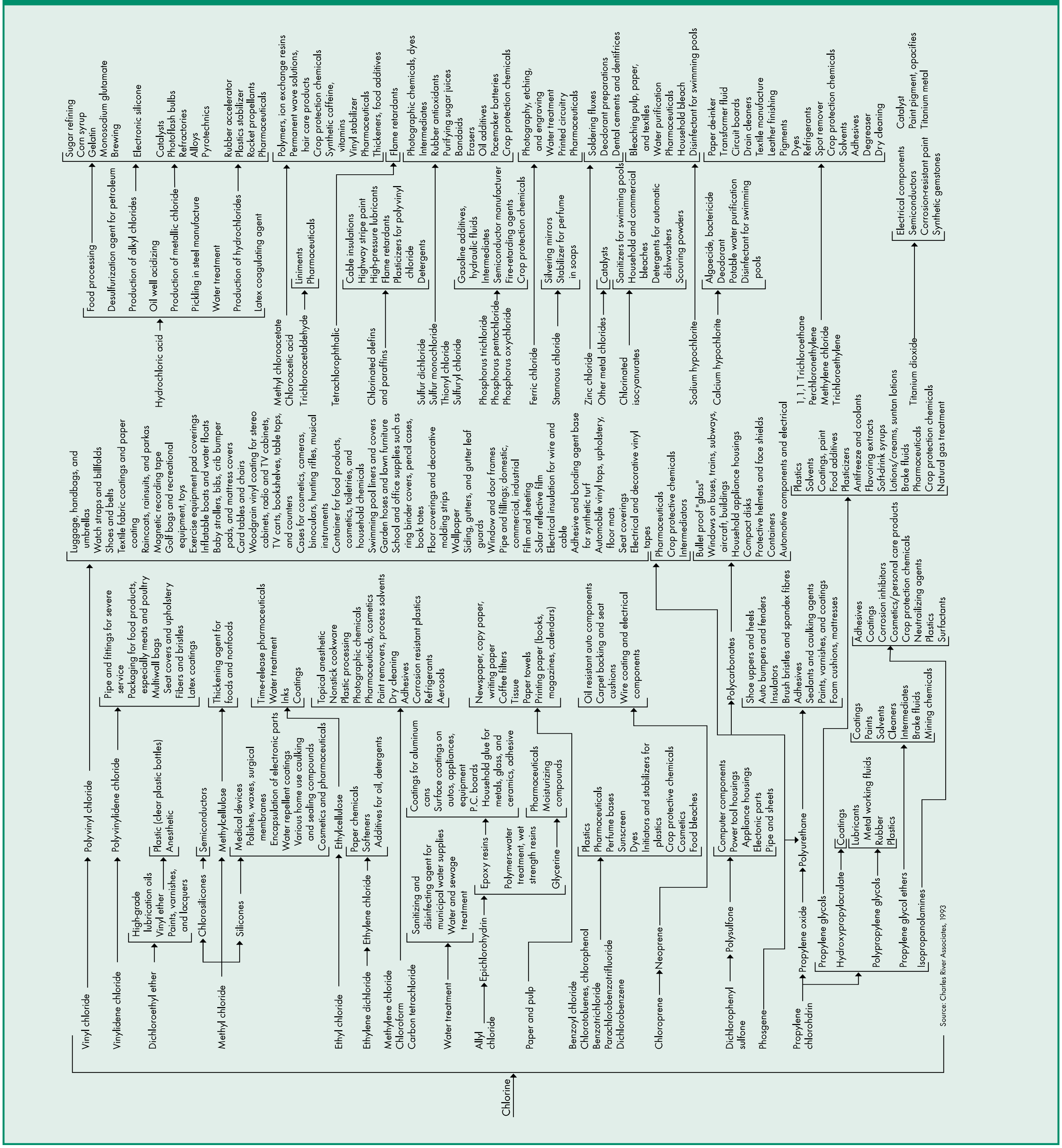
Figure 21. Increasing Cost of Pollution Abatement (Percent of Sales)



For example, the several hundred chemicals cited by activists for "reduction in use" typically include several of the eight basic building block organic chemicals derived from the refining of oil, and from natural gas and coal. Each of these basic building block chemicals, however, is not only an inevitable product of the refining process but is also an essential component for the production of thousands of other more highly refined "downstream" chemicals that, in turn, are essential to other chemicals and other products. Indeed, there could be no petrochemical industry — nor its consumer products — without these basic building block chemicals.

Chlorine, the primary inorganic building block chemical, has also been labeled as "toxic" and is the target of very active efforts by several groups who are calling for bans on its production and use. Chlorine and chlorinated compounds, however, are an essential family of chemicals in perhaps 50 to 60 percent of modern chemistry and are used in the production of about 85 percent of pharmaceuticals (Figure 22).

Figure 22. The Chlorine Chemistry and Product Tree



Given the irreplaceable status of the chemicals involved, reductions in the aggregate production or use of broad groups of "toxic" chemicals from both organic and inorganic sources cannot be accomplished while maintaining the growth in chemical industry production essential to support the nation's production, transportation, communication, and living standards.

Were these movements to succeed in the United States, chemical production would be forced to shift to other countries. Such reduction or elimination and the dislocation of production from the United States would result in enormous costs to our society.

Gradual changes in the composition of chemical production are likely, however. Continuing research, mostly sponsored by the chemical industry, may identify some individual chemicals meriting tighter controls or may even identify some chemicals that should not be manufactured or used. And ongoing research may also discover some new alternative products that are more environmentally friendly than products currently in use. Over time, environmental factors and the advance of knowledge may alter to some degree the composition and global locations of production. But the changes resulting from continued expansion of science-based knowledge about chemicals will be evolutionary and will not displace modern chemical production and its benefits from the United States.

A less dramatic, more subtle, but no less important threat to the industry's competitiveness is the future course of the nation's efforts to improve the environment through additional new regulations. The industry sees itself at a crossroads. The American public and American industry have spent billions of dollars for environmental improvement — much of that spending by the chemical industry. The governmental approach to environmental improvement has often been uncoordinated, responding to each new concern without much consideration of the benefits to be achieved and the costs to be borne.

Nevertheless, much has been accomplished. Emissions of chemicals to the air, land, and water have been sharply reduced, pollution prevention strategies have been adopted, and many other gains have been made. Although there have been numerous mistakes and inefficiencies, air, land, and water that were unquestionably polluted often offered obvious cleanup targets, and the cleanup measures taken provided equally apparent demonstrations of improvements.

Measures that yield a net benefit to our society and make effective use of our society's limited resources should be adopted, giving industry the maximum flexibility in deciding how to achieve the objectives most efficiently.

Now, however, government and industry face a time when the easier, less-costly innovations with the largest payoffs have largely been accomplished. The cost curve for added improvements gets steeper from here on. Further pursuit of emission reductions and some other environmental goals will be increasingly costly but will yield smaller and smaller gains of uncertain benefit to human health and the environment. Moreover, these increasing costs and declining returns will be encountered in an era of an intensifying struggle among producers for world chemical markets.

There is, of course, no identifiable "correct level" of spending for environmental, health, and safety improvements through government regulation and industry initiatives such as the Responsible Care® program. But given the progressively higher costs of further regulatory measures, the industry believes it is now critical — as never before — that careful assessments be given to new environmental regulations that are intended to continue the advances that have been made. The goal must be to focus scarce resources on the greatest threats and to preserve and enhance a high standard of environmental protection while providing balance and efficiency.

New measures should not be implemented absent a careful assessment to establish that the societal benefits justify, or are at least reasonably related to, the societal costs. These assessments should provide realistic estimates of the expected economic and social benefits, including the reductions of risks to human health and the environment. The assessments should also identify the offsetting costs — both economic and social — to society. Measures that yield a net benefit to our society and make effective use of our society's limited resources should be adopted, giving industry the maximum flexibility in deciding how to achieve the objectives most efficiently. Measures that do not yield a net benefit to our society and do not make the most effective use of its limited resources should not be adopted.

With few exceptions, environmental regulatory measures increase the chemical industry's operating costs and lower its ability to fund R&D and P&E investments. In the end, of course, these environmental compliance costs are not borne by "chemical companies" but inevitably are passed on to individual members of our society in a variety of ways. These include higher prices to consumers, lower wages to workers, lower profits that lead to diminished investment, lower productivity growth, and lessened international competitiveness for U.S.-based production that, in turn, results in job displacements.

But when environmental measures do yield a cost-effective net benefit to our society, the chemical industry must consider the resulting cost increases and competitiveness effects to be a necessary part of the cost of doing business. Moreover, environmental improvement is a global problem. When the United States adopts sensible, cost-effective measures that benefit U.S. society, sooner or later, other nations will likely adopt something similar, improving world standards while keeping some degree of international parity in environmental costs. Governments in competitor countries are, however, much less likely to follow a U.S. lead that is costly but provides little or no net benefit to our society.

Moreover, it should be recognized that environmental advances do not come solely from regulation by governments. The Responsible Care® initiative, first developed by the Canadian chemical industry, is now being implemented in 38 countries. The U.S. chemical industry and the chemical industries of other major chemical producing countries are active in advancing international acceptance of the Responsible Care® initiative as an effective, efficient way to achieve international environmental, health, and safety gains.

Effective, efficient use of limited resources to improve the environment is not just a matter of interest to the chemical industry and other U.S. industries. According to U.S. government data, the nation in 1993 spent about 1.72 percent of its GDP on pollution abatement and control — only one part of environmental costs. Pollution abatement and control costs have been projected by EPA to reach 2.83 percent of GDP by the year 2000, a significant portion of the nation's total output of goods and services. Every member of the economy has a stake in ensuring that the costs to our society of new environmental initiatives are merited by the benefits.

Every member of the economy has a stake in ensuring that the costs to our society of new environmental initiatives are merited by the benefits.

The Availability of Energy

Chemicals is an energy-intensive industry. Global supplies of energy in 1995 are ample and prices are relatively low. A marked increase in world energy prices relative to other goods and services would raise the costs and prices of chemicals relative to other products, with resulting downward pressures on chemical production and profits. Higher energy prices would also increase the competitive advantages of those producers that have access to inexpensive energy supplies and thus encourage additional chemical industry investment in energy-rich countries.

A dramatic increase in energy prices in the decade ahead cannot be ruled out but does not now seem likely. There is, however, another energy-related potential threat to U.S. chemical production because of fears about "global warming." There is worldwide concern that global temperatures may be rising as a result of man's activities. The potential threat is from carbon dioxide emissions from the burning of fossil fuels and from other emissions. Although it is uncertain that global warming will actually occur, as a member of the UN Framework Convention on Climate Change, the United States has pledged to reduce its "greenhouse gas" emissions to 1990 levels by the year 2000. Moreover, should the existence of a global warming problem and the linkage of fossil fuel consumption to that problem be confirmed, it may be seen as necessary to continue to control carbon emissions and perhaps to further reduce them below 1990 levels.

The chemical industry is a major consumer of energy. Powering chemical industry production processes, an activity that generates carbon emissions, accounts for about 3.5 percent of total U.S. energy consumption. Efforts to reduce U.S. carbon emissions would likely have significant effects on U.S. chemical production. In a favorable domestic and world economic climate, the volume of U.S. chemical industry output needed to satisfy domestic and export needs should increase about 3 percent annually, perhaps more if major new chemical-based materials are developed. In recent years the industry has made significant gains in energy efficiency, decreasing the energy consumed for fuel and power per unit of output by about 40.1 percent over the 1974–94 period. But the potential for further efficiency gains is limited. It is highly unlikely that energy efficiency gains would be able to offset the increased energy consumption required to power the chemical production increases foreseen in an environment of good U.S. and world economic growth rates.

Determined action to constrain or reduce U.S. energy consumption and carbon emissions through taxes or by other means would clearly have dramatic effects, significantly reducing U.S.-based chemicals production. Unilateral U.S. action — or actions that involved only developed countries — would simply act to stymie reinvestment in the United States and other developed countries and to accelerate the growth of investment and production in developing countries, without achieving global emission reductions. But a difficult-to-achieve global agreement that included developing countries in emission reduction goals would also likely sharply alter both the amount and the distribution of global chemical production.

Changing Geographic Composition of Production and Consumption

The geography of world chemical consumption and production is changing rapidly. The markets for chemicals in major developed countries are maturing. Economic growth in most developed countries is expected to be only moderate, and their demand for chemicals is expected, on average, to grow only slightly faster than their relatively slow economic growth rates. In contrast, many developing countries are industrializing and growing rapidly. Moreover, the demand for chemicals in countries at early stages of their economic development may increase at two or more times their economic growth rates. Industrializing countries that may experience rapid growth in consumption of chemicals include China, India, Indonesia, the four "Asian Tigers" (South Korea, Taiwan, Singapore, and Hong Kong) and several Latin American countries.

The needs of developing countries will provide growing export opportunities for developed countries. But every developing country wants to build its own chemical industry for a variety of reasons noted earlier. This implies a continuing global diffusion of chemical production and consumption among new producers. As more and more countries industrialize, the shares of global chemical production and consumption held by the current major producer countries — the United States, Western Europe, Canada, and Japan — will likely decline.

In this kind of environment, how does the U.S. chemical industry — defined as U.S.-based R&D and production, regardless of the nationality of its ownership — survive, grow, and prosper? How can U.S.-based R&D and production maintain strong global competitiveness?

U.S. Chemical Industry Competitiveness and Foreign Investments

An important — though seemingly anomalous — conclusion of this study is that a major factor in the current competitiveness of the U.S. chemical industry is its existing strong foreign investment position. There is every indication that foreign investment will be even more critical to the industry's future competitiveness. Why is this so? How can foreign investment aid the competitiveness of U.S.-based R&D and production?

Foreign investments have provided economies of scale to the U.S. industry, allowing larger efficiency gains and R&D expenditures than would otherwise be possible.

Increased foreign investment in new, fast-growing markets is essential if the U.S. chemical industry is to maintain its future competitiveness.

As noted earlier, foreign investments now enhance U.S. competitiveness by expanding export opportunities and by enlarging the sales and profits base against which R&D and other fixed costs of U.S.-based companies can be amortized. Foreign investments thus have provided economies of scale to the U.S. industry, allowing larger efficiency gains and R&D expenditures than would otherwise be possible.

What role will foreign investment play in the industry's competitiveness in the years ahead? Most of the foreign investments of U.S.-owned chemical companies are now in other developed countries — Europe, Canada, Japan — where chemical markets are maturing. The growth potential of investments in these developed country markets is positive but limited. Increased foreign investment in other new, fast-growing markets is essential if the U.S. chemical industry is to maintain its future competitiveness.

Looking to the future, the need for a geographic realignment of U.S. company resources seems evident. More than three-fourths of the $51.3 billion total 1994 book value of the U.S. industry's direct investments is in Europe, Canada, and Japan. Less than 15 per cent is in 11 fast-growing countries — Mexico, Brazil, Argentina, Venezuela, South Korea, Taiwan, China, India, Indonesia, Philippines, Thailand — with high economic growth potential that have some 2.8 billion people, more than half of the world's population.

A trend toward geographic reallocation of industry investment is already evident. U.S.-based multinational chemical companies — those headquartered in the United States with affiliates in foreign countries — continue to make the bulk of their new plant and equipment investments at home. But changes in the distribution are occurring.

According to a 1994 CMA economic survey, the larger U.S.-based member companies — those with annual U.S. sales over $1 billion — put 72.6 percent of 1994 P&E spending in the United States but expect that by 1999 the U.S. share will decline to 64.8 percent. The smaller companies — those with annual sales less than $1 billion — put 86.9 percent of their 1994 P&E spending in the U.S. but see that declining to 80.5 percent in 1999.

The CMA survey also shows a projected decline in the portion of total new investment going to the more mature foreign markets — Western Europe, Canada, Japan — and increases in the faster growing markets, including the Asian NICs (Singapore, Taiwan, Hong Kong, South Korea), other Asian countries, Eastern Europe and countries of the former Soviet

Union, and Latin America. For example, according to the 1994 CMA economic survey, the larger U.S. companies (those with annual U.S. sales over $1 billion) put 12.2 percent of their total 1994 investment in Europe and 1.9 percent in Canada. But the survey indicates that by 1999, Europe would get only 8.5 percent, and Canada only 1.4 percent, amounts that may maintain existing output levels but probably would not support major production increases in those markets.

Major multinational chemical producers headquartered in other countries will likely make similar investment reallocations. Because of the maturing of their own domestic markets, they will also shift increasing portions of their total investment in new P&E from domestic production to foreign production. For example, many analysts feel that few, if any, new petrochemical plants will be built in Europe. Instead, major European companies will put an increased portion of their investment in foreign production locations and markets. In the past, the bulk of the foreign investments by European producers was in other developed countries, much of it in the United States. But in the future, the flow of investment between major producer countries will likely decline in relative importance. That is, increasing portions of the total foreign investment of other major producer countries will go to developing countries, declining portions to the home country and to the U.S. and other developed country markets in which they are already invested.

New Foreign Investment Strategies and Problems

Continuing rapid industrialization and strong economic growth rates in many developing countries should cause world trade in chemicals to continue to rise considerably faster than world chemical production, perhaps twice or more as rapidly. This will provide export opportunities for established producers. Export markets should be particularly strong for specialty chemicals not yet produced in countries that are in the earlier stages of developing their own chemical production capabilities. But foreign investments will likely be even more critical than exports to the longer term competitiveness of producers in developed countries.

As a result of population gains, industrialization, and rising per capita consumption, the Asia-Pacific demand for chemicals is expected to grow at twice the rate of developed country markets.

How will foreign investments be allocated? How will choices be made? What will be the limiting factors? Continuing the trends of recent years, most analysts expect the highest economic growth rates — and the more rapid growth of chemical needs — in Asian-Pacific countries. This rapid growth is expected to result both from industrialization and from high population growth rates. The population of the Asia-Pacific region, apart from Japan, is expected to increase by 15 percent — by some 270 million people — in the decade ending with the year 2000, more than double the percentage growth for the United States and Western Europe. Moreover, growth in the high consumption 20–40 age group will account for much of Asia's population increases. As a result of population gains, industrialization, and rising per capita consumption, the Asia-Pacific demand for chemicals is expected to grow at twice the rate of developed country markets — perhaps significantly faster in some of these countries.

But the potential for more rapid economic growth in Latin American countries is also high. In addition, there is significant economic recovery potential in the Eastern European countries and the countries that formerly made up the Soviet Union.

Competition among established producers for export and investment footholds in some of these developing country markets will likely grow. The United States has strong economic and cultural ties with Latin America and location advantages compared to some other producers. These already existing U.S. export and investment advantages could be further increased by expansions of the NAFTA to include countries in Central and South America.

Japan may have similar cultural and locational advantages in exporting to many developing Asian countries. To date, however, Japan's large and sophisticated chemical industry has not been as export-oriented as many of its other manufacturing industries. Indeed, in 1994 only about 10 percent of Japan's chemical production was exported, less than the 15 percent share exported by U.S. chemical manufacturers. In essence, Japan's chemical industry has focused primarily on supporting Japan's large manufacturing sector and on other domestic needs. Neither has the Japanese chemical industry in the past been a very aggressive investor in foreign markets. This may be changing, however.

Western European producers — particularly Germany — probably have cultural and location advantages in Eastern Europe and countries of the former Soviet Union and can be counted on to move aggressively to export to and invest in those markets. European producers, however, may be better able to serve growing needs of their eastern neighbors by exports than can other suppliers. Recognizing this, they may choose to use their limited direct investment capital primarily in other markets — such as Asia — where they do not have similar export advantages.

Rapid growth and industrialization in many developing countries should provide not only many opportunities for goods exports and direct equity investments but will also create many opportunities for the sale and licensing of technology to foreign affiliates.

Competition may be stiff among established producers to be first with direct investments in the best new fast-growth markets.

Given these potential payoffs, competition may be stiff among established producers to be first with direct investments in the best new fast-growth markets. Such competition could lead to a capital shortfall for individual companies. But today many developing countries pose high economic and political risks. These risks and the many other barriers to foreign investments (e.g., flawed legal systems, lack of intellectual property protection, export requirements, capital repatriation restrictions, etc.), rather than lack of capital are probably the more important restraints on increased investments in most developing countries.

Clearly, the risks and barriers associated with investing in many of these new markets remain high. Political upheavals and cyclical downturns or faulty economic policies could cut or reverse economic growth rates and jeopardize reform movements, discouraging new foreign investments. Certainly, uninterrupted political and economic advances by all — or even most — of these growth markets are not likely. But over the longer term, if confidence increases in the political and economic futures of even some of the larger countries such as China, Indonesia, and India, the scale of capital requirements could exceed anything seen before. In such a climate both financial and human capital for U.S. chemical industry investments would likely be strained and probably inadequate to fill the needs of all the desirable projects.

Financial capital may be a particular problem. Funding expansions is often difficult for capital-intensive industries. In recent years the growth of U.S. chemical industry direct investment to all destinations abroad has been quite modest — significantly slower than the growth of foreign investments in the U.S. industry. The flow of new investment capital to fast-growth developing countries has also been quite modest. For example, of the $6.85 billion 1992–94 gain in the book value of foreign chemical investments by U.S. companies, only $406 million was in South America and, excluding Japan, the book value of chemical direct investments in Asia actually declined by $266 million.

Moreover, most of the rather modest growth in U.S. chemical industry foreign direct investments that actually did occur was through reinvested earnings — reinvestments in the host country of the profits made in that country. Indeed, over the seven years 1987 through 1993, rein-

A shift of investment focus from developed to developing countries will likely put increased demands on the reinvestment of industry profits, including the profits from domestic operations.

vested earnings provided an amount equivalent to 84 percent of the net increase in the book value of U.S. chemical industry foreign investments. This heavy reliance on reinvested earnings tends to an expansion of investments in existing foreign locations, rather than to investments in new areas.

Given these tendencies, a shift of investment focus from developed to developing countries will likely put increased demands on the reinvestment of industry profits, including the profits from domestic operations. It will likely also lead to more partnering with local foreign operations — more joint ventures, cooperation agreements, licensing, and other arrangements that reduce the need for U.S. investment capital. These arrangements, however, also reduce downstream control and returns.

The industry's investment capital problems are likely to be particularly difficult for the highly capital-intensive industrial chemicals segment, which in 1994 had $199,000 of fixed capital per employee, compared to $118,000 per employee for pharmaceuticals and $109,000 for other chemical products. New industrial chemical plant construction often requires very large amounts of money — hundreds of millions of dollars — and several years to complete. In addition, the return on investment has typically been significantly lower for industrial chemicals than for pharmaceuticals.

Expanded foreign investments pose less of a potential problem for the more R&D-intensive, more profitable pharmaceutical industry. Establishing foreign production for pharmaceuticals is typically less costly than construction of major industrial chemical production facilities. Foreign investments are a relatively more efficient way to leverage the returns from existing levels of pharmaceutical R&D.

To summarize, the growing portion of total plant and equipment investment that is being allocated to foreign locations need not signal a coming decline in U.S. competitiveness. On the contrary, it seems critical to maintaining the competitiveness of U.S.-based production. Indeed, in a period of sustained global economic advance, the global opportunities for foreign direct investments in chemical production facilities may well substantially exceed the financial capital and other resources available to established, developed country chemical companies. In that situation, finding the financial and human capital to provide the same investment footholds in the new, fast-growing markets that it now enjoys in the more mature, developed country markets is likely to be one of the U.S. chemical industry's most difficult and critical problems. These limitations are likely to particularly affect the capital-intensive, less profitable industrial chemicals portion of the industry.

IV. Major Determinants of Future Competitiveness

This paper seeks to identify the most important of the many interacting factors that will determine the future competitiveness of U.S.-based chemicals R&D and production. In the description that follows, the determining factors are separated into those that are "internal" — under the control of individual companies — and those that are "external" — those over which companies have no control. First, however, a description of the characteristics of an internationally competitive U.S. chemical industry in the period five to ten years hence is provided.

Defining "Success" in the Next Decade

In a world economy that is experiencing rapid change and a continued "globalization" of production, what will likely be the indicators of an "internationally competitive" U.S. chemical industry five to ten years from now — in the years 2000 to 2005?

In a world of generally good economic growth rates, and one in which many developing countries have high growth rates and are striving to build their own production capabilities, the U.S. shares of world production and world exports of chemicals will likely be smaller than today's shares. A major shift in the locus of world chemical production may well now be occurring, with diminishing portions in Europe and North America and rising portions in Asia and, perhaps, in South America. This need not, however, be indicative of a loss of international competitiveness of U.S.-based production by 2005. Rather, a shift in the locus of chemical manufacturing may be the inevitable result of the rapid growth of the production and consumption of goods and services and the rise of living standards in many developing countries — events that U.S. policies have helped to forge.

In that kind of environment, the U.S. chemical industry will be even more globally oriented than it is today, and a strong, internationally competitive U.S. chemical industry — defined as U.S.-based chemicals R&D and production — would likely be evidenced by:

- domestic production volume growth averaging around 3.0 percent annually, modestly above the rate of real GDP growth;
- relatively stable total chemical industry employment, with productivity gains roughly equal to production growth;

- export growth of about 8 to 12 percent per annum, well above world economic growth rates, but reflecting strong participation in the growth of world chemical trade;
- continued strong trade performance, with trade surpluses somewhat above current levels and growing modestly;
- exports and imports both rising percentages of total U.S. industry shipments;
- U.S. shares of world chemical exports and imports that, while gradually declining, are declining in parallel;
- strong levels of domestic P&E spending to support continued future domestic productivity growth and output expansion, but coupled with more rapidly rising amounts of investment in foreign locations, particularly in markets with high growth potential;
- rising portions of total U.S. industry income from foreign investments and the licensing of U.S. technology, resulting in continued, modestly growing U.S. surpluses on chemical industry "services" trade;
- increasing expenditures for R&D, with the bulk of R&D continuing to be performed in the United States;
- appropriate balance between basic and applied research, resulting in an enlarging stream of new products and processes and continued U.S. technological leadership;
- environmental costs that, while continuing to rise in dollar terms to meet increasing environmental standards, level off and begin to decline relative to sales; the decline relative to sales occurs as a result of improved regulatory policies and processes and through increased flexibility and cost-effectiveness allowed companies in meeting environmental goals.

There is one additional indicator of a strong U.S. industry that is necessary to achieving other key indicators:

- profit levels and rates of return must be adequate to motivate the required high levels of R&D and domestic investment, as well as to provide the capital for growing amounts of foreign investments.

The U.S. chemical industry's profitability and its future competitiveness will in large measure be determined by its own decisions — by decisions on internal factors that are within the direct control of the industry. But its competitiveness will also be very much determined by the external environment — by factors that are not within its direct control.

The U.S. chemical industry's profitability and its future competitiveness will in large measure be determined by its own decisions.

Critical Industry Choices Affecting International Competitiveness

Innumerable management choices made in thousands of U.S. companies will in large measure shape the future competitiveness of the U.S. chemical industry. But a few factors seem particularly critical:

- Industry growth strategies;
- Costs of production;
- P&E Investment amounts and locations; and
- R&D amounts and strategies.

Growth Strategies

Faced with a maturing domestic market, some U.S. chemical companies have sought growth by diversification — by acquiring other companies to broaden their product lines and increase sales. Generally, the diversification strategy failed, and the recent trend has been to sell off many components of businesses not closely related to a company's central product line to allow management to concentrate on the company's "core competencies." In an evermore competitive global economy, it seems likely that this concentration on enhancing core competencies will continue.

Major technological breakthroughs that result in large increases in the total domestic consumption of chemicals could provide dramatic new growth opportunities in the decade ahead, but do not seem likely. In the absence of such technological breakthroughs, although individual companies will battle for greater U.S. market share, the major source of future growth for most companies — and the major source for the industry as a whole — must be foreign markets. Such an expansion will be essential in part to provide a growing revenue base over which to amortize the

In today's global economy, foreign markets cannot be seen as residuals but must be part of long-term strategies.

increasing cost of the R&D that, in turn, is essential to develop the new products and processes necessary to maintain international competitiveness.

In part, this expansion into foreign markets can be accomplished by a growth of exports from the United States. In the past, some U.S. chemical producers have looked on export markets primarily as outlets for excess production when the U.S. economy was slow but neglected these markets when strong U.S. economic growth kept the domestic demand for chemicals high. In today's global economy, however, foreign markets cannot be seen as residuals but must be part of long-term strategies. But many large foreign markets cannot be adequately served simply by exporting from the United States. For the most part, competing successfully in major foreign markets will require investments in production facilities in those key markets; investments that, in turn, will enhance exports from the United States. There is thus a seeming anomaly — a large expansion of U.S. foreign investments is essential to sustained strong U.S. export performance and to the continued competitiveness of the U.S. chemical industry.

Shortfalls of financial and human capital will likely make full representation in new foreign markets difficult. This may lead to increased use of joint ventures and various forms of cooperation agreements with companies in the host countries.

Costs of Production

There are many reasons to believe that competition will continue to intensify in the years ahead. Global competition is already tough and the technology and efficiency of producers in other developed countries continue to improve. Moreover, with the rapid addition of new producers in developing countries, if global supplies expand more rapidly than global demand, producers in those countries that have low-cost energy supplies, governmental subsidies, or other forms of production incentives will provide particularly difficult competition.

To survive, grow, and prosper in the global economy, the costs of U.S.-based production will have to be favorable compared to producers around the world. Only part of the costs of U.S.-based production are controllable by individual companies. Many costs — taxes in many forms, the cost of capital, costs of environmental controls — are determined by government or other external factors. But remaining a low-cost producer nevertheless will require that companies make many decisions correctly about those factors that are under their control. Surviving and prospering will, for example, likely require continuing “restructuring” or “re-engineering” to cut costs and increase profitability as well as to adapt to changes in customer needs and to changing competition.

Restructuring in the form of people-cutting to achieve profit enhancements can have strong immediate effects on profits. But personnel reductions cannot be pursued indefinitely. Moreover, other kinds of efficiency gains usually can be copied by other producers and offer only temporary competitiveness advantages. In today’s highly competitive environment, adding greater value to the product than that added by competitors is now a key strategy goal of many companies. R&D that provides new products and processes is one route to adding greater value. Another is evaluating and adapting to changes in the market place. Change is, of course, not new to the chemical industry. But “globalization” implies increased competition that generates a more rapid pace of change. Moreover, it requires attention and response to global — not just domestic — changes in customer demands and competitor strategies.

Making the Right Investment Amount and Location Choices

Making the right investment choices — decisions about timing and amounts, choices about adding new capacity vs. modernizing existing capacity, and many other investment choices — have always been critical. Typically, the industry has invested when it had money — when profits were high. Many companies thus invested at the same time, with resulting capacity growth subsequently outpacing demand. But now the choices also must often include the appropriate profit-maximizing split between domestic and foreign investment. Difficult decisions must also be made about the alternative locations of foreign investments. Some foreign countries offer potentially higher rates of return but also may involve larger economic and political risks than investments in the United States or in other foreign locations. Again, the focus of investment strategies must be global — not just domestic. For some companies this may require new information and skills.

Making the Right R&D Amount and Composition Choices

High levels of R&D investment have made the pharmaceutical segment of the U.S. chemical industry a profitable one and a world leader in

Ability to fund the escalating costs of R&D at levels necessary to retain industry leadership is ultimately determined by industry profitability.

health-improving technical breakthroughs that have been cost-effective for U.S. society. High levels of pharmaceutical R&D will continue as long as rates of return are sufficient. But a nonstop flow of new products and processes is also essential to continued strength of the other segments of the U.S. chemical industry.

Ability to fund the escalating costs of R&D at levels necessary to retain industry leadership is ultimately determined by industry profitability. R&D spending is a form of investment and, as with investments in plant and equipment, R&D budgets inevitably are affected by profits. Profit shortfalls put downward pressure on total R&D budgets and tend to press the balance of spending away from “pure” or fundamental research that offers large but uncertain long-term payoffs and toward “applied” research that offers less uncertainty in return for smaller, quicker results. Rising R&D costs may also provide an important motivation for mergers and joint ventures and other forms of cooperative arrangements among companies. The result may be fewer but larger companies and perhaps some reduction in the total amount of R&D resources as a result of the consolidation.

None of the three major segments of the U.S. chemical industry is likely to remain internationally competitive without the technology leadership provided by sustained global R&D leadership. But while strong R&D performance is a necessary condition to continued competitiveness of the U.S. chemical industry, it is not a sufficient condition. New technologies are now easily transferred to foreign production locations. At best, new technology typically provides only a brief advantage to production in the technology-originating country. Strong R&D performance alone will not sustain production in a country that has an unfavorable production cost environment.

External Factors Determining Chemical Industry Competitiveness

The ability of individual U.S. producers to compete successfully in a global economy will be only partly determined by internal factors — by individual company decisions. Many external factors beyond management’s control will also be critical. These include:

- the domestic U.S. economy and U.S. economic policies;
- the world economy;
- export and investment access to foreign markets;

- global protection for intellectual property; and
- U.S. regulatory policies.

The Domestic Economy and U.S. Policies

Because the United States will remain its single largest market, strong sustained economic growth in the United States and a resurgence of the competitiveness of U.S. manufacturing are both important to the U.S. chemical industry. Economic policies that promote those goals are therefore of great importance to the industry.

Domestic economic policies will also directly influence the competitiveness of U.S.-based chemicals production in both U.S. and foreign markets. For example, energy and tax policies will do much to affect U.S. production costs, international competitiveness, profits, and rates of return on investments in the United States and, therefore, company choices between investments in U.S.- and foreign-based production.

Most important, however, is the overall business climate that results from the web of government laws and policies. Only a profitable U.S. chemical industry can generate the capital needed to fund the needed R&D and domestic and foreign investment. Tax laws have particularly powerful effects on the amounts and location of new investments and R&D spending. Fundamental but difficult-to-achieve changes in U.S. tax laws — changes that, for example, would eliminate the double taxation of corporate earnings and raise U.S. savings rates — would do much to stimulate the new investment and R&D spending required to maintain the competitiveness of U.S.-based production in an increasingly competitive global economy.

The World Economy

Increasingly, success of the U.S. chemical industry will be determined by its performance in the global marketplace. A rapidly growing world economy will aid the competitiveness of U.S.-based production. Growth that raises global demand in rough parallel with the growth of supplies will help to maintain profitability at levels that facilitate additional foreign investment. Good global growth rates will also encourage the reduction of remaining barriers to trade and investment.

Export and Investment Access to Foreign Markets

As foreign markets become relatively more important to the success of the domestic industry, the importance of access to foreign markets will increase. Despite recent gains, many impediments to exports and investments remain — particularly in developing countries. Continued lowering of these barriers, achieved through global, regional, or bilateral agreements, is essential to the continued strength of the U.S. chemical industry.

Global Protection for Intellectual Property

As the science and technology edge of U.S. companies becomes more and more important to their international competitiveness, adequate global protection of intellectual property will become ever more critical.

In an intensely competitive world, successful R&D resulting in a continuing stream of new products is essential to U.S. competitiveness. But the returns from R&D are reduced by unlicensed copying of innovative products and processes — the theft of intellectual property that was generated at high costs to those who initially performed the R&D. As more countries increase their chemical production, the potential for intellectual property theft will increase. As the science and technology edge of U.S. companies becomes more and more important to their international competitiveness, adequate global protection of intellectual property will become ever more critical.

U.S. Regulatory Policies

As global competition becomes tougher and tougher, the costs of environmental and other U.S. regulatory policies will become more important. The burden of environmental costs has become particularly significant for the industrial chemicals segment of the chemical industry and weighs heavily on profits and investment decisions. Continuation of the trend of increases in environmental costs relative to sales will further decrease the competitiveness of U.S.-based production and further increase the portion of total investment allocated to foreign production, particularly in the case of industrial chemicals.

In the pharmaceuticals segment, compliance with increased regulatory requirements has lengthened the average drug development and approval time, increasing costs and delaying the introduction of beneficial new products. The United States continues to lag behind other countries in the timing of new drug approvals.

Rising regulatory costs have other effects as well. Beyond measured dollar costs, there are also opportunity costs in regulatory compliance — for example, diversions of limited company resources from other P&E and R&D investments.

Two steps are essential to achieve the greatest environmental gains while minimizing the effects on the competitiveness of domestic investment and production. First, ensure that the economic and social benefits of new regulations to our society exceed the economic and social costs. Second, when additional regulation is merited by expected net gains to society, avoid the use of "command and control" regulations that specify how goals must be met. Instead, allow industry maximum flexibility in determining how to meet the standards set by regulations. This will enhance the efficiency of environmental improvement, minimize its cost to our society, and help to maintain the international competitiveness of U.S.-based chemical R&D and production.

When additional regulation is merited by expected net gains to society, avoid the use of "command and control" regulations that specify how goals must be met.

Peering into the Future

The chemical industry is one of the nation's strongest and most internationally competitive industries. Large accumulated investments in technology and production facilities and several other major strengths ensure that U.S.-based chemical R&D and production have significant staying power and will not erode quickly.

The world is changing rapidly, however, and given the essential role of chemicals in the production of modern goods and services, every developing nation gives high priority to building its own chemical industry. Thus, the "globalization" of the chemical industry — the international diversification of chemical R&D and production — will continue. As a result, the competition for U.S. and world markets will continue to intensify and the pace of technological change will likely increase. In such an environment, complacency or self-satisfaction are likely preludes to decline, if not demise. With the rapid industrialization of many developing economies, chemical production in the United States and other current major producer countries will almost certainly be a smaller portion of total world production ten years from now than it is today. How much smaller is, however, a key question. A modestly declining U.S. portion of world chemical production and trade need not signal a decline in U.S. competitiveness but may simply represent a smaller U.S. piece of a bigger world production and consumption pie, with larger production and consumption for the United States as well as its competitors.

To survive and grow, major U.S. and foreign chemical companies will have to compete globally, selling — and often investing and producing — in markets around the world. Increasingly, the United States will be competing with other countries to host chemical R&D and production. The benefits of an internationally competitive U.S. chemical industry to the U.S. economy make it critical to keep the industry strong. In an era of tightening competition, the margin for error in both company decisions and government policies will be narrower than ever before.

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