U.S. GLOBAL COMPETITIVENESS: BUILDING-BLOCK PETROCHEMICALS AND COMPETITIVE IMPLICATIONS FOR CONSTRUCTION, AUTOMOBILES, AND OTHER MAJOR CONSUMING INDUSTRIES

Report to the Committee on Finance, U.S. Senate, Investigation No. 332-230, Under Section 332(g) of the Tariff Act of 1930

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United States International Trade Commission / Washington, DC 20436

UNITED STATES INTERNATIONAL TRADE COMMISSION

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This report was prepared principally by

Eric Land, Project Leader,
Robert Feinberg, Cynthia B. Foreso, Aimison Jonnard,
Edward J. Matusik, Elizabeth R. Nesbitt, James P. Raftery,
Edward J. Taylor, and Steven Wanser

with assistance from

Wanda Tolson, Office of Industries
Steve Hudgens, Office of Data Systems

under the direction of

Edmund Cappuccilli and John J. Gersic
Energy and Chemicals Division

Office of Industries
Erland Heginbotham, Director

Address all communications to
Kenneth R. Mason, Secretary to the Commission
United States International Trade Commission
Washington, DC 20436

Errata Sheet

This errata sheet contains material inadvertently omitted from USITC Publication 2005, U.S. Global Competitiveness: Building-Block Petrochemicals and Competitive Implications for Automobiles, Construction, and Other Major Consuming Industries, a report to the Committee on Finance, U.S. Senate, Investigation No. 332-230, Under Section 332(g) of the Tariff Act of 1930.

The attached material contains appendixes A through E. Appendix A contains the request letter from the Senate Committee on Finance. Appendix B contains the notice of institution of investigation No. 332-230 in the Federal Register. Appendix C contains a review of the survey design and methodology. Appendix D contains a review of the literature on competitiveness and methodological concerns. Appendix E is a glossary of terms.

This material should be inserted after page 7-65 of the subject report.

Appendix A

Request Letter From the Senate Committee on Finance

United States Senate

COMMITTEE ON FINANCE
WASHINGTON, DC 20510

1278

February 12, 1986

The Honorable Paula Stern
Chairwoman
U.S. International Trade Commission
701 E Street, N.W.
Washington, D.C. 20436

Dear Madam Chairwoman:

The Committee on Finance requests that the United States International Trade Commission conduct a series of investigations under section 332 of the Tariff Act of 1930, on the international competitiveness of selected major United States industries.

The 99th Congress faces important decisions regarding a wide range of trade issues, including Administration efforts to launch a new round of multilateral trade negotiations aimed at reducing international barriers to trade in goods, services, and investment flows. To guide Congress in decisions about the future of the international trading system, the Committee needs to understand the competitive strengths and viability of key U.S. industries, the extent and nature of competition facing these industries in foreign and domestic markets, and the extent to which any current trade problems result from special situations such as the strong dollar, debt and interest rate problems, or from more fundamental competitive problems.

Several witnesses appearing before this Committee have stressed that U.S. competitiveness and industrial viability must be gauged in terms of performance in international as well as domestic markets. It is important for these studies to examine the viability of these industries and U.S. trade negotiation objectives from the vantage point of the global nature of competition and the internationalization of production and ownership.

For each of these industry studies the Committee requests coverage of:

1. Measures of the current competitiveness of the U.S. industry in domestic and foreign markets;

2. Comparative strengths of U.S. and major foreign competitors in these markets;

3. Nature of the main competitive problems facing the U.S. industry;

4. Sources of main competitive problems; to what extent from:

   a. special transitory or reversible situations such as exchange and interest rate problems, as opposed to

   b. fundamental or structural problems;

5. Competitive strategies; how important are foreign and U.S. markets to future competitiveness, in terms of economies of scale, growth rates, and pre-empting of market advantages.

The Committee decided not to identify specific industries or numbers of studies, but envisages up to seven studies. The Committee has instructed its staff to work out with ITC staff the specific industry selection and production schedule, depending on availability of appropriate staff to conduct them within the requested time. However, it requests that all studies be completed within 18 months and submitted to the Committee individually as completed.

The industries to be studied should be pivotal to overall U.S. industrial and technological strength, by virtue of being (a) either pathbreaking in the development of leading edge technologies that will shape future competitiveness of other U.S. industries, or (b) supplying critical equipment or materiel used in other important industries. The selection should be diverse enough that the range of their impact should reach broadly across the entire spectrum of U.S. industrial strength, represented by the seven tariff schedules. Examples would be key industrial agricultural commodities, selected synthetic organic chemicals, and textile fabrics, along with the equipment producing industries associated with each.

The Committee recognizes that much of the information and data desired may not be available from secondary sources and that primary data gathering may prove essential to understanding global industry competition. It requests that in meeting the objectives of these studies the Commission develop new sources of information outside the United States through both interviews and questionnaires where possible, to assure effective assessment of the strengths and weaknesses of foreign competitors, and of the terms of competition in key foreign markets.

Sincerely,

Bob Packwood

BOB PACKWOOD

Appendix B

Notice of Institution of Investigation No. 332-230 in the Federal Register concerning the building-block petrochemical industry on such end-user industries as the automotive and construction industries.

Public Hearing

The Commission will hold a public hearing on this investigation as well as the four others in this series (Inv. Nos. 332-229 through 332-233) at the United States International Trade Commission Building, 701 E Street NW Washington, DC, beginning at 10:00 a.m. on February 24, 1987.

All persons shall have the right to appear in person or by counsel, to present information and to be heard. Persons wishing to appear at the public hearing should file requests to appear and should file prehearing briefs (original and 14 copies) with the Secretary, U.S. International Trade Commission, 701 E Street NW., Washington, DC 20436, not later than noon, February 2, 1987. If the Commission decides to hold one or more hearings outside of Washington, DC, it will issue a supplemental notice of hearing by January 6, 1987.

Written Submission

Interested persons are invited to submit written statements concerning the investigation. Written statements should be received by the close of business on November 21, 1986. Commercial or financial information which a submitter desires the Commission to treat as confidential must be submitted on separate sheets of paper, each clearly marked "Confidential Business Information" at the top. All submissions requesting confidential treatment must conform with the requirements of § 201.6 of the Commission's *Rules of Practice and Procedure* (19 CFR 201.6). All written submissions, except for confidential business information, will be made available for inspection by interested persons. All submissions should be addressed to the Secretary, United States International Trade Commission, 701 E Street NW., Washington, DC 20436. Hearing-impaired individuals are advised that information on this matter can be obtained by contacting our TDD terminal on (202) 724-0002.

Issued: July 22, 1986.

By order of the Commission.

Kenneth R. Mason,

Secretary.

[FR Doc. 86-17102 Filed 7-29-86; 8:45 am]

BILLING CODE 7020-02-M

[332-233]

U.S. Global Competitiveness: Optical Fibers, Technology and Equipment

AGENCY: United States International Trade Commission.

ACTION: Institution of investigation.

EFFECTIVE DATE: July 9, 1986.

FOR FURTHER INFORMATION CONTACT: Mr. Christopher Johnson or Ms. Linda Linkins, General Manufactures Division, Office of Industries, U.S. International Trade Commission, Washington, DC 20436 (telephone 202-724-1730 or 202-724-1745, respectively).

Background and Scope of Investigation

The Commission on July 9, 1986, approved the institution of investigation No. 332-233, following receipt of letters on February 13, 1986 and April 2, 1986, from the Chairman of the Committee on Finance, United States Senate, requesting that the Commission conduct a series of investigations under section 332(b) of the Tariff Act of 1930 (19 U.S.C. 1332(b)) concerning the international competitiveness of a broad range of selected major United States industries. Institution of this study is scheduled for September 10, 1986.

The Commission investigation will examine the U.S. optical fiber industry, and its major foreign competitors, to determine the impact of global competition on the industry, and to assess how the industry is responding to these dynamic forces. As requested by the Committee, the Commission's report will analyze and address: (1) Measures of the current competitiveness of the U.S. industry in domestic and foreign markets; (2) comparative strengths of U.S. and major foreign competitors in these markets; (3) the nature of major competitive problems facing the U.S. industry; (4) the sources of these problems, including the extent to which they arise from special transitory or reversible situations or are the result of more fundamental or structural problems; and (5) the importance of U.S. and foreign markets to the future competitiveness of U.S. and foreign producers, in terms of economies of scale, growth rates, and pre-empting of market advantages.

Public Hearing

The Commission will hold a public hearing on this investigation as well as the four others in this series (Inv. Nos. 332-229 through 332-233) at the United States International Trade Commission Building, 701 E Street, NW., Washington, DC, beginning at 10:00 a.m. on February 24, 1987. All persons shall have the right to appear in person or be represented by counsel, to present information and to be heard. Persons wishing to appear at the public hearing should file requests to appear and should file prehearing briefs (original and 14 copies) with the Secretary, U.S. International Trade Commission, 701 E Street, NW., Washington, DC 20436, not later than noon, February 2, 1987. If the Commission decides to hold one or more hearings outside of Washington DC, it will issue a supplemental notice of hearing by January 16, 1987.

Written Submissions

Interested persons are invited to submit written statements concerning the investigation. Written statements should be received by the close of business on March 12, 1987. Commercial or financial information which a submitter desires the Commission to treat as confidential must be submitted on separate sheets of paper, each clearly marked "Confidential Business Information" at the top. All submissions requesting confidential treatment must conform with the requirements of § 201.6 of the Commission's *Rules of Practice and Procedure)* 19 CFR 201.6). All written submissions, except for confidential business information, will be made available for inspection by interested persons. All submissions should be addressed to the Secretary, United States International Trade Commission, 701 E Street NW., Washington, DC 20436. Hearing-impaired individuals are advised that information on this matter can be obtained by contacting our TDD terminal on (202) 724-0002.

Issued: July 22, 1986.

By order of the Commission

Kenneth R. Mason,

Secretary.

[FR Doc. 86-17103 Filed 7-29-86; 8:45 am]

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[332-231]

U.S. Global Competitiveness: Steel Sheet and Strip Industry

AGENCY: United States International Trade Commission.

ACTION: Institution of investigation.

EFFECTIVE DATE: July 9, 1986.

FOR FURTHER INFORMATION CONTACT: Ms. Nancy Flecher, Minerals and Metals Division, Office of Industries, U.S. International Trade Commission, Washington, D.C. 20436 (telephone 202-523-0341).

transmitted its report to the President on July 17, 1986. The information in the report was obtained from responses to Commission questionnaires, fieldwork and interviews by members of the Commission's staff, other agencies, information presented at the public hearing, briefs submitted by interested parties, the Commission's files, and other sources.

The view of the Commission are contained in USITC Publication 1866 (July 1986), entitled "Steel Fork Arms: Report to the President on Investigation No. TA-201-60 Under Section 201 of the Trade Act of 1974."

Issued: July 23, 1986.

By order of the Commission.

Kenneth R. Mason,

Secretary.

[FR Doc. 86-17100 Filed 7-29-86; 8:45 am]

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[332-232]

U.S. Global Competitiveness; the U.S. Automotive Parts Industry

AGENCY: United States International Trade Commission.

ACTION: Institution of investigation.

EFFECTIVE DATE: July 9, 1986.

FOR FURTHER INFORMATION CONTACT: Mr. Dennis Rapkins, Machinery and Equipment Division, Office of Industries, U.S. International Trade Commission, Washington, DC 20436 (telephone 202-523-0299).

Background and Scope of Investigation

The Commission, on July 9, 1986, approved the institution of investigation No. 332-232, following receipt of letters on February 13, 1986, and April 2, 1986, from the Chairman of the Committee on Finance, United States Senate, requesting that the Commission conduct a series of investigations under section 332(b) of the Tariff Act of 1930 (19 U.S.C. 1332(b)) concerning the international competitiveness of a broad range of selected major United States industries. Institution of this study is scheduled for September 1, 1986.

The Commission investigation will examine the U.S. automotive parts industry and its major foreign competitors to determine the impact of global competition on the industry, and to assess how the industry is responding to these dynamic forces. As requested by the Committee, the Commission's report will analyze and address: (1) Measures of the current competitiveness of the U.S. industry in domestic and foreign markets; (2) comparative strengths of U.S. and major foreign competitors in these markets; (3) the nature of major competitive problems facing the U.S. industry; (4) the sources of these problems, including the extent to which they arise from special transitory or reversible situations or are the result of more fundamental or structural problems; and (5) the importance of U.S. and foreign markets to the future competitiveness of U.S. and foreign producers, in terms of economies of scale, growth rates, and pre-empting of market advantages.

Public Hearing

The Commission will hold a public hearing on this investigation as well as the four others in this series requested by the Committee (investigation Nos. 332-229 through 332-233), at the U.S. International Trade Commission Building, 701 E Street, NW., Washington, DC, beginning at 10:00 a.m. on February 24, 1987. All persons shall have the right to appear in person or be represented by counsel, to present information and to be heard. Persons wishing to appear at the public hearing should file requests to appear and file prehearing briefs (original and 14 copies) with the Secretary, U.S. International Trade Commission, 701 E Street, NW., Washington, DC 20436, not later than noon, February 2, 1987. If the Commission decides to hold one or more hearings outside of Washington DC, it will issue a supplemental notice of hearing by January 16, 1987.

Written Submissions

Interested persons are invited to submit written statements concerning the investigation. Written statements should be received by the close of business on March 12, 1987. Commercial or financial information which a submitter desires the Commission to treat as confidential must be submitted on separate sheets of paper, each clearly marked "Confidential Business Information" at the top. All submissions requesting confidential treatment must conform with the requirements of § 201.6 of the Commission's *Rules of Practice and Procedure* (19 CFR 201.6). All written submissions, except for confidential business information, will be made available for inspection by interested persons. All submissions should be addressed to the Secretary, United States International Trade Commission, 701 E Street, NW., Washington, DC 20436. Hearing-impaired individuals are advised that information on this matter can be obtained by contacting our TDD terminal on (202) 724-0002.

Issued: July 22, 1986.

By order of the Commission.

Kenneth R. Mason,

Secretary.

[FR Doc. 86-17101 Filed 7-29-86; 8:45 am]

BILLING CODE 7020-02-M

[332-230]

U.S. Global Competitiveness: Building-Block Petrochemicals and Competitive Implications for Construction, Automobiles, and Other Major Consuming Industries

AGENCY: United States International Trade Commission.

ACTION: Institution of investigation.

EFFECTIVE DATE: July 9, 1986.

FOR FURTHER INFORMATION CONTACT: Eric Land or James P. Raftery, Energy and Chemicals Division, U.S. International Trade Commission, Washington, DC 20436, telephone (202) 523-0491 and 523-0453, respectively.

Background and Scope of Investigation

The Commission, on July 9, 1986, approved the institution of investigation No. 332-230, following receipt of letters on February 13, 1986 and April 2, 1986 from the Chairman of the Committee on Finance, United States Senate, requesting that the Commission conduct a series of investigations under section 332(b) of the Tariff Act of 1930 (19 U.S.C. 1332(b)) concerning the international competitiveness of a broad range of selected major United States industries.

The Commission investigation will examine the U.S. building-block petrochemical industry and its major foreign competitors to determine the impact of global competition on the industry and to assess how the industry is responding to these dynamic forces. As requested by the Committee, the Commission's report will analyze and address: (1) Measures of the current competitiveness of the U.S. industry in domestic and foreign markets; (2) comparative strengths of U.S. and major foreign competitors in these markets; (3) the nature of major competitive problems facing the U.S. industry; (4) the sources of these problems, including the extent to which they arise from special transitory of reversible situations or are the result of more fundamental or structural problems; and (5) the importance of U.S. and foreign markets to the future competitiveness of U.S. and foreign producers, in terms of economies of scale, growth rates, and pre-empting of market advantages. In addition, the Commission will examine the competitive implications of its findings

Appendix C

Survey Design and Methodology

Because of the limited and incomplete nature of available data on the U.S. building-block petrochemical industry, the Commission found it necessary to use questionnaires as a primary data-gathering technique in order to obtain the type of information requested by the Senate Finance Committee. Questionnaires were developed to generate statistical data on product mix and the materials produced. These questionnaires were sent to representative U.S. producers/importers of building-block petrochemicals, suppliers of materials with significant petrochemical content, and end users of materials with significant petrochemical content. Information was received, verified, and processed so that determining the identification of an individual firm would not be possible in the public report. A complete explanation of the survey design and methodology follows.

The following tabulation shows the estimated total firms (based on the most currently available data), the number of firms surveyed, and the expected response rate:

	Producers/importers	Suppliers	End users
Estimated total firms......	50	1/ 50	2/
Number to be surveyed......	50	50	50
Expected response rate.....	90	60	60
Actual response rate.......	84	50	3/ 54

1/ The number of firms that can be considered to be suppliers of materials with significant petrochemical content depends on the way these firms are defined. For the purposes of this questionnaire, the Supplier sectors being considered include those which supply materials to the Automotive, Packaging, and Construction industries. As such, an estimate of the total number of firms that may be considered to be Suppliers ranges from at least 10,000 to possibly 100,000. However, the survey is designed to reach 3 specific discrete subsectors of the industry.

2/ There are 7 firms in the Automotive subsector. However, estimates of the number of firms in the construction industry range from 10,000 upwards. An estimate of the number of firms in the packaging industry range from 1,000 to more than 20,000.

3/ The response rate for the construction industry was only 15 percent because of the unavailability of the requested information, as discussed in that section.

The universe of producers was derived from the mailing list for the Commission's Annual Synthetic Organic Chemicals Report. Each domestic producer reporting production or sales of the building-block petrochemicals received the Commission Questionnaire. The universe of firms in the specific subsectors to be surveyed was derived from available lists of producers and from membership lists of the Society of Plastics Industries. The universe for the construction and packaging sectors surveyed via the End-user Questionnaire were determined by compiling lists from Wards Directory of 51,000 Largest Corporations. Construction end users were selected primarily from a listing of the largest public and privately held contractors classified in 4-digit Standard Industrial Classification (SIC) Code 1521, Single Family Housing Contractors, found in Wards Directory of 51,000 Largest Corporations. The Commission staff developed a list of the largest packaging end users, as per advice from the Paperboard Packaging Council, from listings of the largest producers of certain consumer products in the following 3-digit SIC codes (according to Wards Directory of 51,000 Largest Corporations): SIC 284, Soaps Detergents & Cleaning Products; SIC 208, Beverages; and SIC 209, Miscellaneous Food Preparations & Kindred Products. The automobile sector was determined by examining published data. The Producer/Importer Questionnaire, the Supplier Questionnaire, and the End-User Automobile Questionnaire were sent to the universe of firms as compiled by the Commission staff. In order to minimize respondent burden, the End-user Questionnaires for the Construction and Packaging industries were only sent to the largest construction and packaging end users in clearly defined industry subsectors.

Results of the questionnaire for the supply sectors, and the packaging and construction end users will be applicable only for the firms responding, and may not be used to generalize for the entire industry.

The questionnaire responses were reviewed by Commission staff for accuracy. Since some responses were either not usable or inapplicable and because of incomplete information on the actual composition of packaging and construction end-user sectors, our effective sample size was smaller than expected. No adjustments were made to account for the discrepancy between actual and expected response rates because response rates were only substantially different for the construction sector. The following tabulation presents the usable response rate by type of questionnaire:

	Producers/importers	Suppliers	End-users
Applicable questionnaires..	44	30	78
Questionnaires with usable information.	37	18	28
Usable response rate 1/ percent..	84	2/ 60	3/ 36

1/ Usable response rate is defined as the number of questionnaires returned with usable information as a percent of total applicable questionnaires.
2/ Response rates for the individual supplier subsectors were as follows:

	Producers of Caps	Bottles	Dual-Ovenable Cookware
Applicable questionnaires..	8	15	7
Questionnaires with usable information.	6	9	3
Usable response rate.......	75	60	43

3/ Response rates for the end-user sectors were as follows:

	Construction	Packaging	Automotive
Applicable questionnaires..	26	45	7
Questionnaires with usable information.	6	20	4
Usable response rate.......	15	44	57

Appendix D

Review of Literature on Competitiveness and Methodological Concerns

A. Previous Studies of competitiveness

The studies discussed below are believed to be a representative sampling of the extensive recent economic literature on the issue of international competitiveness of U.S. industry. The listing should not, however, be taken to be exhaustive. The focus of the discussion will be on the basic methodologies and measures of competitiveness employed in these studies, rather than on their conclusions for the particular industries under investigation.

1. Annotated bibliography

a. Joseph L. Bower, When Markets Quake (Boston: Harvard Business School, 1986).

This focuses on company and government strategies over the past 10 years in the world petrochemical industry. No explicit definition of competitiveness is given, but there is some discussion of changes in country trade balances and shares of world exports in petrochemicals. In addition, favorable reference is given to Chem Systems' "survival matrix," which ranked companies on the basis of relative cost, product mix, and geographic location of their facilities. The appropriate market is taken to be global because of low transport costs and homogeneous product. Shifts in currency values are seen as crucial. Emphasis is placed on political factors in determining country responses to international pressures, with a slow response observed to market forces.

b. William H. Branson and James P. Love, "Dollar Appreciation and Manufacturing Employment and Output," NBER Working Paper No. 1972, 1986.

They estimate the responsiveness of U.S. manufacturing output and employment to changes in the real exchange rate, using quarterly data from 1963 to 1985, at the level of individual industries. Chemicals industries were found to suffer large employment losses when the dollar appreciates (a 10% real appreciation of the dollar was predicted to cause a 1.7% decline in employment in "plastics materials and resins").

c. Dennis M. Busche, Irving B. Kravis, and Robert E. Lipsey, "Prices, Activity, and Machinery Exports: An Analysis Based on New Price Data," Review of Economics and Statistics, vol. 68 (May 1986), pp. 248-255.

Irving B. Kravis and Robert E. Lipsey, "Prices and Market Shares in the International Machinery Trade," Review of Economics and Statistics, vol. 64 (February 1982), pp. 110-116.

Robert E. Lipsey, "Recent Trends in U.S. Trade and Investment," in Miyawaki (ed.), Problems of Advanced Economies (Heidelberg: Springer-Verlag, 1984), pp. 58-79.

Robert E. Lipsey and Irving B. Kravis, "The Competitiveness and Comparative Advantage of U.S. Multinationals, 1957-83," NBER Working Paper No. 2051, 1986.

This series of papers examines changes in U.S. shares of world exports and investigates the causes. The first two listed make no explicit mention of competitiveness, but focus on determinants of the demand for U.S. exports of machinery and transport equipment. They find that changes in U.S. export prices relative to those of our competitors have a substantial effect on relative export quantities (and so shares of the world export market) but that the full effect may take up to 4 years to be felt--this suggests that it may take several years for the desirable trade balance effects of a currency depreciation to be felt.

The last two papers analyze trends in U.S. export shares, as an indicator of U.S. competitiveness. The comparative advantage of the United States and its multinational firms is measured in terms of the distribution of exports across industries (e.g., industries with larger shares of U.S. exports than of world exports are taken to be industries in which the United States has a comparative advantage vis-a-vis the rest of the world). They do point out two limitations of measuring international competitiveness by export share movements: (1) a decline in the U.S. share of world trade has accompanied declines in the U.S. share of world population and income, suggesting that a constant share "is not a reasonable norm against which to judge changes in the U.S. share of trade;" and (2) this measure of competitiveness ignores distortions in the composition of trade due to government intervention.

The paper by Lipsey and Kravis distinguishes between factors determining the competitiveness of the United States as a production location and those determining the competitiveness of U.S. firms (whatever the geographical distribution of their production). They identify two competing hypotheses for the loss of U.S. competitiveness: (1) macroeconomic factors, such as national price levels and incomes; and (2) factors internal to firms, such as research and development, technology, investment, or management strategies. These latter factors are transferable across countries, within firms, and so will be unlikely to contribute to national competitiveness or comparative advantage. Lipsey and Kravis suggest that a large difference between the trade performance of the United States and U.S.-based firms would allow one to determine the policy relevance of the two hypotheses. They report that although the U.S. share in world manufacturing exports fell from 22 percent to 14 percent over that period, the share of U.S.-based multinationals was steady at about 18 percent. The conclusion is that American management and technology remained competitive, maintaining export shares in rapidly growing world markets, and that the decline in the U.S. country share of world exports is largely because of relative price changes determined primarily by movements in exchange-rates and inflation.

d. James M. Jondrow, David E. Chase, and Christopher L. Gamble, "The Price Differential between Domestic and Imported Steel," Journal of Business, vol. 55 (July 1982), pp. 383-399.

They discuss reasons why imports of a seemingly homogeneous product (steel) sell for a lower price than the domestic product without rapidly increasing their share of the market. The explanation supported by evidence is unfavorable service characteristics (e.g., long lead times required and insecurity of supply). This suggests that--in the absence of specifically controlling for all such relevant characteristics--domestic and foreign product are best treated as imperfect substitutes, with the demand for imports depending on the prices of both imports and domestic goods. To the extent changes in relative costs pass through into differences in the prices of imports and domestic goods, import penetration will be affected.

e. Robert Z. Lawrence, Can America Compete (Washington: Brookings Institution, 1984).

This study, looking only at the period up to 1980, analyzes the sources of structural change in U.S. manufacturing. The author finds changes in domestic consumption to be a more important cause of structural change than changes in international trade, with U.S. comparative advantage declining in products of unskilled labor and standardized capital-intensive products, but increasing in high-tech products. Lawrence mentions the terms "international competitiveness" and "U.S. industrial competitiveness" without explicit definition, but seems to use a country's "success" in international markets as synonymous with international competitiveness and focuses in his analysis on growth in exports compared with import growth, the trade balance, the U.S. share of world trade in manufacturing, productivity growth, investment and R&D spending, and profit rates as indicators of that success.

He compares U.S. industrial performance with that of other developed economies from 1973 to 1980, and generally the U.S. manufacturing sector fares well--in terms of growth in production, employment, R&D, and capital spending. He estimates the effects of exchange rates on U.S. manufacturing and attributes most of the changes in U.S. exports and imports during 1980-83 to the dollar appreciation; however, by measuring real-exchange-rate movements with relative export and import prices (which may be related to relative costs and industrial structure) this doesn't rule out the importance of more industry-specific explanations for changes in U.S. competitiveness.

f. Richard Baldwin and Paul R. Krugman, "Market Access and International Competition: A Simulation Study of 16K Random Access Memories," NBER Working Paper No. 1936, 1986.

Marvin Lieberman, "Learning-By-Doing and Industrial Competitiveness: Autos and Semiconductors in the U.S. and Japan," NBER Working Paper, 1986.

John Zysman and Laura Tyson (eds.), American Industry in International Competition (Ithaca: Cornell University Press, 1983).

These works take a more dynamic view of industrial (and international) competition than that traditionally taken by economists.

Baldwin and Krugman model international competition in an oligopoly market with "strong learning effects," simulating the U.S.-Japanese rivalry in 16K RAM's from 1978 to 1983. Their results suggest that a protected home market was a crucial advantage to export performance of Japanese firms but that this policy produced more costs than benefits for Japan (through higher prices for consumers). Lieberman discusses the implications of "learning-by-doing" -- "production technology undergoing continual improvement that is largely a function of accumulated experience" -- which he claims to be a common feature of complex manufacturing industries. In these industries, the behavior of prices, profits, and shares of the market will depend on the slope of the learning curve (rate of productivity gains), the time horizon used by firms in decision making, and the rate at which learning diffuses among firms. A role for government in influencing these factors will be important in international competition.

The Zysman and Tyson volume is a series of industry case studies depicting the problems of adjustment and change in response to international competition in seven sectors: consumer electronics, steel, semiconductors, footwear, textiles, apparel, and autos. The editors, in their introductory essay, state that "[the] well-being of firms in these sectors depends on defending home markets against foreign firms and selling in markets abroad." This suggests at least an implicit view of international competitiveness in terms of export-shares and import-penetration. They do define "comparative advantage" as the relative export strength of a particular sector compared with other sectors in the same nation (and acknowledge the need to adjust for market-distorting government policies). On the other hand, "competitive advantage" is defined as the relative export strength of the firms of one country compared with the firms of other countries selling in the same sector in international markets.

Zysman and Tyson argue that in many cases a nation can create its own comparative advantage by the efforts of government and industry to create competitive advantage in the market; they refer specifically to government policies protecting a home market so as to allow either production economies of scale or learning curve economies. The case studies highlight the role of Japanese industrial policy in promoting expansion of growth-linked industries. Typical of competition between advanced countries is apparently that market success depends on the management of complex processes of product development and manufacturing, not simply national differences in factor costs such as wages or raw materials.

g. J. David Richardson, "Constant-Market-Shares Analysis of Export Growth," Journal of International Economics, vol. 1 (May 1971), pp. 227-239.

This is a critique of the constant-market-shares analysis, both in theory and in practice. This analysis attributes any change in a country's exports in a particular sector not due to growth in the market but to changed "competitiveness." Richardson questions the use of relative prices to measure relative competitiveness (ignoring quality, service, financing differences between the products of competing nations) and suggests that a measure of "a country's true competitiveness ... might be whether the country was increasing its export shares in rapidly growing commodities and markets" (the analysis assumes the commodity and geographic distribution of exports to be unrelated to competitiveness).

h. John W. Suomela, "The Meaning and Measurement of International Price Competitiveness," Business & Economics Section, Proceedings of the American Statistical Association, 1978.

This paper discusses the ambiguities in the term "competitiveness," as it applied to firms, industries, and countries. It reviews several empirical studies that have attempted to measure "competitiveness" or "price competitiveness"-- these have interpreted the measures employed as predictors of relative export quantities or relative export shares or the balance of trade in an industry sector. These measures include ratios of wholesale price indexes, export unit values, relative unit labor costs, import prices divided by export prices, and relative profits. An import demand model is formulated to specify theoretically correct price indexes, which unfortunately do not correspond to available data.

i. U.S. Federal Trade Commission, Staff Report on the U.S. Steel Industry and its International Rivals: Trends and Factors Determining International Competitiveness, Bureau of Economics, 1977.

Despite the title, no definition or strict measure of international competitiveness is given. At various places the study suggests the importance of exports, import penetration, and rates of growth in production as indicators of a country's "competitive position" or "importance" in the world steel industry or "relative standing ... among the world's steel producing nations." However, in the summary chapter, the study is described as one attempting to explain the pattern of trade flows of the U.S. steel industry over a 20-year period.

Chapter 3 examines relative trends in steel-producing costs in the United States Japan and the EC, evaluating the impact of relative costs on international trade flows. Implicitly, the authors seem to have a spatial oligopoly model in mind--changes in relative production costs among countries may have a strong influence on trade flows as relative cost reductions by one country allow it to expand into areas formerly controlled by other countries. (This is not to say that relative cost changes do not play a role in spaceless models; there, cost changes imply supply shifts which are likely to lead to changes in export shares even if, in a homogeneous world market, price and marginal cost are unchanged.)

After comparing quantities and average prices for inputs involved in steelmaking in the United States and Japan, covering 70 percent of variable costs in the United States, comparisons of levels and trends in unit costs in the two countries are given. Problems with these comparisons are acknowledged: (1) the assumption that the relative cost of excluded inputs has not changed significantly over time is crucial (and no check of the realism of this assumption is given); and (2) price and quantity data are not exactly comparable for the two countries because of industry definition differences, product-mix differences, and differences in the use of spot vs. contract prices or arms-length versus transfer prices. The primary difference between U.S. and Japanese unit costs was found to be unit labor costs, mainly because of the wage-rate differential; the overall Japanese cost advantage increased from 1956 to 1968, but changed little during the 1968-76 period.

Less sophisticated methods, using product-specific average revenue less an overall-industry return on sales, were used to estimate the U.S./EC cost differential; results showed relative U.S. costs increasing from 1954 to the late 1960's and then decreasing. Some discussion of shipping costs is given but there is no analysis of changes over time.

Partly on the basis of a simple linear regression of Japanese and EC import penetration in the United States on relative costs, the study concludes that the primary explanation for increasing import penetration is relative production cost changes. It should be noted that since exchange-rate effects are incorporated in the measured cost changes there is no allowance for a separate influence for these effects.

j. U.S. Department of Labor, Office of Foreign Economic Research, Report of the President on U.S. Competitiveness, 1980.

This is essentially a study of U.S. export performance, although other indicators of international competitiveness used include the trade balance and the "terms of trade"; the latter is measured by the U.S. export/import price ratio. A long list of determining factors is considered: inflation, rates of investment, productivity growth, skilled labor resources, technological innovation, unit labor costs, tariff and nontariff barriers to U.S. exports, U.S. foreign investment and technology transfer, tax measures, energy factors, labor-management relations, the role of engineering, and other services in the export of capital goods. Of these factors, investment, technology, and productivity were seen as areas where the United States had lagged behind its competitors; in addition, nontariff barriers and exchange-rate movements had major impacts on U.S. exports. As an index of "revealed comparative advantage" the study adjusts the U.S. export-share in a particular product by the U.S. share of total world exports; similarly, for industries without much exporting, a relative import penetration ratio might be useful in judging comparative advantage among U.S. industries.

2. Summary of results

The conclusion to be drawn from these studies is that "international competitiveness" does not have a precise, theoretically derived definition, but rather is a term that different people use to mean somewhat different things. However, the unifying theme is that the interest is always in some measure of "success" in world markets. The most common measures of this success in particular product markets seem to be shares of world exports or production or the level and trends of a country's trade balance in a sector. Determinants of this success are the relative production costs and exchange rate effects predicted by a simple static model of international competition, as well as more dynamic factors such as productivity growth, investment, and management (and perhaps government) strategies. The comparison of these studies should alert one to the importance of choosing appropriate statistics to answer a question: e.g., R.Z. Lawrence finds R&D in manufacturing grew faster in the United States than in other OECD countries, and the Labor Department study finds that the U.S. ratio of R&D to GNP has declined in the United States relative to other developed nations. Both of these results are correct yet they lead a reader towards opposite conclusions on the trend of U.S. investment in technology.

B. Methodological concerns

The preceding section found that discussions of international competitiveness of U.S. industries generally fail to precisely define how competitiveness should be measured. The problem is that there is no unique measure, but rather several dimensions of the issue. The purpose of this section is to set out an analytical framework relating several measures of competitiveness to determinants of industrial performance in world markets.

1. Definitions of competitiveness

Consider the U.S. industry facing a competing industry in world markets, with the two industries selling somewhat differentiated, though similar, products; for example, suppose the U.S. and Japanese automobile industries competed in markets throughout the world but were viewed by consumers as selling products not perfectly substitutable for each other. Separate but interrelated markets for the products of the two industries exist with prices and quantities sold determined by elements of supply and demand. Given that the U.S. and foreign products are substitutes, anything that serves to lower the price of the U.S. [foreign] product will reduce the demand for the foreign [U.S.] product. In turn, the U.S. price will be determined by marginal cost, the sensitivity of demand to price (price elasticity of demand), and the market structure and strategic behavior of the U.S. industry.

Now, what is meant by competitiveness? At the most basic level, it is simply "success" in world markets, which can be measured by the share of the combined markets for U.S. and foreign-made products held by U.S. producers (or the U.S. share of world exports); this seems to be the most commonly adopted measure of international competitiveness. Clearly, by this measure, any change that increases world sales of U.S. products while reducing (or even increasing less than proportionally) sales of foreign-made products implies an increase in U.S. competitiveness; it should be recognized that competitiveness so defined includes the effects of all governmentally imposed aids and sanctions affecting both the U.S. and foreign industries. Such a measure, if examined over a period of years, will be quite sensitive to the changing stages of economic development occurring in both competitor and consumer nations. It has been argued, for example, that with the post-war re-emergence of Japan and the European Community, followed by the rise of the newly industrializing countries of the Pacific Rim, that one would expect to see the U.S. share of world exports declining (and whether we view this as a decline in competitiveness or not may be a matter of semantics).

An alternative measure of competitiveness is simply the profitability of the domestic industry, although, again, this measure is quite sensitive to government-imposed import barriers and export aids. Finally, net investment in the domestic industry is both an indicator of competitiveness and a predictor of future profitability and market share. These latter two measures are probably more directly affected by the overall state of the domestic economy than is the share of world consumption or world exports (although this will also be affected by macroeconomic factors influencing exchange rates and inflation). While there are exceptions, generally all three of these indicators of competitiveness will move together and will be similarly affected by changes in circumstances of supply or demand.

2. Determinants and indicators

Suppose there is an increase in the cost of producing an additional unit of the domestic product; this could be because of increases in resource costs, inefficiencies in management techniques, use of outdated or inappropriate technologies, increasing interest rates, higher regulation-related costs, or a depreciation of the domestic currency value (raising the cost of imported inputs). This increase in costs will be translated into reduced supply and a higher price for the U.S. product. The higher price will stimulate increased world demand for the foreign-made product. The result will be a reduced U.S. share of the world market (and of world exports), lower profits, and (especially if the lower profits are expected to persist) reduced investment in the U.S. industry. Similar results would ensue from reduced costs to the foreign industry: a lower foreign product price would lead to reduced demand for the U.S. product, a smaller world market share, and reduced profits and investment.

If transportation costs are an important consideration in world trade of a particular product (as where the ratio of value to weight is relatively low), a reduction in costs in the industry of one country will enable it to expand the geographical area in which, including transport costs, it enjoys a cost advantage. We would expect to see this translated into increases in world export shares, profitablity, and domestic investment. Similarly, a reduction in transportation costs specific to a particular producing country (as could occur if shipping cost was subsidized by the government) would expand that country's geographical marketing area and increase the three measures of competitiveness discussed above.

It should be emphasized that anything which affects the cost of production to the U.S. industry relative to foreign production will have an influence on competitiveness. The cost factors mentioned above are just examples and should not be taken to be an exhaustive list; different elements of cost will be more important in determining U.S. competitiveness in different products.

Changed conditions of demand, specific to one of the two countries' industries, would also have an impact on international competitiveness. An increase in demand for the product of the U.S. industry could be due to a change in consumer tastes or an improvement in the perceived quality either of the basic product or of service and distributional aspects related to the U.S. product; it could also be due to more rapid income growth in parts of the world targeted by the U.S. producers than in the rest of the world market. Regardless of the cause, an increase in demand for the U.S.-made product would increase sales and the price of that product. Although there may be a resulting increase in demand for the foreign-made product as well this should be of smaller magnitude, leading to the conclusion that the world market share of the domestic industry will rise, as will profits and investment. Improved technology, resulting from increased research and development in the industry, may have the dual effect of reducing costs and improving quality (and, therefore, demand).

Finally, the nature of competition in the domestic industry may affect the industry's success in world markets. The U.S. industry will be better able to compete with imports and to sell abroad, to the extent that vigorous competition among domestic producers allows for pricing closely aligned to costs, and still allow for profits to be invested in research and development and capital equipment. Such competition may also stimulate improved management techniques, which by lowering costs will further reduce prices and enhance the U.S. industry's competitive position.

3. Summary

The brief discussion above suggests that international competitiveness is an issue that needs to be evaluated from a multidimensional perspective, examining both indicators and determinants of competitiveness. Three indicators of competitiveness are (1) world export shares (or shares of world consumption); (2) profitability of the domestic industry; and (3) trends in net investment in the domestic industry. Determinants of competitiveness are (1) cost factors, both specific to the industry (including resource costs, labor costs, interest rates) and economy-wide (such as capital costs, general input-cost inflation, exchange-rate changes); (2) demand factors, including the quality and reputation of the domestic product, as well as the growth of incomes in primary export markets; and (3) domestic market structure and conduct considerations. To the extent government actions influence any of these factors they will affect the international competitiveness of the industry. Of course, explicit nontariff barriers erected by governments will have more direct impacts on indicators of competitiveness.

Under the cost factors determining competitiveness, one may consider differing U.S./foreign trends in--

(a) wage rates and labor productivity, or unit labor costs (which effectively combines the two);
(b) feedstock prices;
(d) intensity of use of inputs, which may be related to differing technologies, age of capital equipment, or the degree of vertical integration;

(e) transportation and distribution costs --their importance, and the geographical distance to major markets from U.S. and other suppliers. Note that to the extent cost measures are converted to dollar equivalents, the issues of general inflation and exchange rates are controlled for.

Under demand factors, one may consider whether the U.S. and foreign products are homogeneous or differentiated in some way, whether primary markets of the U.S. industry have grown at different rates than primary markets of foreign competitors, patterns and changes in delivery lags, service, and quality from competing sources.

Market structure can be evaluated by looking at the number of firms in the industry, the share of the top firms, conditions of entry into the global industry, the type of ownership, and the degree of vertical integration and diversification in the industry. Some qualitative assessment on the competitive environment, the extent to which firms compete or cooperate, is useful.

Finally, government aids such as subsidies (including subsidies to related industries), tariffs, quotas, and other nontariff measures should be mentioned, with some attempt at assessing their impact.

Appendix E

Glossary of Terms

GLOSSARY OF TERMS

Petrochemicals: Those chemical materials that are based on or derived from hydrocarbon raw materials (usually petroleum or natural gas.

Primary petrochemicals: First-stage materials produced directly from a petroleum-based or a natural gas-based feedstock. The following is a list of the primary petrochemicals:

Olefins	Aromatics	Other
Ethylene	Benzene	Methanol
Propylene	Toluene	Ammonia
Butylenes	Xylenes	Carbon black
1,3-Butadiene	Naphthalene	
Acetylene		

Building-block petrochemicals: Those primary petrochemicals from which most, if not all other petrochemicals are produced.
Note: As this study specifically considers the olefins and aromatics, certain primary petrochemicals are excluded from consideration as "building-block petrochemicals." Among those specifically excluded are methanol and ammonia. The following are the primary olefins and primary aromatics considered in this study as "building-block petrochemicals:"

Primary olefins	Primary aromatics
Ethylene	Benzene
Propylene	Toluene
1,3-Butadiene	Mixed xylenes

The most important of the "building-block petrochemicals" is ethylene, used in the production of plastics, textile fibers, and solvents such as ethylene glycol (anti-freeze). The following tabulation shows the end-use markets for ethylene in 1975 and 1985:

End-Use Market	1975 Share	1985 Share
	(percent)	
Packaging	21.3	29.8
Construction	9.5	12.8
Transportation	10.1	7.3
Coatings 1/	15.0	13.3
Surfactants	9.8	10.2
Other 1/ 2/	34.2	26.6
Total	100.0	100.0

1/ A significant amount of the end-products of these markets are used in the packaging, construction and automotive industries.
2/ Includes the textile end-use market.

Petrochemical derivatives: Those petrochemicals that are produced from the primary petrochemicals in a chemical reaction. Since there are physical difficulties associated with the transportation of some of the primary petrochemicals, related to their gaseous state at room temperatures, most of the trade in petrochemicals takes place in the form of the derivatives. The following is a list of derivatives that account for the majority of petrochemical trade:

- Acrylonitrile
- Cumene
- Dimethylterephthalate (DMT)
- Ethylene dichloride (EDC)
- Ethylene glycol
- Ethylene oxide (EO)
- Phenol
- Phenolic resins
- Polyester resins
- Polyethylene resins (PE)
- Polypropylene resins (PP)
- Polystyrene resins
- Polyvinylchloride resins (PVC)
- Propylene glycol (PG)
- Propylene oxide (PO)
- Styrene
- Styrene-butadiene latexes (SB)
- Synthetic elastomers 1/
- Vinyl chloride monomer (VCM)

1/ Includes styrene-butadiene rubber (SBR), polybutadiene, nitrile rubber, neoprene, and butyl rubber.

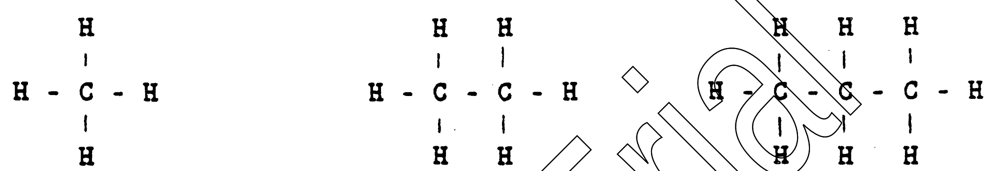
Feedstocks: Those hydrocarbon materials (i.e., natural gas, natural gas liquids, or petroleum liquids) that are used as the raw materials for production of petrochemicals. The following tabulation indicates the specific hydrocarbon raw materials that are used as "feedstocks" for petrochemicals:

Natural gas	Natural gas liquids	Petroleum liquids
Methane	Ethane	Naphtha
	Propane	Reformate
	Butanes	Raffinate
	LPG 1/	Gas oil
	Natural gasoline	Crude petroleum

1/ Liquefied petroleum gas (LPG) contains mostly propane, with a lesser amount of butanes.

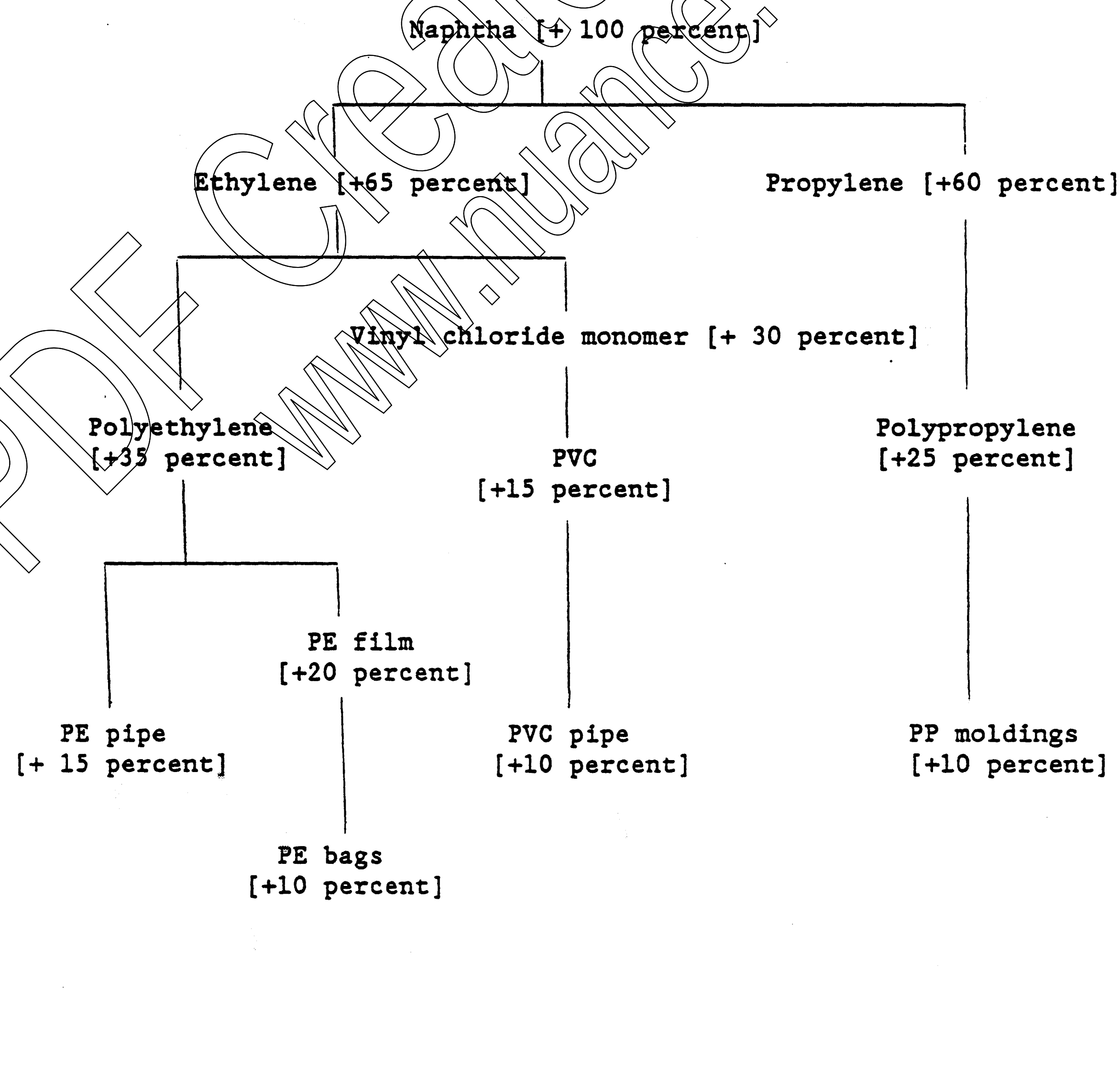
Refinery processes of interest to petrochemical producers are those that produce streams that have an economical supply of the basic building-blocks. The primary aromatics, for example, may constitute from 45 percent to 65 percent of the reformate stream. The primary olefins, however, are not found directly in the refinery streams. Instead, liquid fractions are "cracked" to yield ethylene and its coproducts (e.g., propylene, butadiene, butylenes, and pyrolysis gasoline, a source of aromatics). Larger volumes of olefins are also obtained in other refinery operations, such as from catalytic cracking and thermal units.

The primary U.S. source for primary aromatics, as well as methanol and ammonia, is natural gas and its components. Most components of natural gas have one to four carbon molecules and have mostly single bonds. Methane, ethane, and propane, the three primary components are shown below:



Methane Ethane Propane

The flowchart below shows how the actual costs of feedstock material may be transferred to the primary petrochemicals and to various downstream product materials. For example, if a price increase in naphtha to a producer of ethylene would be passed down to purchaser of PVC pipe, there would be a $1 increase in the price of the PVC pipe for every $10 increase in the naphtha price.



Producers of primary petrochemicals, when possible, can take advantage of the different yields of the various products and coproducts that are obtained from the use of different feedstocks and different reaction conditions (high or low cracking severity). The following tabulation shows typical yields from cracking ethane and propane and from cracking naphtha feedstocks.

Products	Ethane and propane	Naphtha Low severity	Naphtha High severity
	------------	(Percent)	-----------
Methane	21	10	15
Ethylene	62	26	31
Propylene	9	16	12
Butadiene	2	5	4
Butenes	1	8	3
BTX	-	10	13
C_5's	5	17	9
Fuel oil	-	3	6
Other	-	5	7
Total	100	100	100

Byproduct: Any of a number of products without significant commercial value that are produced in addition to the main product of the petrochemical production process.

Byproduct credit: Revenue generated by the sale of byproduct materials produced in addition to the main product of an operation.

Coproduct: Any of a number of products with significant commercial value that are produced in addition to the main product of the petrochemical production process.

Cryogenic: Science that deals with processes that occur at very low temperatures, such as the liquefaction of ethylene so that it may be transported by ship.

Plastics blends (or composites): Mixtures of different plastics materials in which each of the individual plastics materials remains a separate component.

<u>Plastics alloys</u>: Mixtures of plastics resins that are fully compatible with one another. These mixtures allow for new and different characteristics that are associated with the alloy, and not with any of the individual component materials. An example of this type of material is an ABS-polycarbonate alloy, which is easier to process, has high heat and impact resistance, and is less expensive than polycarbonate itself.

<u>Thermoplastic resins</u>: Plastics capable of being repeatedly softened by inreases in temperature and hardened by decreases in temperature. The changes are physical rather than chemical. Examples of thermoplastics are ABS, nylons, polyesters, polyethylenes, and vinyls.

<u>Thermosetting resins</u>: Resins that are cured by chemical reaction when heated, and, once cured, cannot be softened by reheating. These resins are produced by the additional polymerization reactions, usually with polyester resins.

<u>Blow molding</u>: A method of fabrication of thermoplastic materials in which a tube is forced into the shape of the mold cavity by internal air pressure.

<u>Reaction Injection Molding (RIM)</u>: A method in which the constituent resins are pumped by a metering device into a mixing head from which the reaction ingredients are rapidly injected into a closed mold.

Preface

On July 16, 1986, at the request of the Committee on Finance of the U.S. Senate 1/ and in accordance with section 332(g) of the Tariff Act of 1930 (19 U.S.C. 1332(g)), the U.S. International Trade Commission instituted investigation No. 332-230, U.S. Global Competitiveness: Building-Block Petrochemicals and Competitive Implications for Construction, Automobiles, and Other Major Consuming Industries. The Commission was asked to provide information on, and analyze, measures of the current competitiveness of the U.S. industry in domestic and foreign markets; the competitive strengths of U.S. and major foreign competitors in these markets; the nature of the main competitive problems facing the U.S. industry; the sources of these problems and to what extent they are transitory or reversible situations as opposed to fundamental or structural problems; and the competitive strategies of U.S. and foreign industries and the importance of global markets to future competitiveness.

Notice of the investigation was given by posting copies of the notice of investigation at the Office of the Secretary, U.S. International Trade Commission, Washington, DC, and by publishing the notice in the Federal Register (51 F.R. 27263, July 30, 1986). 2/

The Commission held a public hearing on this investigation as well as the four others in this series (investigation Nos. 332-229 through 332-233) at the U.S. International Trade Commission Building in Washington, DC, on February 24, 1987. At that time, however, there were no interested parties testifying in relation to this investigation. During the course of the investigation, Commission staff attended three meetings sponsored by associations that represent firms in the U.S. building-block petrochemicals industry to facilitate data collection for the investigation. The first meeting, sponsored by the National Petroleum Refiners Association (NPRA), was held on August 29, 1986; the second meeting, sponsored by the Chemical Manufacturers Association (CMA), was held on October 7, 1986; the third meeting, cosponsored by the NPRA and the CMA was held on March 24, 1987. A statement was received by the Commission from an association representing a part of the U.S. petrochemical industry.

In the course of this investigation, the Commission collected data and information from questionnaires sent to producers of the building-block petrochemicals, end users of petrochemical products, and suppliers of the petrochemical products to the end users. 3/ In addition, information was gathered from various public and private sources, industry meetings, foreign fieldwork in Brussels and London, interviews with industry executives representing producers and importers of the building-block petrochemicals, suppliers and end users of the petrochemical products, and public data gathered in other Commission studies and from other sources.

1/ The request from the Committee on Finance is reproduced in app. A.
2/ A copy of the Commission's Notice of Investigation is reproduced in app. B.
3/ A discussion of the survey design and methodology appears in app. C.

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Executive Summary

Building-block petrochemicals are the primary aromatics (benzene, toluene, and xylenes) and the primary olefins (ethylene, propylene and butadiene). 1/ These products, derived from first-stage processing of crude petroleum and natural gas, are used to produce thousands of petrochemical products including plastics, detergents, pharmaceuticals, and other consumer products. Of the many thousands of petrochemicals that have been developed from these building-block petrochemicals, about 14,000 have achieved significant commercial status. These petrochemicals account for about 75 percent of the total output of the U.S. chemical industry.

Historically, the United States has been, and remains, the largest producer of building-block petrochemicals. However, during the last 15 years, changes in the global industry have eroded the preeminence of the U.S. industry, which now faces significant competitive challenges in most world markets. These challenges come both from traditional producers, such as Japan and Western Europe, as well as from newly industrializing conventional energy-rich nations (CERN's). Dramatic increases in world prices of crude petroleum have substantially changed the world petrochemical industry since the first energy price shock in 1973. Although the current situation is relatively stable, future changes in the price of crude petroleum would have additional significant impacts on the industry. 2/ This report analyzes the competitiveness of the U.S. producers of the primary aromatics (benzene, toluene, and mixed xylenes) and the primary olefins (ethylene, propylene, and butadiene), and then presents the implications of this analysis for the automobile, packaging, and construction industries. Table A presents an industry and market profile for 1982-86.

The principal findings of this investigation are as follows:

- <u>During 1980-85, the U.S. share of world production of building-block petrochemicals declined from 42 percent to 35 percent</u>.

During 1980-85, the average annual rate of growth in free-world production of the six primary petrochemicals was 1.9 percent. The leading growth areas were the Middle East and Africa with average annual growth rates of 51 percent, Mexico with 14 percent, and Asian and Pacific nations, excluding Japan, with 14 percent. Over the same period, the United States registered a decline in production of 1.9 percent per year. Newer producers, such as those located in Saudi Arabia, emphasize the production of primary

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1/ See Glossary of Terms.
2/ For a further analysis of effects of changes in world energy prices, see <u>Possible Effects of Changing World Crude Petroleum Prices</u>, USITC Publication 1494, February 1984.

Table A
Profile of U.S. building-block petrochemical industry and market, 1982-86

Item	1982	1983	1984	1985	1986	Absolute change, 1986 from 1982	Percentage change, 1986 from 1982
Net sales (million dollars)	6,518	6,809	7,107	6,718	5,693	(825)	-12.7
Net profits (million dollars)	-76.4	-167.9	110.9	-102.8	514.0	590.4	-
Ratio of net profits to net sales (percent)	-1.2	-2.5	1.6	-1.5	9.0	10.2	-
Capital expenditures, domestic:							
Total (million dollars)	323.5	246.1	185.8	168.0	140.1	(183.4)	-56.7
Ratio of domestic capital expenditures to net sales (percent)	5.0	3.6	2.6	2.5	2.5	-2.5	-
R & D expenditures, domestic:							
Total (million dollars)	19.9	17.0	15.9	14.6	9.3	(10.6)	-53.3
Ratio of domestic R & D expenditures to net sales (percent)	.31	.25	.22	.22	.16	-0.15	-
Available capacity: 1/							
Primary olefins (million pounds per year)	66,493	64,048	63,770	59,915	61,724	(4,769)	-7.2
Primary aromatics (million pounds per year)	40,535	38,744	38,719	39,366	41,372	837	2.1
Capacity utilization:							
Primary olefins (percent)	58.6	70.2	78.0	78.6	85.5	26.9	45.9
Primary aromatics (percent)	44.0	52.0	55.2	50.8	52.6	8.6	19.5
Employment:							
Total (number)	25,709	25,028	25,166	24,363	23,377	(2,332)	-9.1
Production and related workers engaged in the production of:							
Primary olefins (number)	9,557	9,810	8,979	8,425	7,999	(1,558)	-16.3
Primary aromatics (number)	1,465	1,409	1,445	1,438	1,408	(57)	-3.9
Production: 2/							
Primary olefins (million pounds)	38,951	44,992	49,769	47,074	52,800	13,849	35.6
Primary aromatics (million pounds)	17,847	20,166	21,385	20,006	21,770	3,923	22.0
Total (million pounds)	56,798	65,158	71,154	67,080	74,570	17,772	31.3
Exports: 3/							
Primary olefins (million pounds)	149	154	258	431	446	297	199.3
Primary aromatics (million pounds)	2,199	1,930	2,056	1,795	1,840	(359)	-16.3
Total (million pounds)	2,348	2,084	2,314	2,226	2,286	(62)	-2.6
Imports: 3/							
Primary olefins (million pounds)	1,399	1,548	1,734	1,521	1,128	(271)	-19.4
Primary aromatics (million pounds)	2,243	2,129	2,487	3,045	3,196	953	42.5
Total (million pounds)	3,641	3,677	4,221	4,566	4,324	683	18.8
Apparent consumption:							
Primary olefins (million pounds)	40,201	46,387	51,245	48,164	53,483	13,282	33.0
Primary aromatics (million pounds)	17,891	20,365	21,816	21,256	23,126	5,235	29.3
Total (million pounds)	58,092	66,751	73,061	69,420	76,609	18,517	31.9
Trade balance:							
Primary olefins (million pounds)	(1,250)	(1,395)	(1,476)	(1,090)	(683)	567	-
Primary aromatics (million pounds)	(44)	(199)	(431)	(1,250)	(1,356)	(1,312)	-
Total (million pounds)	(1,294)	(1,593)	(1,907)	(2,340)	(2,039)	(745)	-
Imports to consumption ratio:							
Primary olefins (percent)	3.5	3.3	3.4	3.2	2.1	-1.4	-
Primary aromatics (percent)	12.5	10.5	11.4	14.3	13.8	1.3	-
Total (percent)	6.3	5.5	5.8	6.6	5.6	-0.7	-

1/ Compiled from SRI International Directory of Chemical Producers, 1983-87 editions.
2/ Data for 1982-85 compiled from statistics published in U.S. International Trade Commission, Synthetic Organic Chemicals, U.S. Production and Sales, 1982-85; data for 1986 are estimated from preliminary quarterly statistics published in Preliminary Report on U.S. Production of Selected Synthetic Organic Chemicals Preliminary Totals, 1986, Mar. 31, 1987.
3/ Compiled from official statistics of the U.S. Department of Commerce.

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission, except as noted.

petrochemicals and less advanced derivatives. Such an emphasis is also true of other new petrochemical industries in Brazil and Taiwan (pp. 2-5 to 2-6).

o <u>During 1980-85, the U.S. share of total world exports of derivatives of building-block petrochemicals fell from 27 percent to 22 percent</u>.

Most of the foreign trade of primary petrochemicals is in the derivative form of plastics, petrochemical intermediates, and other petrochemical products, since ethylene and propylene are gases under ambient conditions and therefore too expensive to transport except by pipeline. The largest consumers of petrochemicals are the United States, Japan, and Western Europe. Canada, Mexico, and Saudi Arabia have smaller but more rapidly growing petrochemical industries.

Changes during 1980-85 in world production have changed trade patterns. The following tabulation shows net trade for major primary petrochemical derivatives and highlights the changing trade patterns (in million tons ethylene equivalents) (pp. 2-1 to 2-5):

Item	1979	1982	1985	Net change, 1985 over 1979
Major ethylene derivatives:				
United States...............	1,400	1,700	1,350	-50
Western Europe...............	1,025	825	625	-400
Japan.....................	425	50	-225	-650
Canada....................	75	150	250	175
Mexico 1/..................	-750	-575	-300	450
Middle East................	-350	-375	-175	175
Major benzene derivatives:				
United States...............	575	600	450	-125
Western Europe...............	50	25	50	0
Japan.....................	75	-25	-175	-250
Canada....................	50	75	250	200
Mexico 1/..................	-175	-150	-50	125
Middle East................	-75	-75	-75	0

1/ Includes other Latin American nations.

o <u>The most important factor explaining changes in the competitiveness of the primary petrochemical industries of different nations is changes in world prices of crude petroleum</u>.

The large crude petroleum price increases during 1973-82 provided many energy-rich nations with the incentive to invest in facilities that convert previously discarded or otherwise unused natural gas to primary petrochemicals. The attractiveness of this investment increased as the prices of energy and feedstock materials continued to increase. 1/ When prices of crude petroleum were low (before 1973), prices of petrochemical feedstocks in industrialized countries were also low. This meant that energy-rich countries (such as Saudi Arabia) could not viably produce and export petrochemicals because they could not cover the costs of processing and transportation (even though the price of natural gas feedstocks were zero). This situation changed when the price of crude petroleum rose sharply after 1973. After 1973, prices of feedstocks in industrialized countries were much higher, as were the prices of petrochemicals. The sharp increases in the latter prices were sufficiently great to cover the costs of petrochemicals processing operations and transport in these countries (e.g., Saudi Arabia) so that these countries had an incentive to use their previously discarded natural gas. Currently, the pricing policies and practices for the natural gas associated with the recovery of crude petroleum in energy-rich nations are affected by lower-than-average production costs and alternate use values. 2/ Also, in nations in which natural gas fields have been discovered that, because of a limited size, would not support an export-oriented energy industry have often instead opted to develop a petrochemical industry.

With the decline in crude petroleum and other energy prices in 1986, the comparative advantage in prices lessened but still remained. 3/ For example, the natural gas used to produce ethylene in Saudi Arabia has been priced at a constant $0.50 per thousand cubic feet since its initial commercial use, in order to amortize the capital costs of the Saudi Master Gas System. Although U.S. natural gas prices declined during 1983-86, the prices paid by industrial consumers have remained above $2.75 per thousand cubic feet throughout the period.

The following tabulation shows the average total production cost along with the average feedstock cost, for ethylene and benzene during 1985-86 in major producing areas of the world:

1/ It is prohibitively expensive to transport natural gas.
2/ For additional information on such pricing policies and practices, see <u>Potential Effects of Foreign Government's Policies of Pricing Natural Resources</u>, USITC Publication 1696, May 1985.
3/ According to U.S. data from questionnaire responses; foreign data estimated by the staff of the Commission.

Country 1/	Ethylene Feedstock cost	Ethylene Total production cost 2/	Benzene Feedstock cost	Benzene Total production cost
	----Cents per pound---		---Cents per gallon---	
United States	6-13	6-21	43-95	59-123
West Europe............	4-13	10-21	60-130	75-160
Middle East/Saudi Arabia................	1-3	5-9	3/	3/
Canada..................	5-9	10-17	4/	4/

1/ Japan, for the first time, imported ethylene from U.S. producers (203,000 pounds) in 1986 for the production of derivatives. This material was valued at approximately $1.00 per pound because of the liquefaction of the ethylene and other transportation costs.
2/ Total production cost can be as low or lower than actual feedstock cost owing to income generated from coproducts credits.
3/ No trade-significant production of benzene for chemical use in Saudi Arabia.
4/ Canadian benzene production costs are slightly higher than those in the United States, since there is 1 plant that accepts tar sands, which are more expensive than traditional feeds, as a feedstock.

The great concern of the primary petrochemical industry is that feedstock and energy costs account for 70 percent or more of the total production costs. The following tabulation highlights the effects of past major feedstock and energy price changes on the structure of production costs: 1/

	1972	1977	1980
Naphtha cost 1/.................	100	510	1,360
Capital cost 1/.................	100	180	300
Feedstock and energy cost 2/.....	46	73	85
Other costs 2/..................	6	2	2
Fixed costs and manpower 2/.....	48	25	13

1/ 1972=100
2/ As a share of total production cost.

Although not all of the effects of the recently declining feedstock prices have yet been exhibited, certain immediate positive impacts for the producers that rely on these materials have already become evident. Especially for the Western European petrochemical industry, which relies

1/ Organization for Economic Cooperation and Development, Petrochemical Industry Energy Aspects of Structural Change, 1985, p. 46.

heavily on the petroleum-based feedstocks, the variable costs of production decreased between fourth quarter 1985 and first quarter 1986. The feedstock share of total ethylene production costs decreased from 60-70 percent during fourth quarter 1985 to 30-40 percent in early 1986. The reported variable costs for producing ethylene from gas-based feedstocks in Saudi Arabia during this same period were only $50 per metric ton; however, costs of more than $100 per metric ton to transport Saudi ethylene derivatives to European markets kept some European producers competitive in their home markets. It is the transportation costs that also have prevented Saudi derivatives from entering the United States (pp. 2-7 to 2-11).

- <u>Primary petrochemicals are produced by 44 companies whose production facilities are principally located in Texas and Louisiana near feedstocks and energy sources. The five largest petrochemical producers account for about 51 percent of total annual production of these petrochemicals</u>.

The U.S. primary petrochemical industry includes purely domestic companies, as well as multinationals with operations and facilities located throughout the world. There are non-integrated producers with limited lines of production, while others are integrated both horizontally and vertically. Foreign ownership/investment in the U.S. chemical industry is currently estimated to be about 20 percent of book value.

Petrochemicals are produced both by petroleum companies and chemical companies. The following tabulation shows the share of total U.S. production of the primary petrochemicals accounted for by petroleum companies and chemical companies in 1985 (in percent) (pp. 3-1 to 3-3):

Primary petrochemical	Share of U.S. production: Petroleum companies	Share of U.S. production: Chemical companies
Ethylene	49.7	50.3
Propylene	70.8	29.2
1.3-Butadiene	58.6	41.4
Benzene	84.5	15.5
Toluene	94.6	5.4
Mixed xylenes	92.0	8.0

o <u>During 1982-86, U.S. primary olefins capacity was reduced at an average annual rate of 1.4 percent and U.S. primary aromatics capacity increased at an average annual rate of 0.4 percent</u>.

During 1982-85, the U.S. petrochemical industry, along with the Western European and the Japanese primary petrochemical industries, reduced its production capacity because of world overcapacity (table B). Some of the production capacity shut down during 1981-85 could be brought back onstream, including incorporation of state-of-the-art technology, with a significantly lower capital investment than would be necessary to build entirely new facilities (pp. 3-3 to 3-5).

Table B
U.S. building-block petrochemical capacity

Building-block petrochemical	1982	1983	1984	1985	1986	Percentage change, 1986 over 1982
	------------	Million pounds	------------			
Olefins:						
Ethylene........	39,345	37,725	37,725	34,650	35,609	-9.5
Propylene.......	22,680	22,285	22,290	21,510	22,260	-1.9
1,3-Butadiene...	4,468	4,038	3,755	3,755	3,855	-13.7
Total.........	66,493	64,048	63,770	59,915	61,724	-7.2
Aromatics:						
Benzene.........	17,720	17,028	16,476	16,947	16,821	-5.1
Toluene.........	11,405	10,890	10,578	10,367	12,459	9.2
Mixed xylenes...	11,410	10,826	10,665	12,052	12,092	6.0
Total.........	40,535	38,734	38,719	39,366	41,372	2.1

Source: Compiled from data in <u>SRI International Directory of Chemical Producers</u>, 1982-86 editions.

o <u>During 1982-86, U.S. primary petrochemical production fluctuated, showing a net gain for the primary olefins, and a small net loss for the primary aromatics.</u>

The primary petrochemical production data during 1982-84 show a net increase followed by a decline in 1985 and another rise in 1986 in both the primary olefins and primary aromatics (table C).

Table C
U.S. building-block petrochemical production

Building-block petrochemical	1982	1983	1984	1985	1986	Percentage change, 1986 over 1982
	---------------Million pound------------					
Olefins:						
Ethylene........	24,501	28,680	31,383	29,847	32,811	33.9
Propylene.......	12,535	13,959	15,559	14,887	17,343	38.4
1,3-Butadiene...	1,915	2,353	2,452	2,340	2,646	22.2
Subtotal......	38,951	44,992	49,394	47,074	52,800	2.6
Aromatics:						
Benzene.........	7,700	9,025	9,646	9,390	10,053	30.6
Toluene.........	5,148	5,623	5,249	5,074	5,845	13.5
Mixed xylenes...	4,999	5,518	6,490	1/ 5,542	1/ 5,872	17.5
Subtotal......	17,847	20,166	21,385	20,006	21,770	22.0
Total.........	56,798	65,158	70,779	67,080	74,570	31.3

1/ Estimated by the staff of the U.S. International Trade Commission.

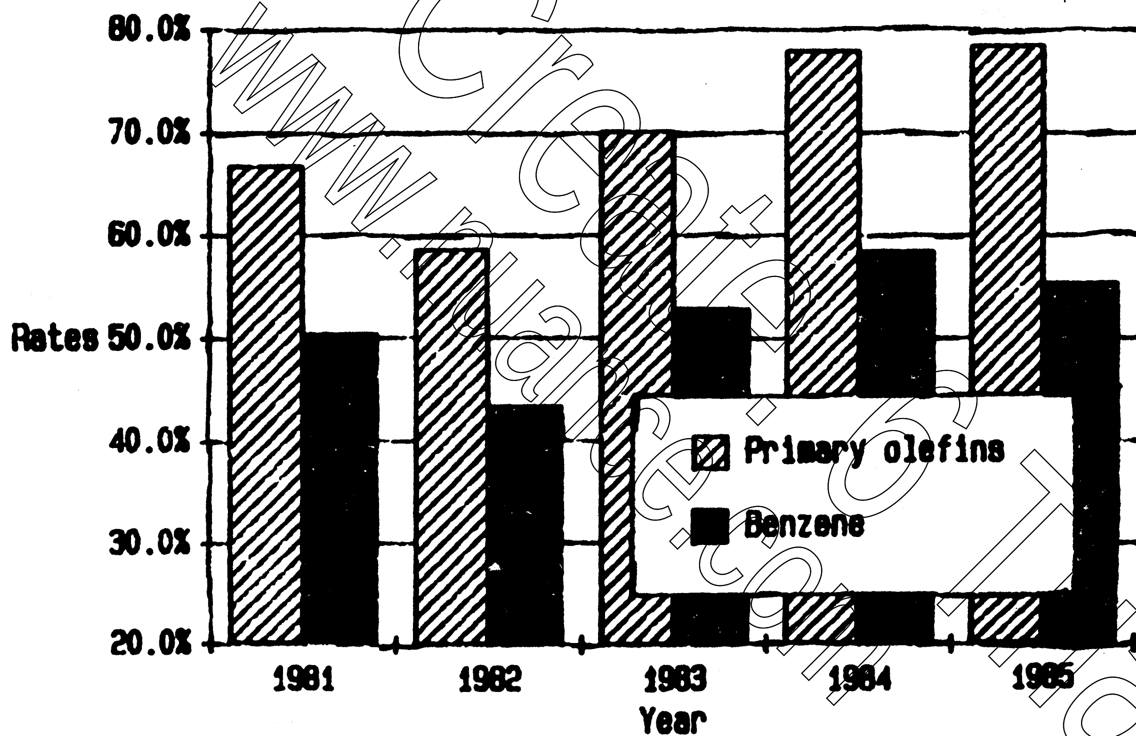
Source: U.S. International Trade Commission, Synthetic Organic Chemicals, U.S. Production and Sales, 1982-85, and Preliminary Report on U.S. Production of Selected Synthetic Organic Chemicals Preliminary Totals, 1986, Mar. 31, 1987.

However, these production volumes, examined together with the reductions in U.S. capacity and changing consumption that were taking place during the same period, show an improvement in capacity utilization rates, as shown in figure A (pp. 3-4 to 3-8).

- In 1986 exports of primary olefins and primary aromatics were valued at only $422 million while exports of the major derivatives were valued at $3.3 billion.

The following tabulation contains data supplied by the respondents to the Commission questionnaire concerning the value of their export shipments of primary petrochemicals and derivatives, and total industry exports of primary

Figure A
Capacity Utilization Rates



Source: U.S. International Trade Commission Publication, Synthetic Organic Chemicals, U.S. Production and Sales, 1981-85 editions and, SRI International Directory of Chemicals Producers, United States, 1982 through 1986 editions.

petrochemicals and derivatives (see tables 3-2 through 3-4 in the text for details of the total industry exports) (pp. 3-8 to 3-14): 1/

(In millions of dollars)

Item	1982	1983	1984	1985	1986 1/
	Exports of questionnaire respondents 2/				
Primary olefins.........	38.1	32.8	39.1	57.5	31.7
Primary aromatics.......	114.9	72.7	67.7	31.3	24.0
Olefin derivatives......	316.4	338.3	448.0	468.8	480.0
Aromatic derivatives....	209.8	136.3	144.6	182.0	244.1
Total...............	679.2	580.1	699.4	739.6	779.9
	Exports of total petrochemical industry				
Primary olefins........	43.4	43.5	63.5	95.6	65.5
Primary aromatics......	561.3	432.7	474.3	405.3	356.8
Major derivatives......	2,944.4	2,932.1	3,181.5	3,057.0	3,344.5
Total..............	3,549.1	3,408.3	3,719.3	3,557.9	3,766.8

1/ Estimated from partial-year data supplied in response to questionnaires of the U.S. International Trade Commission.
2/ Producers of primary olefins and aromatics only.

Although the primary petrochemical producers and the entire petrochemical industry do export primary petrochemicals per se, by far the largest portion of trade in primary petrochemicals is in the form of derivatives. The primary petrochemical industry accounts for only a minor share of the total petrochemical industry's exports, a natural outgrowth of the involvement of other petrochemical firms that further process the primary petrochemicals into more advanced intermediate petrochemicals and petrochemical products.

1/ See App. C for complete survey methodology. Questionnaires were sent to the 44 firms that comprise the domestic primary petrochemical industry. Useable responses were received from 38 firms, a response rate of 86 percent. These firms are estimated to have accounted for between 85 and 99 percent of the total domestic production of each of the individual primary olefins and primary aromatics during 1982-86; Compiled from official statistics of the U.S. Department of Commerce.

o <u>Trade barriers were cited by Commission respondents as inhibiting exports of both primary petrochemicals and their derivatives</u>.

The 11 barriers to international trade most often mentioned by the respondents to the Commission questionnaire were, in order of the number of responses, as follows: 1/

1. Government subsidies
2. State trading, Government monopolies, and exclusive franchises
3. Government laws and practices which discourage imports
4. Licensing requirements
5. Government procurement (procedures)
6. Discriminatory bilateral agreements
7. Exchange and other monetary or financial controls
8. Antidumping practices
9. Customs valuation
10. Restrictive business practices
11. Documentation requirements.

The countries most often associated with these various barriers to international trade were cited by the respondents to the Commission questionnaire in the following order (pp. 3-14 to 3-19):

1. Mexico
2. South American countries
3. European Community
4. Japan
5. Other Asia/Pacific Rim nations
6. Canada

o <u>Imports of primary petrochemicals increased by more than 5 percent during 1982-85, but declined by 35 percent during 1985-86. In 1986, Canada accounted for nearly 100 percent of U.S. imports of ethylene, for 92 percent of propylene imports, and was the principal source of toluene and mixed xylenes imports</u>.

U.S. imports of primary petrochemicals totaled 4.3 billion pounds in 1986 and were valued at $508 million; overall, Canada accounted for 37 percent of all U.S. primary petrochemical imports. The U.S. dependence on Canada as a source of primary petrochemical imports was due primarily to its proximity to U.S. facilities and the availability of a ground and pipeline transportation infrastructure that connects facilities in both nations (pp. 3-19 to 3-21).

1/ There were 21 firms responding to this question in the Commission questionnaire.

- <u>New foreign primary petrochemical-producing industries have based their facilities on existing and anticipated export markets, thus changing the historic relationships between traditional suppliers and consumers</u>.

The traditional petrochemical-producing areas of the world--the United States, Western Europe, and Japan--are now competing with energy-rich nations that have built and are continuing to build world-scale petrochemical facilities supplied with low-cost crude petroleum and/or associated natural gas. Leading the new participants are Saudi Arabia, Canada, Mexico, Indonesia, Kuwait, the U.S.S.R., and the People's Republic of China (China). Often, a significant share of these nation's production is intended for export.(pp. 5-8 to 5-10).

- <u>U.S. primary petrochemical producers are responding to changes taking place in the primary petrochemical industry worldwide and assess their own position in the world market as one of competitive strength</u>.

Respondents to the Commission questionnaire indicated that, although the U.S. industry's level of competitiveness has declined, the industry will remain competitive once capacity reductions and rationalizations are completed. Commission questionnaire respondents indicated that although they place great importance on pricing policies, other strategies such as product quality, a captive sales force, and improved technical service will continue to be relied on to remain competitive. U.S. producers believe foreign competitors rely almost exclusively on pricing policies to obtain, maintain, and increase market share (pp. 5-10 to 5-12 and 5-13).

- <u>The U.S. petrochemical industries' evaluation of competitiveness factors reinforces the importance of feedstock price and availability both to the primary petrochemical producers and to the producers of derivatives, also citing the importance of environmental regulations, taxes, and safety regulations.</u>

The U.S. producers' responses substantiated the theme that fuel and feedstock price and availability are the most important competitive factors. However their responses also emphasized the importance of environmental and safety regulations and taxes, compared with lesser regarded factors such as antitrust measures, investment restrictions, nontariff barriers, profit repatriation, and barter and countertrade relationships (pp. 6-1 to 6-2).

- The productivity index for the primary petrochemicals industry, based on data for the primary olefins sector, has been erratic during 1981-86, particularly compared with the index for all manufactures and the chemical and allied products industry.

During 1982-86, there was a swift climb in productivity of the primary olefins, which rose from an indexed value of 100 in 1982 to about 137 in 1986. Corresponding productivity indexes for the overall U.S. chemicals and allied products industries and for all domestic manufacturing industries, both of which have a larger base and a more diverse product mix, rose at a slower rate during the same period. Also, the labor factor used in calculating productivity accounts for 5 percent or less of the total costs of production of the primary olefins and aromatics, whose manufacture is capital rather than labor intensive (pp. 6-10 to 6-13).

- The packaging, construction, and automotive industries are the most significant consuming industries either employing or incorporating materials with significant petrochemical content into their output.

The implications of the competitiveness of the U.S. primary petrochemical industry for the U.S. consuming industries varies with respect to the economic, financial, and sociopolitical considerations associated with each of the individual consuming industries. On a purely quantitative basis, the degree of impact is associated with (1) the share of the consuming industry's total material cost accounted for by the petrochemical content, (2) the availability, price, and quality of alternate sources of supply or alternate materials, and (3) the relative importance of the petrochemical content in the context of the finished end product (pp. 7-1 to 7-3).

The following conclusions may be drawn from the information discovered in this investigation:

1. The positive impacts on the U.S. building-block petrochemical industry attributable to the decline in world crude petroleum prices during early 1986 have not been reversed by the subsequent slight price recovery and stabilization of prices seen in late 1986 and early 1987. This does not mean dramatic or even continued further gradual price increases would not effect the industry. Feedstock and energy prices are a significant cost component of the total production cost of primary petrochemicals.

2. The competitive advantage conferred on certain producing nations by virtue of the availability of abundant, low-cost natural resource materials, particularly crude petroleum and natural gas, is the primary factor determining a particular nation's building-block petrochemical industry's global competitiveness.

3. Direct or indirect intervention by national governments in either the energy and/or primary petrochemicals industries can impact a nation's industrial competitiveness via low-cost loans, energy, feedstock, etc., from government-owned or government-directed entities, which increase a nation' primary petrochemical industry's competitiveness, or by environmental and workplace safety regulations, which decrease it.

4. Rationalization (i.e., reorganization, restructuring, closing facilities, etc.) of the building-block petrochemical industries in traditional producing countries (i.e., United States, Western Europe, and Japan) has improved the competitive status of these nations' industries to the extent that the production capacity that came onstream during 1982-86 in Canada, Mexico, Saudi Arabia, and other energy-rich nations may be absorbed into the world market. As additional primary petrochemical industry capacity comes onstream in these nations, further realignment may be required in the petrochemical industries of the traditional producing nations.

5. If and when additional primary petrochemical derivative capacity comes onstream in the energy-rich nations, further pressure will be brought to bear on the competitiveness of the U.S. primary petrochemical industry. Such action will also increase the pressure on the entire U.S. petrochemical industry.

6. Indirect influences and factors, particularly changes in the fuels and energy industries, play a significant role in determining petrochemical industry competitiveness; such changes as the switch from leaded to unleaded fuel affect the available supply of certain primary petrochemicals, and therefore may influence the pricing of these materials and any of their coproducts.

7. Exchange-rate fluctuations are an important factor in the competitiveness of a nations primary petrochemical industry; stimulating either imports or exports.

The expected direction of changes in the level of competitiveness of the U.S. building-block petrochemical industry as they relate to certain factors are shown in the following tabulation: 1/

Factor	Expected direction of change of competitiveness
Decreased world price of crude petroleum.....	Increase
Imposition of U.S. petroleum import fees.....	Decrease
Increase in strength of U.S. dollar versus foreign currencies..................	Decrease
Change from leaded to unleaded fuels.........	Increase
Development of new petrochemical processes/ products..................................	Increase
Development of new markets for petrochemical materials....................	Increase
Increasing production of building-block petrochemicals and derivatives in energy-rich nations..............................	Decrease
Increased government environment and safety regulations and taxes on domestic producers................................	Decrease

1/ Assuming all other factors remain constant.

Chapter 1. Definitions of Petrochemical Industry Competitiveness and Scope of This Report

1.1 The petrochemicals industry

Since the early 1980's, many sectors of the petrochemical industry within the industrialized world (e.g., Western Europe, the United States, and Japan) have suffered from overcapacity. In response, companies have restructured their industry by shutting down or selling production sites. One segment of the industry that has been particularly active in this respect is the primary or "building-block" petrochemicals sector.

Primary or building-block petrochemicals include the primary aromatics (benzene, toluene, and xylenes) and the primary olefins (ethylene, propylene and butadiene). 1/ These products are derived from first-stage processing of crude petroleum and natural gas, which are used to produce thousands of petrochemical products (fig. 1-1).

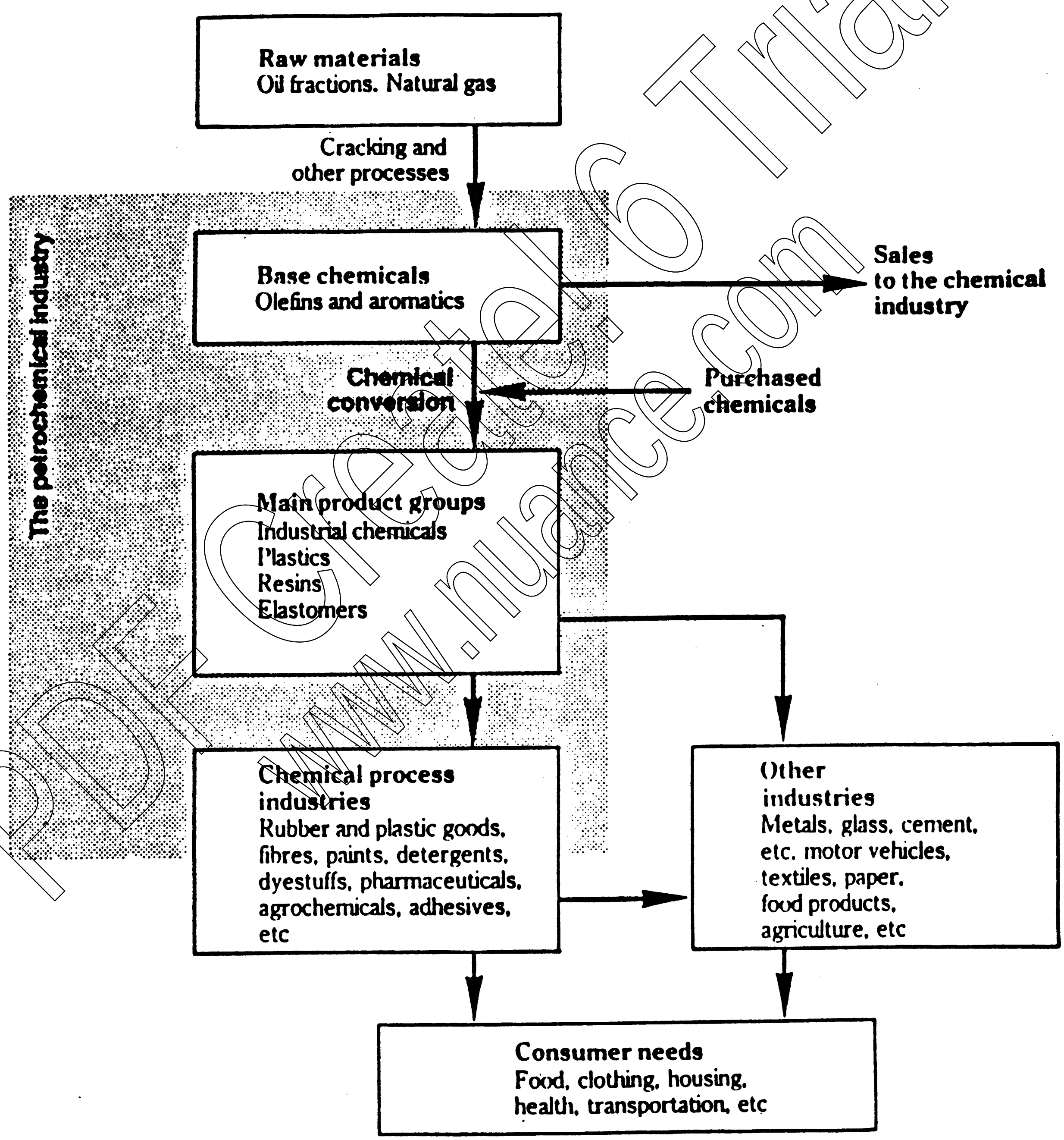
For this study, petrochemicals will be classified by stage of production. Figure 1-2 divides the petrochemical industry into three stages. The first stage is where the primary olefins and primary aromatics are produced. The second stage is where the primary petrochemicals are converted to many different intermediate petrochemicals. In the third stage, the chemical process industries convert the intermediates into final petrochemical products. As figure 1-2 implies, the final stage is extremely broad and encompasses much of the industrial economy.

Besides the primary olefins and primary aromatics, this report also looks at certain intermediates (e.g., ethylene glycol and vinyl chloride) and certain resins (e.g., polystyrene and polyethylene). These products are included because they are more likely to be traded internationally than are the primary olefins and primary aromatics and thus reflect changing world trade patterns and the international competitiveness of primary petrochemicals.

Petroleum refinery operations, particularly reforming (of naphtha) and catalytic cracking, are the source of some of the primary aromatics and primary olefins. These products, along with ethylene (the principal product), butadiene, and other olefins, are also produced in high-temperature crackers. Because of this close relationship with the feedstocks, the cost to produce the primary petrochemicals is highly dependent upon the prices of their feedstocks. The varying ratio of feedstocks used in the production of ethylene, by volume, in 1984 and anticipated for 1994 are shown in the following tabulation: 2/

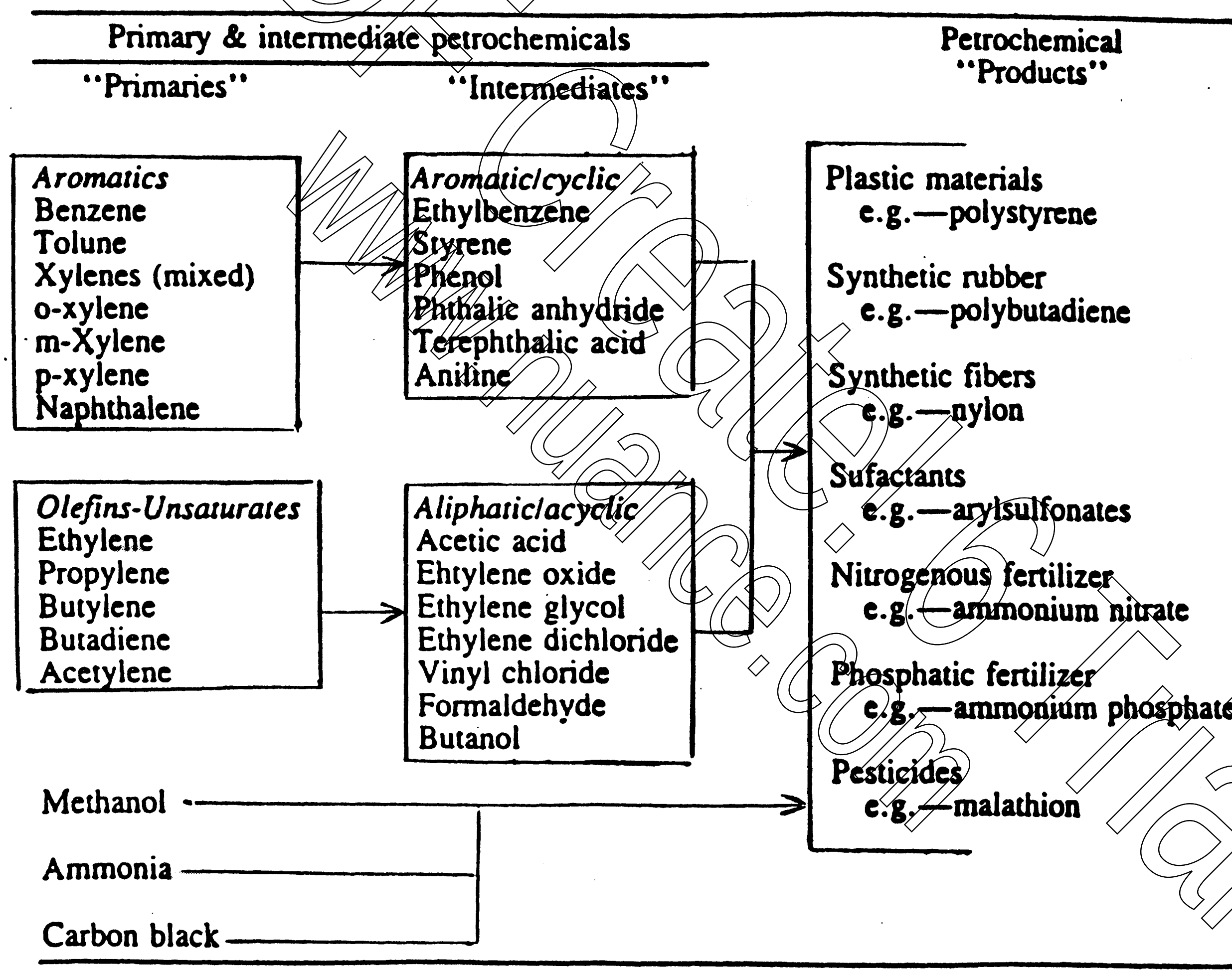
1/ For purposes of this report "building-block petrochemicals", primary petrochemicals" and "basic petrochemicals" are used interchangeably and mean primary olefins (i.e., ethylene, propylene, and butadiene) and primary aromatics (benzene, toluene, and xylenes).
2/ SRI International, Chemical Engineering, Nov. 25, 1985, p. 22, and DeWitt & Co., "Commodity Petrochemicals," Presentation to Chemical Marketing Research Association, May 1985.

Figure 1-1
Petrochemical Industry Relationships



Source: Shell International Cemicals, Ltd., Petrochemicals Handbook, 1986

Figure 1-2
Petrochemical Industry Stages



Source: U.S. Industrial Outlook. 1984

Feedstocks	1984	1994 1/
Ethane.................	24	30
LPG (propane, butane)..	13	12
Naphtha................	52	47
Gas oil................	9	10
Other..................	2	1
Total..............	100	100

1/ Estimated.

Figures 1-3, 1-4, 1-5 and 1-6 show the derivatives that are made from the olefins and aromatics. The large number of derivatives that are made from each of these primary petrochemicals is the reason they have been called building-block petrochemicals. They can be combined in various ways to produce other petrochemicals, which in turn can be made into many others, and so forth.

Over the years, many thousands of petrochemicals have been developed, of which about 14,000 have achieved significant commercial status. These 14,000 chemicals are derived from a small number of building-block petrochemicals--the primary aromatics (i.e., benzene, toluene, and the xylenes) and the primary olefins (i.e., ethylene, propylene, and butadiene). In terms of the value of shipments, petrochemicals account for about 75 percent of the total output of the U.S. chemical industry (not including petrochemical-dependent products such as pharmaceuticals, paint, finished detergents, molded plastic products, rubber products, and pesticide formulations). In terms of production quantities, the share of production attributed to petrochemicals is even greater.

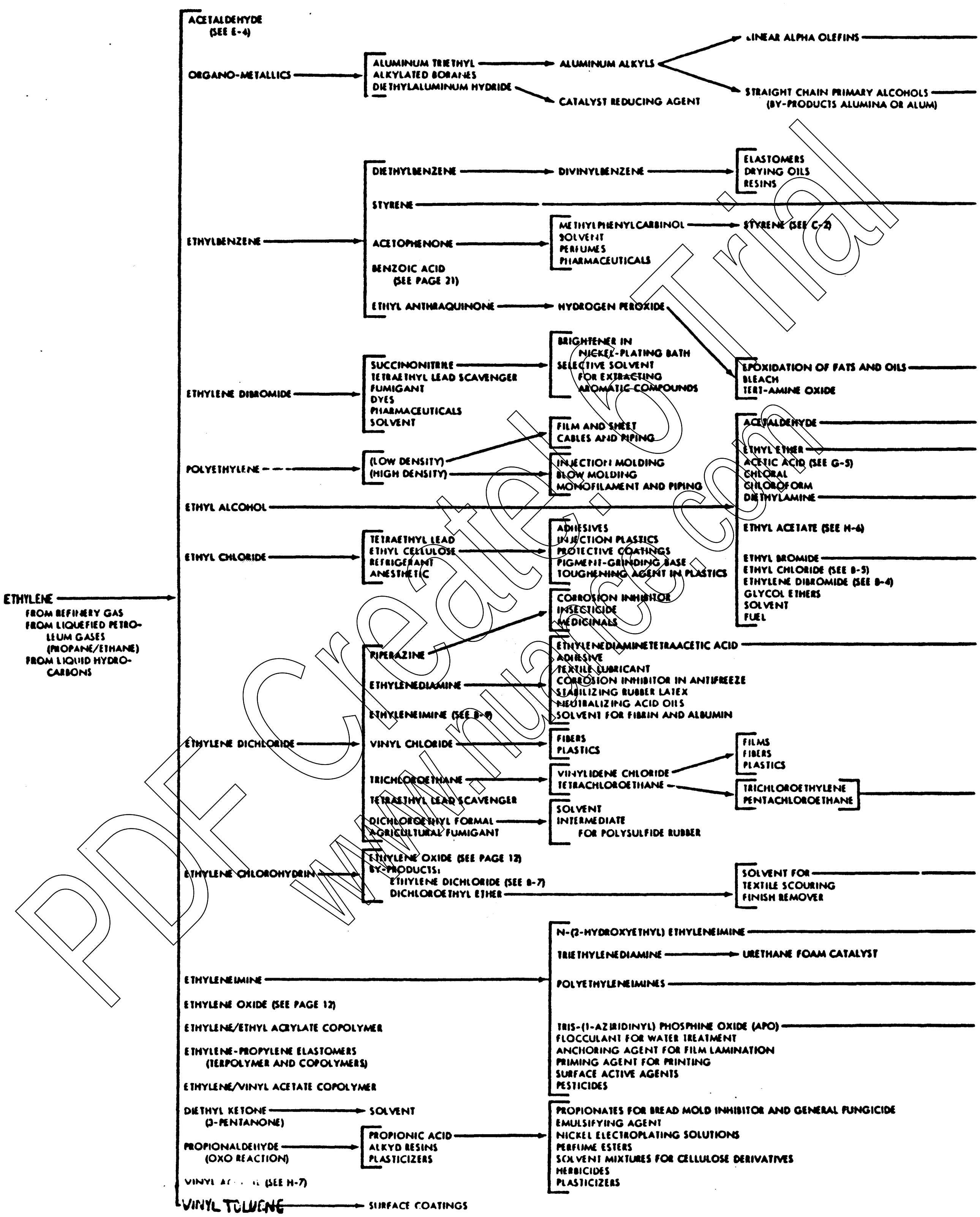
1.2 Concepts of competitiveness 1/

The deterioration of the U.S. trade balance has stimulated numerous discussions and articles on the competitiveness of U.S. industry and the nature of U.S. comparative advantage. Although these terms are discussed intuitively and are often interchanged, they are, in fact, terms that do not easily lend themselves to quantitative measures. Competitiveness, in particular, is an elusive concept. It has been said that competitiveness is an idea that everyone understands, but none can define. Therefore, quantifying the concept presents many problems. As discussed by Suomela, "we cannot say that a firm is twice as price competitive if it cuts all of its prices by 50 percent, only that the firm has become more price competitive". 2/

Comparative advantage and product life cycle.--Traditionally, the pattern of a country's imports and exports is explained by the principal of

1/ See app. D for a review of literature on competitiveness.
2/ John W. Suomela,"The Meaning and Measurement of International Price Competitiveness," Business and Economics Section, Proceedings of the American Statistical Association, 1978.

Figure 1-3
Ethylene derivatives flowchart



Source: Stanford Research Institute, Chemical Origins and Markets, 1967

Figure 1-3 (Cont.)

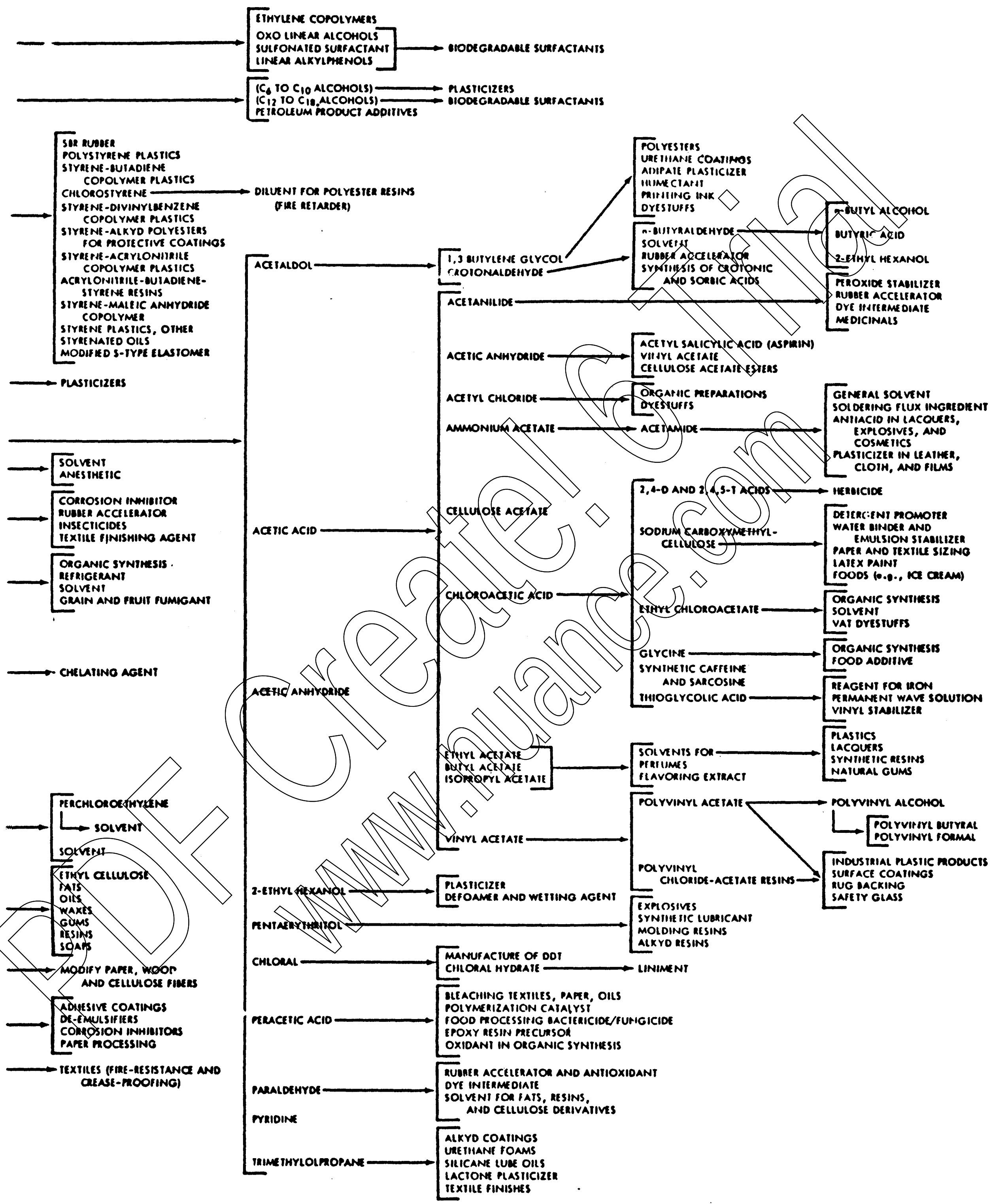
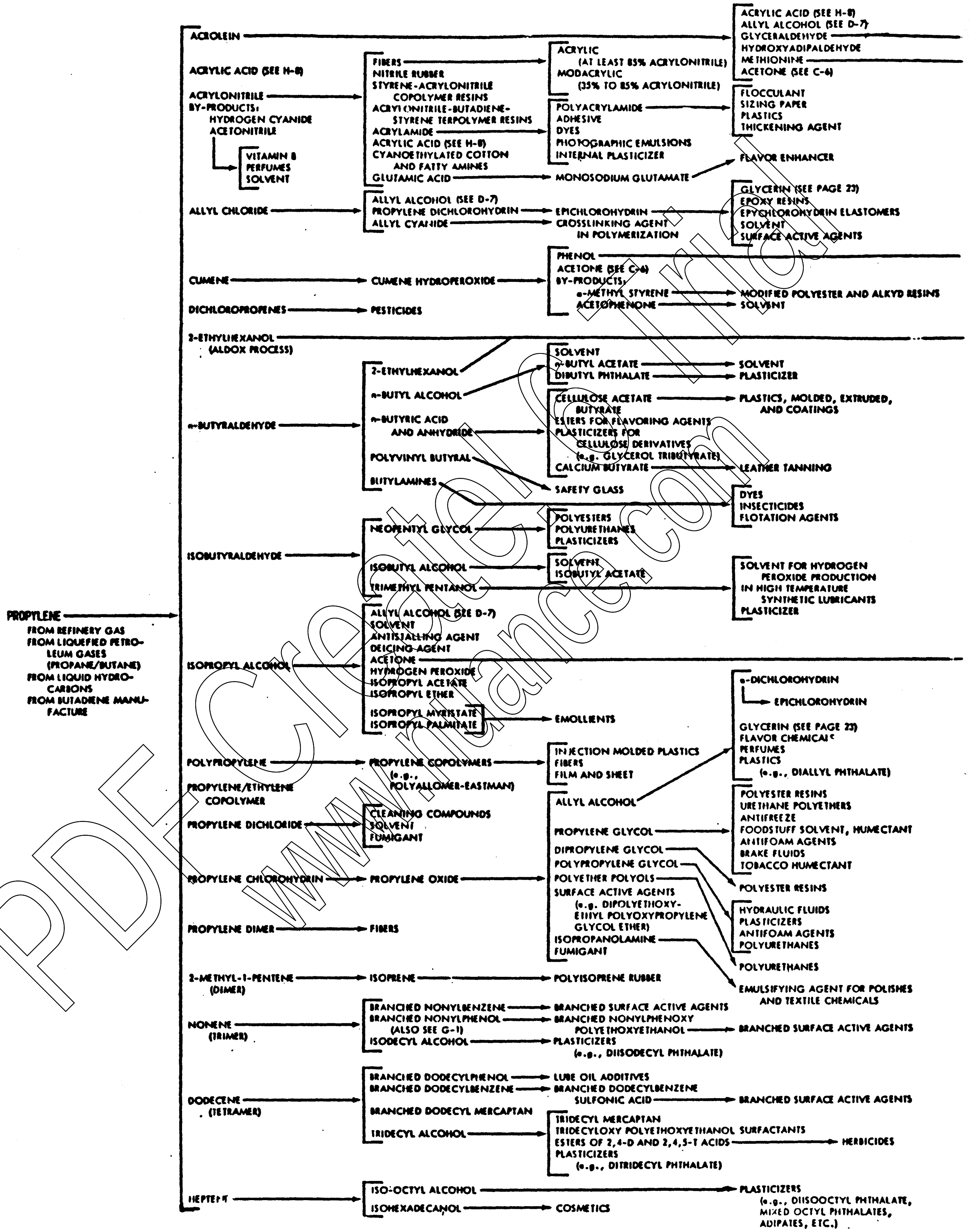


Figure 1-4
Propylene derivatives flowchart



Source: Stanford Research Institute, op. cit.

Figure 1-4 (Cont.)

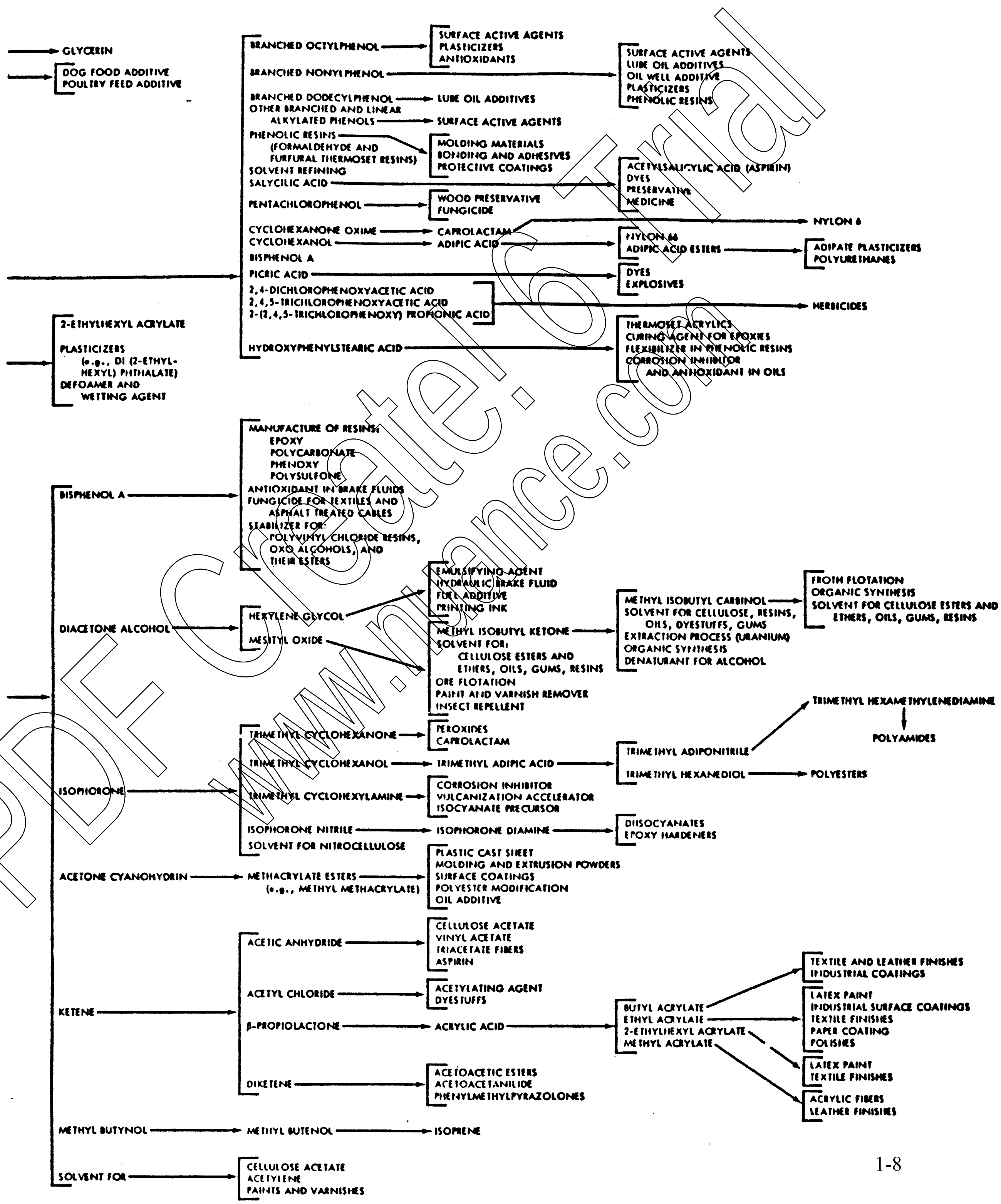
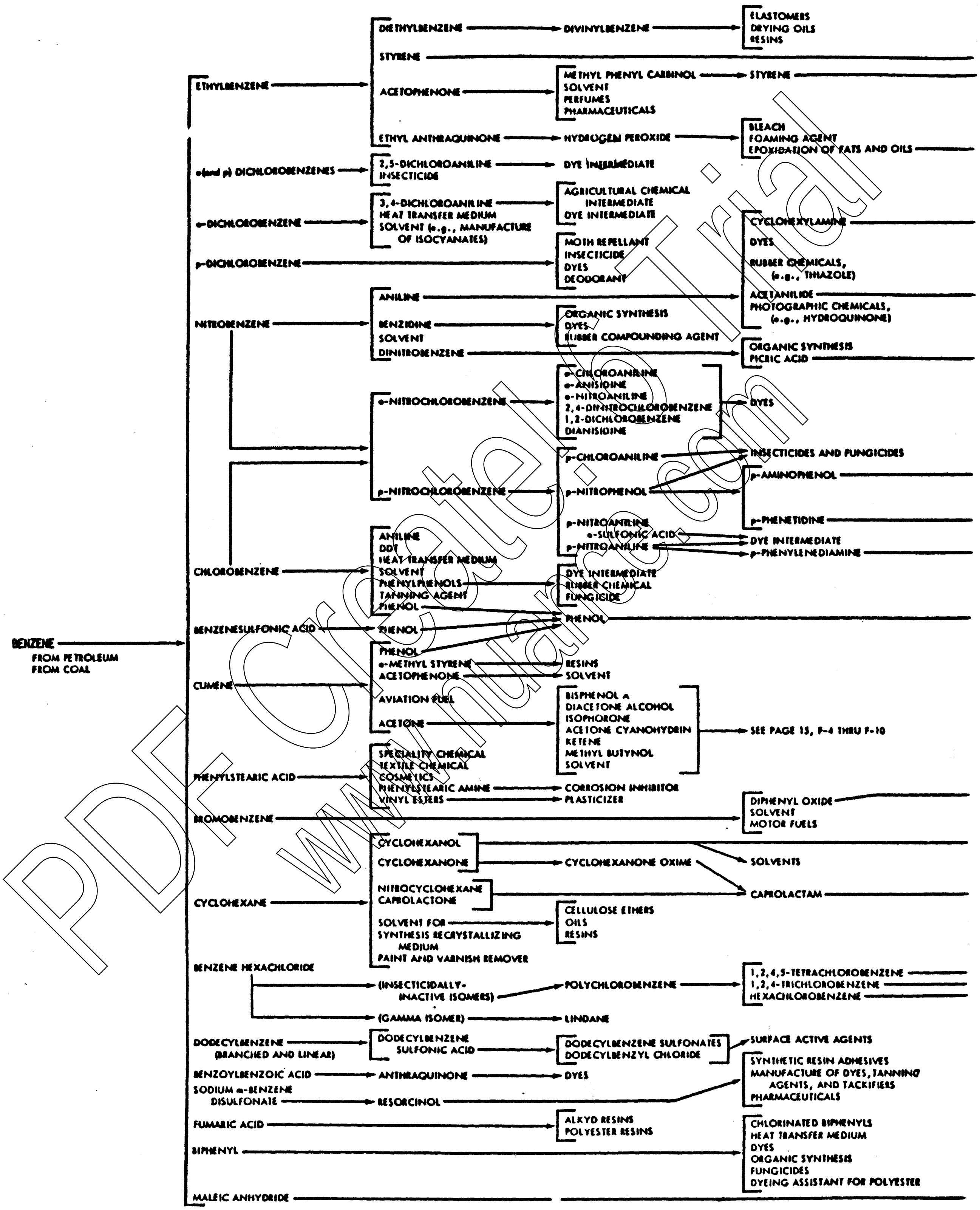


Figure 1-5
Benzene derivatives flowchart



Source: Stanford Research Institute, op. cit.

Figure 1-5 (Cont.)

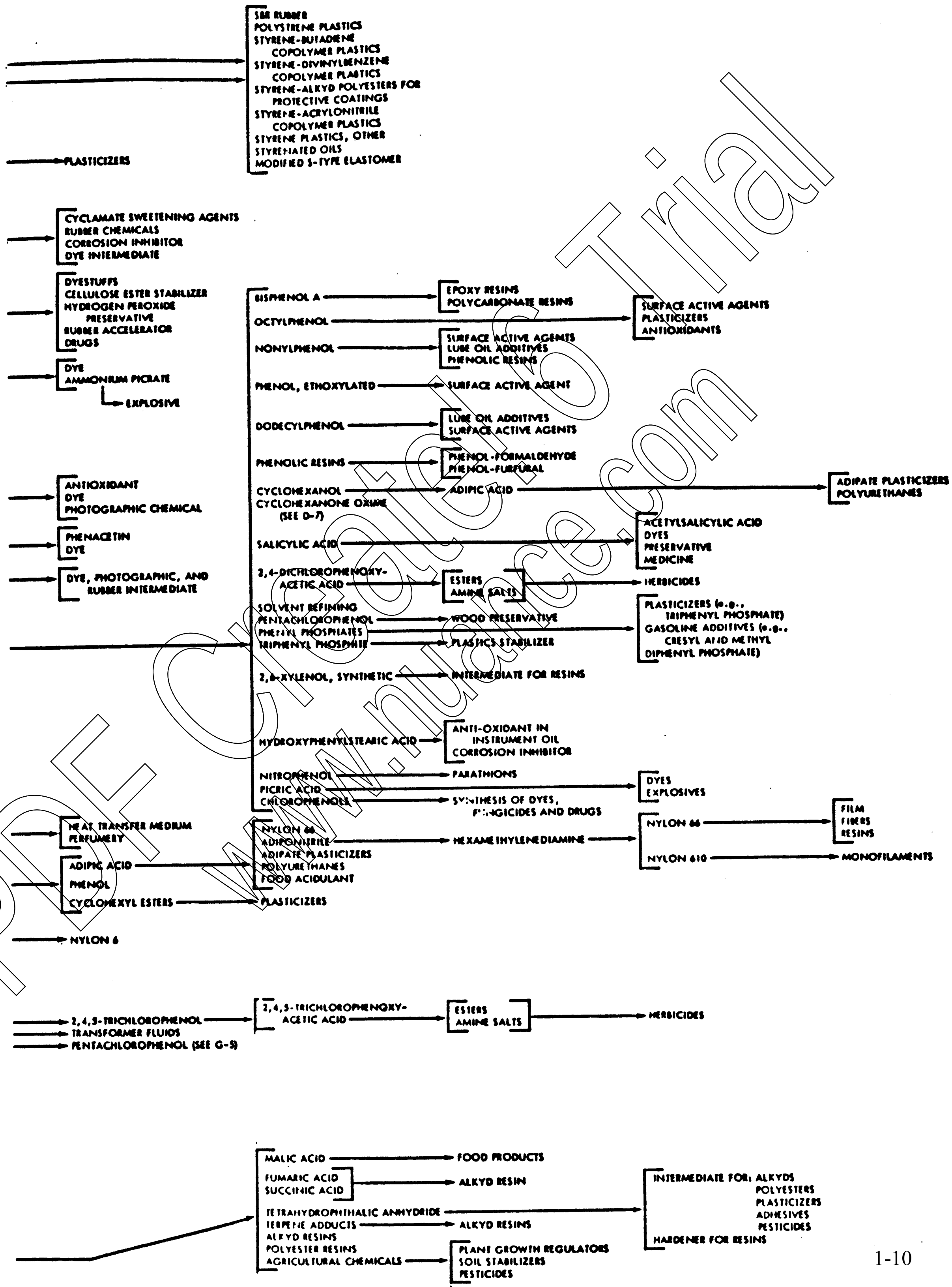
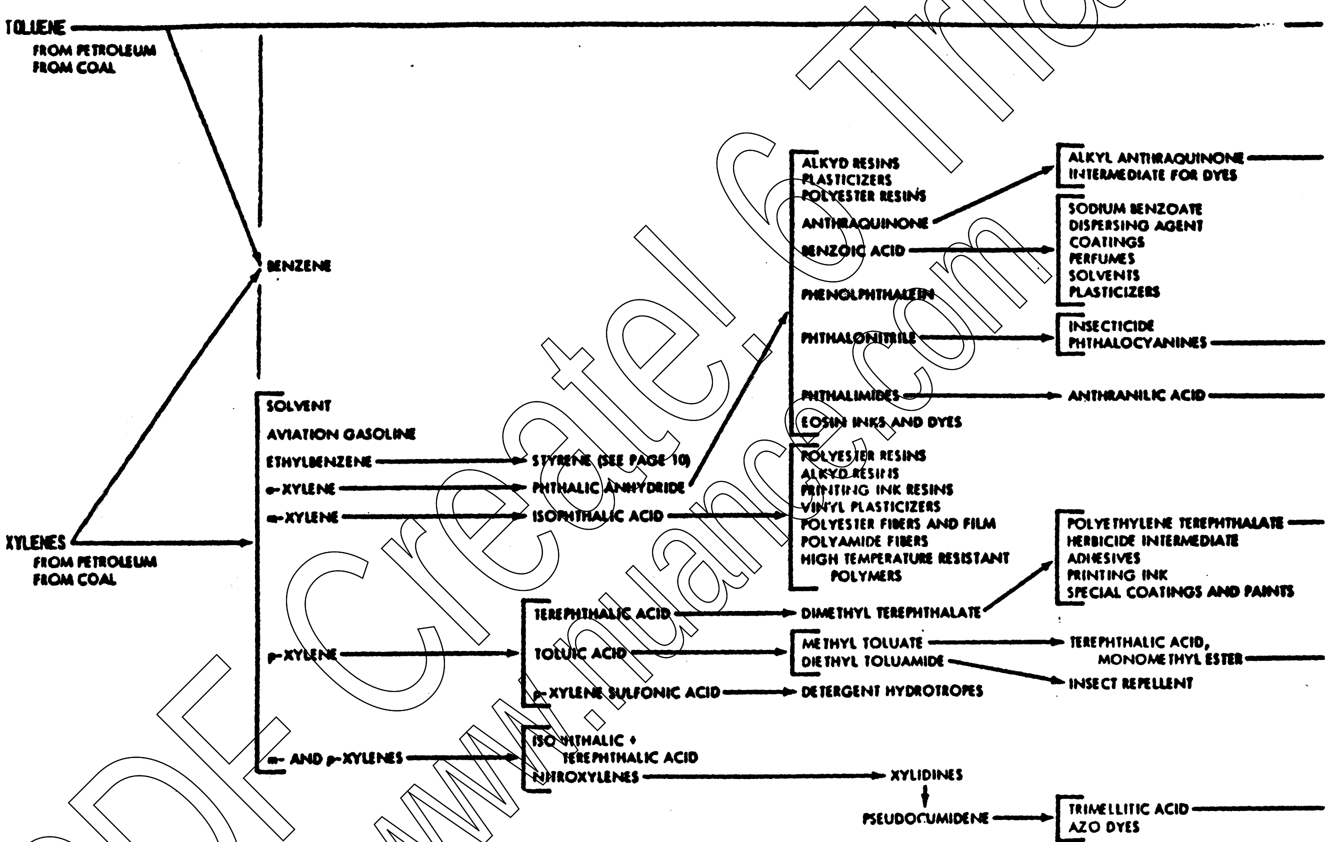
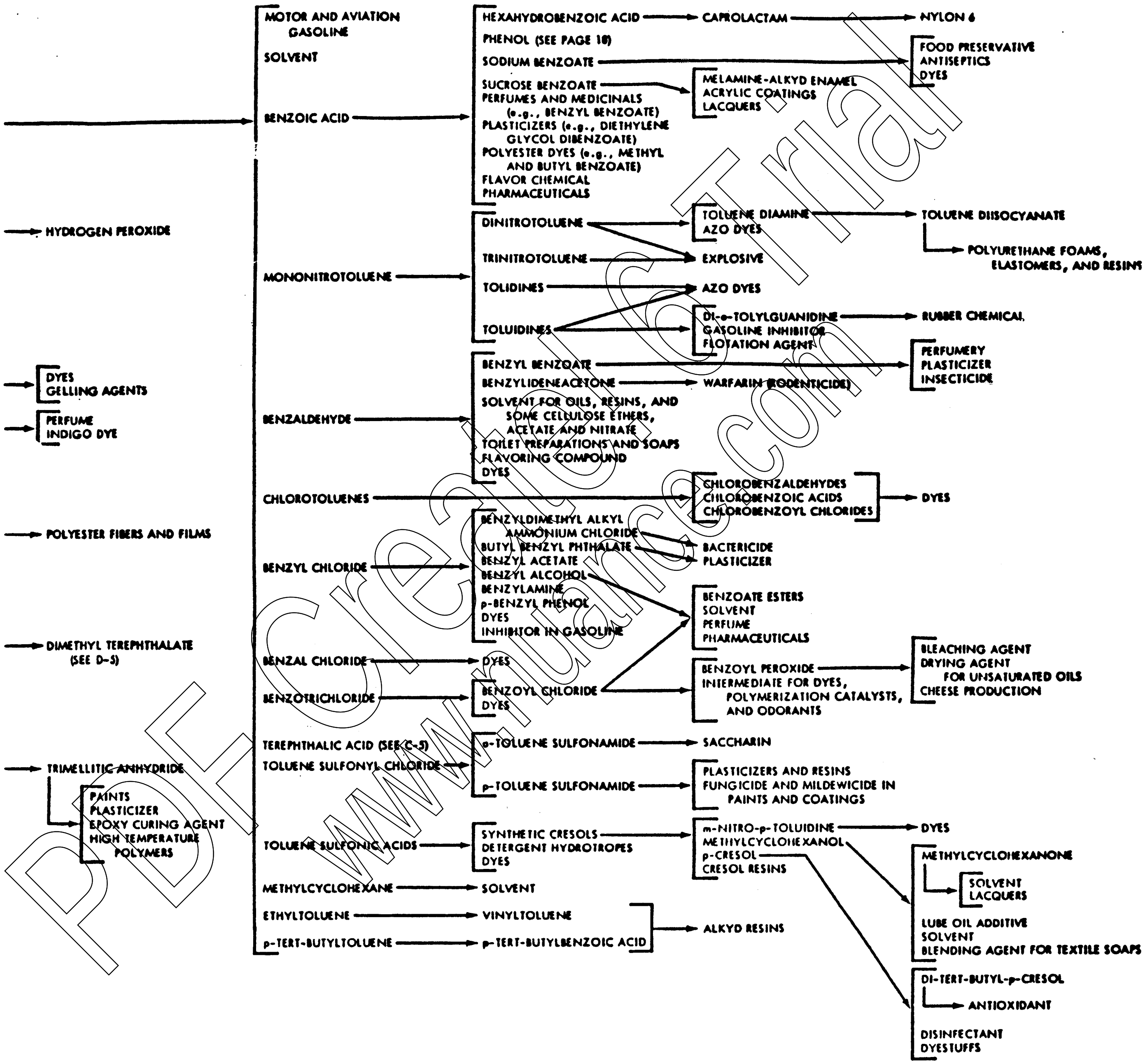


Figure 1-6
Toluene and mixed xylenes derivatives flowchart



Source: Stanford Research Institute, op. cit.

Figure 1-6 (Cont.)



Source: Stanford Research Institute, Chemical Origins and Markets, 1967.

comparative advantage. 1/ The principal theory of trade is the factor environment (Heckscher-Olin) theory. Building on a number of assumptions, this theory states that a country will export those products whose production intensively uses that country's relatively abundant resources and import those products whose production intensively uses the country's relatively scarce resources. Thus, capital-abundant countries are expected to export capital-intensive goods and labor-abundant countries are expected to export labor-intensive goods. Whereas early theory used labor and capital as the explanatory variables, later studies included such factors as natural resources and distinguished between skilled versus unskilled labor.

In a major review, Stern 2/ classified the determinants of comparative advantage into the following factions: factor endowment, technological differences, scale economies, market impediments and imperfections, and demand factors. Studies of comparative advantage are broad multiindustry, multicountry studies comparing the structure of trade over time. As such, these studies can overlook industry-specific institutional factors affecting international trade.

As more and more variables were tested empirically, new theories of international trade evolved emphasizing dynamic and technological influences such as differences in knowledge about productive opportunities, noncompetitive markets, and technological change. Perhaps the most significant theory to evolve from the empirical work was the "product life cycle" formulated by Raymond Vernon in 1966. 3/ The theory predicts that industries pass through four phases: introduction, growth, maturity, and decline. As these phases progress, the nature of competition changes. When the product matures and becomes more standardized, production will shift to low-cost areas--typically low-labor-cost developing countries. One flaw with a strict interpretation of this theory is that it assumes all industries follow the same course of events. There is neither theoretical nor empirical justification for such a strong conclusion. The theory does, however, emphasize that comparative advantage is dynamic and that expenditures on research and development are important to explaining trade patterns.

The principle of comparative advantage is helpful in understanding major changes occurring in the global petrochemical industry in recent years. For example, the multifold increase in the world price of crude petroleum since the early 1970's has encouraged conventional energy-rich nations (CERN's) to collect natural gas previously flared and tap smaller natural gas reservoirs and use it as a feedstock for primary petrochemicals. A high level Saudi Arabian Government official recently stated that industrialized nations would "look increasingly to the energy-rich regions to provide commodity chemicals, supplied to world markets at lower prices using their comparative advantage. Upgrading these bulk chemicals to higher value-added consumer products, specialty and fine chemicals can be optimally accomplished in the

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1/ For a review of the theory of comparative advantage, see Caves & Jones, World Trade and Payments: An Introduction, (Boston: Little,Brown) 1981

2/ R.M. Stern, "Testing Trade Theories," International Trade and Finance: Frontiers of Research, (1976) P.B. Kennen, editor, New York: Cambridge University Press.

3/ Raymond Vernon, "International Investment and International Trade in the Product Cycle," Quarterly Journal of Economics, 80 (1966), pp. 190-207.

industrialized nations with their greater technology and access to broad markets. This would be the case until such time when the developing countries become developed." 1/

Competing in world markets.--In general, competitiveness considers how successfully a country competes in world markets. Price and cost are obvious dimensions of competitiveness. Competitiveness is also influenced by many other factors including product quality and features, post-sales support and service, transportation costs, certainty of delivery, financing conditions, and market imperfections. 2/

A 1984 New York Stock Exchange (NYSE) study listed the following four facets of international competitiveness:

1. Price (landed) - Is an industry cost competitive? Can it compete pricewise in world markets? . . .

2. Quality - A good which can match or underprice its competitors at the expense of quality usually enjoys only short-term success.

3. Exchange rates - The value of a currency relative to foreign currencies has a major impact on its ability to sell abroad. . .

4. Trade policies and agreements - Some countries . . . subsidize exports; and penalize imports . . . Further, differences in tax policies translate into tax rebates - and lower total costs." 3/

With the exception of company-specific strategies, most aspects of competitiveness can be listed under one of these catagories.

Factor endowment and the product life cycle along with various other factors of competitiveness are all relevant to understanding the global competitiveness of the U.S. basic petrochemicals industry. Thus, when large quantities of low-cost natural gas are found in Alberta, the Canadian petrochemical industry has a newfound comparative advantage. When the United States regulates the price of natural gas below the world price, the U.S. petrochemical industry has increased its level of competitiveness in world markets. When the U.S. exchange rate increases by 30 to 40 percent, the level of U.S. petrochemical industry competitiveness in world markets has decreased. As downstream products mature and production facilities are transferred to

1/ H.E. Hisham Nazer, "The Royal Commission for JUBAIL and YANBU and the Petrochemical Industry in Saudi Arabia," Speech at the Twelfth International Petrochemical Conference, National Petroleum Refiners Association, San Antonio, TX, Apr. 5-7, 1987.
2/ For example, since there are only a limited number of world-scale producers of crude petroleum (i.e., oligopoly) they may, under certain conditions, have significant market power.
3/ "U.S. International Competitiveness: Perception and Reality" New York Stock Exchange Office of Economic Research, August 1984, p. 8

developing countries (as suggested by the product life cycle theory), production facilities for basic petrochemicals may also be transferred to new areas.

Analyzing competitiveness quantitatively involves constructing two types of measures. The first measure should indicate an industry's competitiveness (e.g., share of world trade); the second should quantify the major determinant of competitiveness. Although difficult to interpret, a number of measures have been used to indicate international competitiveness. One often-used indicator of U.S. international competitiveness is the trade balance. However, this measure is limited because "(1) It does not speak directly to the level or growth in U.S. exports; (2) U.S. trade deficits partially reflect the relative growth rates of the U.S. and its trading partners." 1/

A second indicator is the share of U.S. exports in world markets, which attempts to measure how well an industry does in world markets. This measure also suffers from a number of shortcomings. What is the appropriate base year? What are the influences of exchange rates? Is a large share in the world market a desirable goal from the standpoint of the country as whole?

A third indicator of competitiveness is the profitability of a domestic industry. When an industry, like basic petrochemicals, is composed of multinational companies with production facilities throughout the world, it can be difficult to equate industry profitability with geographic competitiveness. 2/ Furthermore, when a company produces a number of products in a vertically integrated environment, it is often difficult to relate profitability of the company to one production facility.

Since prices, ultimately based on cost considerations, are important determinants of overall international competitiveness (i.e., over all industries), a number of aggregate price indexes have been developed. Morgan Guaranty Trust Company has published ratios of wholesale price indexes for manufacturing. The Department of Commerce has used the ratio of U.S. wholesale price index for manufactured goods to the import unit value index for manufactured goods. The United Kingdom Treasury has used a variety of ratios including ratios of export unit values, wholesale price indexes, and wholesale prices to import unit values and unit labor costs. The OECD has also produced similar ratios that they call competitiveness indicators.

A more narrowly focussed approach to analyzing international competitiveness is the industry-specific competitiveness study. For example, the Office of Competitive Assessment, U.S. Department of Commerce, has produced several studies, including a study of the U.S. petrochemical industry. 3/ These studies outline recent developments in the industry and summarize predictions of future growth rates.

1/ Ibid., p. 9.
2/ Robert E. Lipsey and Irving B. Kravis, "The Competitive Position of U.S. Manufacturing Firms," Banca Nazionale del Lavoro Quarterly Review, No. 153, June 1985.
3/ U.S. Department of Commerce, Office of Competitive Assessment, A Competitive Assessment of the U.S. Petrochemical Industry, Aug. 31, 1982.

1.3 Determinants of competitiveness

In a study of the U.S. steel industry, the Federal Trade Commission developed a number of unit factor cost variables. They then compared the unit factor costs with those major international competitors of the U.S. industry. This study assumed steel technology was universally available and capital costs were constant throughout the world. Therefore, international competitiveness in the steel industry was dependent on changes in variable costs.

The numerous international competitive studies published in the past have focused on a number of factors influencing international competitiveness. Most can be listed under one of the catagories of the NYSE study. They also viewed these factors as conditions influencing either supply or demand. On the supply side, we are ultimately concerned with the cost of supplying the product but this is very difficult to assess. While it may be relatively easy to obtain data for the prices of major raw materila inputs, there are a number of other factors that are very difficult to quantify. These include such factors as quality of management, labor relations, quality of the workforce, availability of specialized resources, industry structure, product and production technologies, and marketing strategy. Some of these combined influences are often captured in some type of productivity measure such as output per worker. However, management studies typically assess these factors, along with company strategy, in greater detail.

Government policy is another important factor that can influence competitiveness through taxes and social regulation. For example, the cost of environmental regulations throughout the U.S. energy and chemical industries has direct effects on the volume and cost of the production of basic petrochemicals. For example, the removal of all lead from gasoline will increase the demand in the motor fuels market for the primary aromatics--benzene, toluene, and mixed xylenes (BTX) (as octane enhancers) and, therefore, will increase the price. Although the United States has already substantially lowered lead levels in gasoline, Western Europe is just beginning the process. By the end of the century, the demand for BTX used for gasoline in Western Europe may increase the price for BTX used in chemicals worldwide and lower the international competitiveness of the European producers of downstream aromatic products vis-a-vis the U.S. industry.

Government involvement can also lower costs by subsidizing capital investment and research and development, and by setting or regulating raw material costs. Many analysts believe governments in certain energy-rich developing countries are subsidizing new plant construction with low-interest loans. A country's tax structure can also influence an industry's supply. In a country with a value-added tax (VAT), the method by which a company is charged to value a feedstock will affect the respective industry's competitiveness. 1/

1/ For a discussion of the effects of changing the tax valuation of feedstocks in Great Britain, see "ICI Wins Appeal Court Ruling Against Ethane Tax Concessions Granted BP, Shell and Esso," Chemical Marketing Reporter, Mar. 3, 1986, p. 1.

In sum, assessing the competitiveness of the U.S. basic petrochemicals industry is difficult because there are many factors that are difficult to quantify. In addition this report is studying a fairly new industry that has grown rapidly since the end of World War II. It was only in the late 1970's and early 1980's, when growth slowed, that overcapacity became apparent. The focus of this report is on the time period since the late 1970's, which makes it hard to develop a quantitative measure against which analyses of various causal factors can be performed.

1.4 Scope of the report

This report summarizes the global market dimensions of basic petrochemicals (and selected derivatives) and presents a profile of the U.S. industry. To further clarify and define the focus of this report, the U.S. industry is viewed as being composed of those firms operating domestic facilities for the production of building-block petrochemicals. Although there are many foreign facilities owned and/or operated by firms that are based in the United States, these foreign facilities are not considered to be part of the domestic industry for the purposes of this study. Detailed profiles of other major international producers (both industrialized and developing countries) are presented in app. E. Major foreign competitiors are also discussed where appropriate in the report.

Next, the report builds on the results of an extensive questionnaire sent to U.S. producers of primary aromatics and primary olefins. This section summarizes how the U.S. industry views its competitive position in the changing world market, and analyzes the data supplied to the Commission by respondents to the questionnaire. (Survey design and methodology are contained in app. C). In particular this section focuses on certain measures and factors of competitiveness as computed from the questionnaires, as well as data compiled from various public sources. 1/

The report then uses the information obtained from the questionnaire and the various national industry profiles to compare the international competitiveness of the major world producers. Based on this information, the report then discusses the implications for U.S. producers of building-block petrochemicals.

The final section assesses the implications of the U.S. basic petrochemicals industry competitiveness for major consumers of basic petrochemicals. This analysis is based on questionnaire response, fieldwork, and in-house analysis of secondary source data.

1/ Secondary sources of information that have previously compiled information reported directly by the U.S. industry to such agencies as the Securities and Exchange Commission are used. The Commission questionnaires did not resolicit data from respondents already available in the public domain.

Chapter 2. Global Market Dimensions

2.1. World consumption

The quantity of primary olefins and aromatics consumed in most nations differs relatively little from production, because most of these basic petrochemicals are converted to derivatives in adjacent or nearby plants. In addition, ethylene and propylene, being gases under normal conditions, are especially costly to transport, except in pipelines. Most of the foreign trade in this industry, therefore, involves the products derived from the olefins and aromatics such as plastics, intermediates, and other downstream petrochemical products.

In 1985, estimated free-world consumption and production of the primary olefins and aromatics was 187.8 billion pounds--plus an additional 28 billion pounds of other primary petrochemicals; i.e., methanol, C4's, and C5's. 1/ The total was valued at $34 billion. 2/ On a worldwide basis an estimated 2.6 pounds of plastics and other derivatives were produced from each pound of building-block petrochemicals. Whereas the average unit value of the building blocks in the Free world was 15.8 cents per pound, that of the value-added derivatives was an estimated 39 cents per pound. Hence, the estimated value of all the thousands of petrochemical derivatives was $221 billion, as shown in the following tabulation of the free world's petrochemical output for 1985:

	Value (billion pounds)	Value (billion dollars)
Six major building blocks........	188	34
Other building blocks............	28	1/
Derivatives......................	565	221
Total.......................	781	255

1/ Combined with the value for the 6 major building blocks.

These estimates are based on the following data and assumptions: 1/ In the United States, production of petrochemicals in 1985 was approximately 68 billion pounds. The value of these primary olefins and aromatics was approximately $11.1 billion. 2/

The following statistics highlight changes in the U.S. petrochemical industry: 3/

1/ C4's are petrochemicals that contain 4 carbon atoms, and C5's are petrochemicals that contain 5 carbon atoms.
2/ These figures do not include 104 billion pounds of ammonia, valued at $6 billion. Methanol is an alcohol made from the principal component (methane) of natural gas.

	1980	1985
Average unit value of building blocks...	17.9 cents/lb	16.4 cents/lb
Average unit value of derivatives.......	40.0 cents/lb	40.5 cents/lb
Ratio of derivatives/building blocks, by quantity.	2.45	2.88
Ratio of derivatives/building blocks, by value.	5.65	7.37

It is estimated that the ratios in the above tabulation were also roughly the same for the petrochemical output of Western Europe and Japan, and average U.S. unit values were ascribed to those regions' output in calculating a world total. 4/

In contrast, in the large new petrochemical facilities in Saudi Arabia, using plant capacity figures for existing and nearly completed plants, the quantity ratio of derivatives to building blocks is only 1.15, while the value ratio (again using U.S. unit values) is only 2.1. These values reflect the emphasis on the production of primary petrochemicals and less advanced derivatives by the newly emerging petrochemical industry in Saudi Arabia that is based on the utilization of readily available lower cost feedstocks. It is assumed that these lower ratios can be applied to the other newer petrochemical industries in such countries as Brazil, Taiwan, Korea, Singapore, and India, while the ratios for more established countries such as Canada and Mexico lie somewhere in between those of traditional and newer producers, but closer to those of the newer group.

In recent years and continuing through 1986, producers in the large industrialized countries were cutting back and withdrawing from some of the

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1/ The United States is almost the only country that publishes full statistics annually on both quantity and value of all petrochemicals. Many of the statistics for foreign countries are collected/estimated by various chemical market research groups (e.g., SRI International), no two of which are likely to produce the same numbers. However, nearly all of the leading petrochemical-producing countries do publish statistics on production of the six major olefins and aromatics and some of the other building blocks. These, and available data from the private groups and publications on nonreporting countries, are the basis for the following tabulations and explanations.
2/ Derived from the unit values of that share of domestic production sold in the merchant market, as reported in U.S. International Trade Commission, Synthetic Organic Chemicals, U.S. Production and Sales, annual issues.
3/ Ibid.
4/ Department of Commerce data for petrochemicals rely on 8 SIC groups but omit most of the building blocks produced in petroleum refineries. The Department of Commerce data for 1980 show shipments of $86 billion, which is close to the $89.6 billion shown above for derivatives. The latter figure, however, includes on-site captive consumption as well as shipments to other establishments, and is from U.S. International Trade Commission, Synthetic Organic Chemicals, United States Production and Sales, an annual report.

major markets in which petrochemicals seem to have reached a growth limit as a replacement for more traditional materials such as metals, wood, glass, and paper. In the United States, Western Europe, and Japan, petrochemical consumption grew at a rate of at least 7 to 10 percent per year until the 1980's, but since that time it has slowed and only grown at a rate approximately equivalent to that of the real growth in GNP. In contrast, consumption growth for petrochemicals has been and remains at or above the early 1980's rate cited above in the developing areas of the world, such as the Middle East, Southeast Asia, Mexico, and Brazil.

In energy-rich nations such as Saudi Arabia and Mexico, growth in petrochemical production has been prompted by the availability of low-cost natural gas and crude petroleum, government policies favoring the industry, and availability of competitive technology. In other countries, such as Taiwan, Brazil, the Republic of Korea (Korea), and Singapore, the latter two factors again are applicable, along with campaigns to promote exports and the availability of naphtha from petroleum refineries for use as petrochemical feedstocks. In 1985, the consumption of building-block petrochemicals in the United States, Western Europe, and Japan--with more than 150 billion pounds of capacity--was about 85 percent of free world consumption. In 1980, at nearly the same volume, it had been close to 90 percent. These data indicate that because of the faster growth rate in consumption for the other areas of the world, consumption patterns are changing.

The largest consumers of petrochemicals, by far, are the United States, Japan, and the Western European nations, particularly West Germany, France, the United Kingdom, and Italy; but growth of their own petrochemical industries in recent years has been small or even negative. Prominent among countries with smaller but more rapidly growing petrochemical industries are Canada, India, China, Brazil, Mexico, Taiwan, and Korea.

Consumption of chemicals in almost every country depends on population and per-capita GNP, with the latter far more important than population alone. 1/ For this reason the industrial nations of Western Europe, the United States, and Japan, as well as some leading developing countries, far outstrip nations such as China and India in both production and consumption. Petrochemical feedstocks are widely available because almost every sizable country, energy-rich or energy- poor, operates petroleum refineries producing (1) naphtha, which may be used for chemical conversion to olefins and aromatics, and, to a lesser degree, (2) the aromatics themselves--benzene, toluene, and xylene.

1/ U.S. International Trade Commission, Chemical Industry Growth in Developing Countries and Changing U.S. Trade Patterns, USITC Publication 1780, November 1985, p. 26.

2.2. World production

A regional breakdown of recent overall world production statistics for the six major building-block petrochemicals is given in the following tabulation. 1/

Region	Quantity 1980	Quantity 1985	Share of world, 1985	Annual growth during 1980-85
	--Million pounds--		----------Percent---------	
United States............	73,638	67,080	35.9	-1.8
Canada...................	7,630	9,046	4.8	3.5
Mexico...................	1,801	3,499	1.9	14.3
South America............	5,390	6,451	3.5	3.6
Western Europe...........	54,360	61,560	32.9	2.5
Japan....................	25,392	27,233	14.6	1.8
Other Asia & Pacific.....	5,280	8,974	4.8	11.0
Middle East and Africa...	1,100	3,100	1.7	23.3
Total, free world....	174,591	186,943	1/ 100.1	1.5

1/ Figures may not add to 100.00 because of rounding.

These data show the progress of the relatively new competitors in Mexico, Southeast Asia, and, especially, the Middle East and Northern Africa. The following tabulation shows world capacity for the six major petrochemical building blocks in 1980, 1985, and that expected in 1990: 2/

Region	Quantity 1980	Quantity 1985	Quantity 1990	Share of free world 1985	Growth 1980-1990
	--Billions of pounds--			--Percent per year---	
North America..........	110.6	111.3	113.0	43.5	.2
South America..........	6.6	9.5	11.7	4.5	5.9
Western Europe.........	81.0	75.2	74.0	28.5	-1.0
Asia and Pacific.......	40.4	41.5	51.0	19.7	2.6
Mideast and Africa.....	2.2	7.4	9.8	3.8	16.2
Total, free world..	240.9	244.9	259.5	100.0	.7

In this tabulation, the North American and Asian totals obscure the fact that the United States and Japan are only holding their own or retrenching, while real growth has been and is continuing in Mexico, Canada, and Southeast Asian countries other than Japan.

1/ SRI International, industry sources and trade publications, and Commission staff estimates.
2/ Ibid., ethylene, propylene, 1,3-butadiene, benzene, toluene, and mixed xylenes.

During the 1970's, world consumption of petrochemicals was still growing at an average rate exceeding five percent per year in terms of quantity. Prices had more than doubled. Encouraged by these trends, construction of new capacity was underway not only in the large industrial countries but also in the energy-rich countries of the Middle East, Mexico, and Canada, and in other developing countries such as Brazil, Taiwan, Korea, and Singapore. By 1980, there was an overcapacity in petrochemicals just as the worldwide growth trend slackened. In 1980-81 in Europe, and in 1982 in the United States (and Canada) there was a recession in the chemical industry that led to a shutdown of older plant capacity in the industrial countries. But the newer entrants in petrochemicals continued to build.

2.3 Comparison of international competitors

This section contains comparisons of factors of competitiveness of the major international producer areas of the primary olefins and aromatics. The information specific to the products involved in this investigation, however, is very inconsistent. In particular, such data concerning the newly industrializing and developing areas, even in relation to much broader industrial categories such as their overall chemical industry, were in many cases unavailable. 1/ Therefore, the best available information on the competitive factors is used throughout this section. 2/

Changes in net trade of ethylene and benzene equivalents.--Since the mid-1970's, the energy price shocks, the discoveries of major new fields of natural gas in Canada and Mexico, and the efforts of many nations to develop industrial economies based on available and abundant natural resources has changed the complexion of the global basic petrochemical industry. Entrants into the industry have sought to enter the world market by employing the latest available technology. Their routes of entry have often been via joint ventures with established multinational companies for their assistance in the construction of the plants, production expertise, as well as access to these multinationals' established marketing networks. The following trade balance statistics compiled from various trade publications 3/ for major ethylene derivatives and major benzene derivatives are indicative of the changes that have taken place in the global basic petrochemical industry.

1/ Questions were posed in the Commission questionnaire relevant to the foreign industry; however, there were insufficient data collected regarding these questions to compile meaningful responses for the report.
2/ See ch. 1 for detailed discussion of these factors.
3/ Based on data compiled from various issues of European Chemical News, Oil & Gas Journal, Chemical Week, and Chemical & Engineering News.

(In millions of tons equivalents)

Producing area/nation	1979	1982	1985	Net change, 1985 over 1979
Major ethylene derivatives:				
United States.................	1,400	1,700	1,350	-50
Western Europe................	1,025	825	625	-400
Japan.........................	425	50	-225	-650
Canada........................	75	150	250	175
Mexico 1/.....................	-750	-575	-300	450
Middle East...................	-350	-375	-175	175
Major benzene derivatives:				
United States.................	575	600	450	-125
Western Europe................	50	25	50	0
Japan.........................	75	-25	-175	-250
Canada........................	50	75	250	200
Mexico 1/.....................	-175	-150	-50	125
Middle East...................	-75	-75	-75	0

1/ Includes other Latin American nations.

The United States, Western Europe, and Japan have long been the major producer areas that have competed to supply both the demand in their own markets and that of all other consuming nations.The trade balances of the traditional producing countries generally declined during 1979-85, and those of Canada, Mexico (including other Latin American nations), and the Middle East increased, as shown in the above tabulation.

Exports share in world market.--During 1980-85, as shown in the following tabulation, mutual trade of petrochemicals between the United States, Western Europe, and Japan remained relatively constant, decreasing slightly in some instances, except for the increase in exports to the United States from Western Europe and Japan (in billions of dollars): 1/

Market	United States 1980	United States 1985	Western Europe 1980	Western Europe 1985	Japan 1980	Japan 1985
United States..............	-	-	2.1	3.8	0.5	1.1
Western Europe.............	3.3	3.0	-	-	.8	.9
Japan......................	.8	1.0	.7	1.0	-	-

Western European exports to the U.S. market increased by $1.7 billion, or 81 percent, while Japanese exports to the U.S. market increased by $600 million, or 120 percent. Individual country shares of total worldwide

1/ Compiled from statistics of the OECD.

exports of these products, however, have displayed an interesting shift as shown in the following tabulation: 1/

	1980		1985	
Country	Exports	Percent of total	Exports	Percent of total
	Billion dollars		Billion dollars	
United States.............	10.9	27	10.3	22
Western Europe............	15.1	38	17.2	37
Japan.....................	6.0	15	6.6	14
Rest of world.............	8.0	20	12.0	26
Total................	40.0	-	46.1	-

This shift in shares illustrates the increasing export orientation of countries other than the traditional producers. It is expected that as exports from Canada, Mexico, and the Middle East increase, demand in Third World countries for products from traditional suppliers will decrease.

Exports from the new producers are currently oriented towards major markets traditionally supplied by the United States, Western Europe, and Japan. Exports by these countries are generally used as a means to offset relatively small domestic market demand.

Feedstock costs.--The most important factor for comparing building-block petrochemical industry's competitiveness among nations is the variation in the cost of feedstocks and fuel. During 1973 to the present, there have been sudden and dramatic changes in these costs that have drastically altered levels of competitiveness in certain countries. Although the current situation represents a period of relative stability, a change in the price of petroleum or natural gas could have a significant impact on the world petrochemical market. 2/ The current low level of crude petroleum prices has led to a relative increase in imports of crude petroleum-based feedstocks. As the world price of crude petroleum declines, the ability to produce high-cost crude petroleum from domestic wells decreases, while the demand for crude petroleum is simultaneously stimulated. U.S.-production of crude petroleum decreased during 1985-86 by 3.5 percent while imports increased by 28 percent; the import share of U.S. consumption increased from 26 percent to 32 percent during that same period.

Because of the multitude of feedstocks, the effects of the price changes for these materials affect industries in various countries differently. The

1/ Ibid.
2/ For a further analysis of effects of changes in world energy prices, see USITC Publication 1494, Possible Effect of Changing World Crude Petroleum Prices, February 1984.

following tabulation shows data for 1986 concerning feedstock prices, as well as costs of production of two major building-block petrochemicals in the major producing nations. 1/

Country 1/	Ethylene: Feedstock price	Ethylene: Total production cost	Benzene: Feedstock price	Benzene: Total production cost
	----Cents per pound---		---Cents per gallon---	
United States	6-13	6-21	43-95	59-123
Western Europe..........	4-13	10-21	60-130	75-160
Middle East/Saudi Arabia................	1-3	5-9	2/	2/
Canada..................	5-9	10-17	3/	3/

1/ Japan imported ethylene from U.S. producers (203,000 pounds) for the production of derivatives for the first time in 1986. This material was valued at approximately $1.00 per pound because of the added expense of liquefaction of the ethylene and other transportation costs.
2/ No trade-significant production of benzene for chemical use in Saudi Arabia.
3/ Canadian benzene production costs are slightly higher than those in the United States, since there is 1 plant that accepts tar sands.

Since there are no absolute cost data, ranges of costs are used to highlight the variability within the industry that derives from (1) the use of either natural gas-based feedstocks or different petroleum-based feedstocks, and (2) whether the costs associated with the production process are charged to the particular petrochemical product, or to another chemical product (or a fuel product) in which case the petrochemical produced is considered a byproduct.

In 1986, the rapid decline in the price of crude petroleum along with the less rapid domestic price decreases for natural gas also contributed to the increased variability in prices of feedstocks and total production costs as well as shown in the following tabulation: 2/

1/ U.S. data from questionnaire responses; foreign data estimated by the Commission staff.
2/ Compiled from official statistics of the U.S. Department of Energy.

Period	Refiner acquisition cost of crude petroleum	Wellhead natural gas prices
	Per barrel	Per 1,000 cubic feet
November 1985......................	$26.86	$2.36
January 1986.......................	25.64	2.28
March 1986.........................	14.87	2.16
May 1986...........................	13.05	1.87
July 1986..........................	11.51	1.70
September 1986.....................	13.11	1.67
November 1986......................	13.30	1.65

As noted during 1986, the costs of production of the primary petrochemicals directly reflect the cost of their main raw material. Consequently, the market price for the primary petrochemicals is also directly reflective of the cost of the feedstock used in the production process. 1/

Although the final effects of the decline in feedstock prices in 1986 have not yet been exhibited, certain immediate positive impacts were immediately evident. For the Western European petrochemical industry, which relies heavily on the petroleum-based feedstocks, the variable costs of production dropped significantly between October-December 1985 and January-March 1986. The share of feedstock cost as a share of the total cost of making ethylene fell from 60-70 percent of cost during fourth quarter 1985 to 30-40 percent in early 1986. 2/ As of fourth quarter 1985, variable costs for the production of ethylene were reported to be approximately $270 per metric ton (or 12 cents per pound) as the naphtha price was about $250 per metric ton. 3/ However, the price of naphtha fell to between $120 and $125 per ton in early 1986, precipitating an estimated decline in ethylene's variable production costs to as low as $90 per metric ton (4 cents per pound). 4/ The reported variable costs for producing ethylene from gas-based feedstocks in Saudi Arabia during this same period were only $50 per metric ton; however, transportation costs of more than $100 per metric ton to transport Saudi ethylene derivatives to European markets kept the European production strongly competitive in the home markets. 5/

1/ "Key Chemicals," Chemical & Engineering News, Feb. 9, 1987, p. 11. A detailed analysis of the relationship of feedstock price and product price is contained in Ch. 4.
2/ "Naphtha Price Slide Turns Tables on Ethane Crackers," European Chemical News, Mar. 17, 1986, p. 9.
3/ Ibid.
4/ Ibid.
5/ Ibid. As of the first quarter in 1987, crude petroleum prices had increased and stabilized at about $18 per barrel on the world market.

The change in the U.S. industry's costs were neither as dramatic nor as rapid as that for the European industry because of the ability of U.S. producers to vary feedstocks to a greater extent than can European producers. As illustrated earlier, the cost for feedstocks for the U.S. producers declined at a slower pace, reaching their lowest levels during late summer to early fall of 1986. As a result of the swifter and more dramatic price decline of petroleum-based feedstocks compared with the gas-based feedstocks, U.S. producers with dual-fire capability 1/ substituted the naphtha feedstocks and other feeds from petroleum sources (such as gas oil) for ethane (from natural gas) in the production of ethylene. The use of petroleum-based feedstocks increased to account for more than 30 percent of the U.S. ethylene produced in 1986 compared with about a 23-percent share in 1985. 2/ The resulting increased production of coproducts created a market oversupply situation and prices for propylene and 1,3-butadiene fell by more than 50 percent, from more than 20 cents per pound in late 1985 to less than 10 cents per pound, during the fourth quarter of 1986. 3/

In general terms, lower prices for petroleum and natural gas feedstocks in the United States have a negative impact on chemical producers in energy-rich areas, as their feedstock cost advantages disappear. 4/ The European and Japanese petrochemial industries tend to be most favorably affected, as they are most dependent on outside sources for their feedstock and fuel needs and can, during periods of intense price competition in fuel markets, obtain the materials at relatively low prices. The U.S. producers are, in such situations, faced with increased competitive pressures from Western European and Japanese producers despite their improved level of competitiveness vis-a-vis the energy-rich nations of Canada, Mexico, and Saudi Arabia. 5/

Capital costs.--Capital costs for all plant construction have increased steadily since the first petroleum price shock of the 1970's. Also, there were significantly higher costs, upwards of 40 percent higher, associated with plant construction in a Middle East country as opposed to the U.S. gulf coast. 6/ Estimates of up to a 90-percent differential were made by a U.S. multinational involved in a particular Middle Eastern project. 7/ Additionally, off-site facilities which would need to be built would also cost significantly more than for a new plant constructed on an existing site in an

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1/ The ability to alternate, when dictated by economics, the feedstock used to produce the desired product.
2/ "A Make-Do Decade for Petrochemicals," Chemical Business, March 1987, p. 14.
3/ Ibid.
4/ "Oil Price Crash Impact Evaluated for the Petrochemical Industry," Hydrocarbon Processing, June 1986, p. 19. Feedstock costs in many of the energy-rich nations, such as Saudi Arabia, are often static and do not rise and fall along with changes in the world market.
5/ OECD, Petrochemical Industry, 1985, p. 59
6/ Wharton Middle East Economic Service, The Petrochemical Industry in the Middle East; Special Report #2, April 1983, p. 56.
7/ OECD, Petrochemical Industry, 1985.

industrialized area. Estimates of cost differences for developing a new site in a less developed area ranged up to an 80-percent cost differential. 1/

To provide a better perspective into the relationship between capital costs, feedstock costs and total production costs, the feedstock costs account for 67 percent of the total cost of production in a hypothetical plant 2/ built in 1980. The total capital costs of the plant would be as follows (in millions of dollars):

Plant....................	320
Offsite..................	128
Total fixed capital.....	448
Working capital.........	200

The depreciation, at 10 percent of fixed capital, would account for about 15 percent of the production cost of ethylene produced at this plant.

In spite of these additional capital costs, political and social goals set by a government may encourage the development of such an industrial base. These may be manifest in low-interest loans and packages involving tax rebates or holidays.

Other costs.--The fuel-cost advantage for energy-rich areas in a low-cost feedstock market situation is probably not large enough to offset any disadvantages elsewhere in the cost structure; for example, for capital costs. Estimated fuel requirements for a world-scale ethylene plant (that required after fuel generated in the cracking process itself) would be about 200,000 metric tons per year. At a price for fuel gas of \$120 to \$150 per metric ton as in early 1986, the annual cost would be \$3.6 million to \$4.5 million. 3/

Other fixed costs 4/ in developing or less developed countries would, in most cases, parallel the 40-percent differential of the capital cost structure, primarily because of higher maintenance costs and generally more expensive on-site services. 5/ However, interest rates, for example, may have an exaggerated effect on competitiveness. In some cases, governments in developing nations attempt to offset difficulties of initiating industrial development by offering special low-interest loans to firms involved in the industrial developments.

Transportation costs.--There is a considerable transportation cost disadvantage facing the new Middle Eastern facilities attempting to supply the

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1/ Ibid., p. 62.
2/ Based on an assumed 990 million pound-per-year naphtha cracker operating at capacity. Organization for Economic Cooperation and Development (OECD), Petrochemical Industry Energy Aspects of Structural Change, 1985, p. 58.
3/ Ibid.
4/ Operating and maintenance costs, includes tax and insurance.
5/ OECD, Petrochemical Industry, 1985, p. 62.

traditional consuming markets (North America, Japan, and Western Europe), compared with producers located in those areas. However, the continued industrial development of the nations located in Africa, Asia, and the Pacific Rim are expected to provide new markets and increased demand for the Middle Eastern production, as well as some Canadian production. As such demand becomes a reality, it would also tend to expand markets for U.S., Japanese, and Western European production of more specialized materials derived from the building-block petrochemicals.

Wage rates.--One factor of competition generally accepted as having a significant impact on the competitive status of most industries is the cost of labor. Although many competitiveness studies show wage rates in developing countries are considerably lower than in developed countries, labor costs for producing petrochemicals in developing countries may not be significantly lower than those of developed countries. The reason is that the industry requires skilled labor not readily available domestically. The industry thus imports foreign labor at high wages. However, since only a small share of costs in this industry are accounted for by labor, wage rates will remain only a minor factor in determining international competitiveness in the petrochemical industry.

Chapter 3. U.S. Industry Profile

3.1 Historic perspective

Significant production of petrochemicals in the United States from petroleum and natural gas feedstocks was achieved in the 1930's as an outgrowth of success in upgrading byproducts 1/ of the petroleum refining process. Even earlier, natural gas liquids (NGL's) were converted to ethylene oxide, ethylene glycol, and other products by chemical producers. Soon ethylene plants 2/ were built in order to satisfy the growing demand for the newly developed range of ethylene derivatives. As the rapidly increasing demand for gasoline soon consumed all of the available hydrocarbons from the petroleum refining process, the petrochemical industry was forced to turn to liquefied petroleum gas (LPG), mainly propane, as an alternative feedstock for ethylene production. After cryogenic and absorption technology became more efficient and lower in cost, the ethane in NGL's became the main alternative feedstock for ethylene production. To protect the long-term feedstock supply for ethylene production in the late 1960's, the industry petitioned for, and was granted, permission to import low-cost naphtha feedstocks (restricted at that time under petroleum import regulations). As a result of this change in U.S. trade policy, several naphtha/gas-oil based ethylene plants were constructed on the gulf coast. 3/

Petrochemical growth during the 1960's was rapid, driven by the low-cost raw materials and the technological development of major end-use sectors, such as plastics, synthetic fibers, synthetic rubbers, and other products. However, the ethylene plants built during the 1950's and 1960's had little flexibility to change feedstocks. As a result of the increased prices for petroleum and petroleum products between 1973 and 1979 (coupled with the decontrol of U.S. natural gas prices), many U.S. firms modified ethylene plants to enable them to use both NGL's and naphtha/gas-oil as feedstocks. 4/

3.2 Structure of the industry

Petrochemicals are produced both by companies oriented toward producing petroleum products (petroleum companies) and companies oriented toward the production of chemicals and their products (chemical companies); the distinction connotated by "petroleum company" or "chemical company" is often blurred. The following tabulation shows the share of the total domestic production of basic petrochemicals accounted for by petroleum companies and chemical companies in 1985 (in percent): 5/

1/ The chemical production using these byproducts was performed both by petroleum companies and chemical companies purchasing materials from the petroleum companies.
2/ Ethylene was already being produced from coal-based feedstocks.
3/ U.S. Industrial Outlook 1986, Chemicals, pp. 11-2 and 11-3.
4/ Ibid, p. 11-3.
5/ Compiled from data submitted for the Synthetic Organic Chemicals report.

Petrochemical	Share of total domestic production accounted for by firms oriented towards the production of-- Petroleum products	Chemicals
Ethylene................	49.7	50.3
Propylene...............	70.8	29.2
1,3-Butadiene...........	58.6	41.4
Benzene.................	84.5	15.5
Toluene.................	94.6	5.4
Mixed xylenes...........	92.0	8.0

Petroleum companies usually have the largest facilities for producing primary aromatic petrochemicals and are also often the major producers of primary olefins. Petroleum companies have the advantage in the production of primary petrochemicals compared with chemicals companies in that they can take back into their petroleum operations byproducts including fuel products from the production of primary petrochemicals.

A number of U.S. firms are subsidiaries of foreign multinational companies. Foreign chemical firms currently favor entering the U.S. market by purchasing U.S. firms and facilities. An estimate of foreign ownership in the U.S. industry is approximately 20 percent in 1987. 1/ Currently three of the largest multinationals, one West German, one Dutch, and one based in the United Kingdom operate in the U.S. basic petrochemicals industry. In 1985, these firms accounted for less than 10 percent of U.S. production of basic petrochemicals.

Primary petrochemicals are produced domestically by 44 companies, 2/ whose production facilities are located mainly in Texas and Louisiana. The five largest producers, of which four are petroleum companies, account for about 50 percent of total annual production of these petrochemicals. In 1985, they accounted for 52 percent of domestic production. All of these companies are forward integrated through to the production of synthetic rubber, plastics, and textile materials. Of the 38 respondents to the questionnaire, there were a total of 74 production facilities devoted to the production of the primary olefins. Of these facilities, one is 3 to 4 years old, 16 are between 5 and 9 years old, 43 units were between 10 and 19 years old, and the

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1/ George B. Megman, "Mergers & Acquisitions: The Impact on the U.S. Chemical Industry," paper presented at the Energy Bureau, Inc., Conference, Sept. 15, 1986.

2/ Questionnaires were sent to 46 "companies"; however, in two cases, there were questionnaires sent to two separate divisions within one parent company. In both cases, the responses were consolidated into one questionnaire.

Useable responses were received from 38 firms, a response rate of 86 percent. These firms are estimated to have accounted for between 85 percent and 99 percent of the total domestic production of each of the individual primary olefins and primary aromatics during 1982-86.

remaining 14 units are at least 20 years old. There were a total of 46 units producing primary aromatics among the questionnaire respondents, one of which is aged 0-2 years, 2 are aged 3-4 years, 4 are aged 5-9 years, 12 are aged 10-19 years, and 27 units are at least 20 years old.

3.3 Production capacity

The total capacity of the U.S. building-block petrochemical industry was reduced significantly during 1981-85. The following tabulation shows the total annual production capacity for each of the six major building-block petrochemicals. 1/

Building-block petrochemical	1982	1983	1984	1985	1986	Percentage change, 1986 over 1982
	Million pounds					
Olefins:						
Ethylene.......	39,345	37,725	37,725	34,650	35,609	-9.5
Propylene......	22,680	22,285	22,290	21,510	22,260	-1.9
1,3-Butadiene..	4,468	4,038	3,755	3,755	3,855	-13.7
Total......	66,493	64,048	63,770	59,915	61,724	-7.2
Aromatics:						
Benzene........	17,720	17,028	16,476	16,947	16,821	-5.1
Toluene........	11,405	10,890	10,578	10,367	12,459	9.2
Mixed xylenes..	11,410	10,826	10,665	12,052	12,092	6.0
Total........	40,535	38,734	38,719	39,366	41,372	2.1

During 1982-86, firms shut down older, less efficient facilities and concentrated on improving the efficiency of the active facilities. Reducing capacity in the petrochemical industry does not usually involve the total dismantling of the plants. Instead, rationalization allows for the eventual restarting of the plant, or instead, the use of parts to service operating plants (cannibalization). Although the U.S. industry had far less rationalization to accomplish than did the Western European and Japanese producers, the U.S. industry had to proceed without assistance from the Federal Government, such as was available to the French, Italian, and Japanese industries.

Primary olefin capacity during 1985 declined to a low of 59.5 billion pounds per year; of that volume ethylene accounted for 34.7 billion pounds

1/ Compiled from data in SRI International Directory of Chemical Producers, United States, 1982 through 1986 editions.

(approximately 60 percent). 1/ Other sources indicate that ethylene nameplate capacity may have been higher, approximately 36.5 billion pounds, although there was only 33.9 billion pounds of capacity available. 2/

The following tabulation shows the differences between nameplate capacity (the amount of production the plant can produce according to the designer's specifications), available capacity (the amount the plant can produce assuming 24-hour, 365-day-per-year operation), along with the effective capacity (capacity assuming normal production schedules including routine maintenance and servicing) for the U.S. ethylene industry during 1981-85 (in billions of pounds): 3/

Item	1981	1982	1983	1984	1985
Nameplate capacity..............	40.8	37.4	37.4	37.4	36.5
Available capacity..............	39.5	31.8	32.2	34.2	33.9
Effective capacity..............	36.4	29.3	29.6	31.5	31.2

The effective capacity may vary from plant to plant depending on factors such as age and the current condition of the facility. As a rule, effective capacity is assumed to be approximately 92 percent of the available capacity.

3.4 Industry production

The following tabulation shows reported production volumes of the building-block petrochemicals: 4/

1/ Stanford Research Institute, SRI International Directory of Chemical Producers, 1986.
2/ "Ethylene-Capacity Shortage Looms in Early 1990's, New Study Shows," Hydrocarbon Processing, July 1986, p. 17.
3/ Ibid.
4/ Data in this tabulation are derived from data previously published in the U.S. International Trade Commission Publication, Synthetic Organic Chemicals, U.S. Production and Sales, 1981-85 editions.

Building-block petrochemical	1982	1983	1984	1985	1986	Percentage change, 1986 over 1982
	Million pounds					
Olefins:						
Ethylene.......	24,501	28,680	31,383	29,847	32,811	33.9
Propylene......	12,535	13,959	15,559	14,887	17,343	38.4
1,3-Butadiene..	1,915	2,353	2,452	2,340	2,646	22.2
Subtotal...	38,951	44,992	49,394	47,074	52,800	[illegible]2.6
Aromatics:						
Benzene........	7,700	9,025	9,646	9,390	10,053	30.6
Toluene........	5,148	5,623	5,249	5,074	5,845	13.5
Mixed xylenes..	4,999	5,518	6,490	1/ 5,542	1/ 5,872	17.5
Subtotal...	17,847	20,166	21,385	20,006	21,770	22.0
Total........	56,798	65,158	70,779	67,080	74,570	31.3

1/ Estimated.

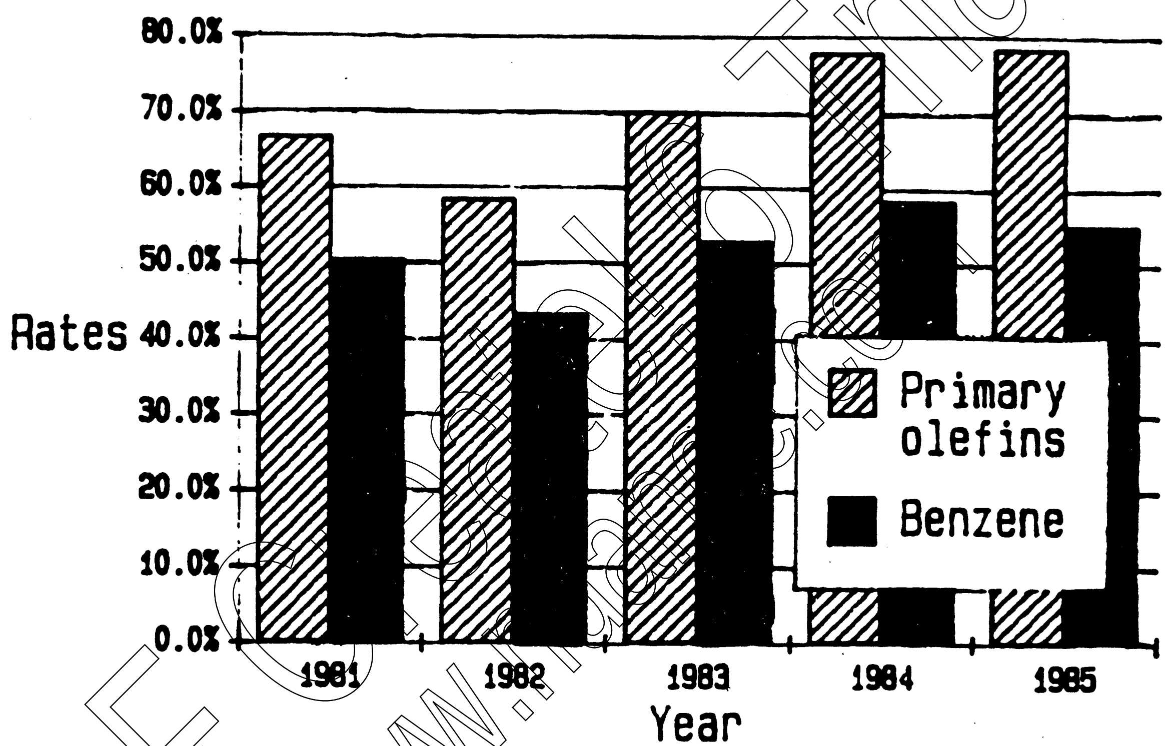
The volume of production of the primary olefins and aromatics is a function of both the demand for downstream derivatives and, in some cases, a result of the amount of coproduct 1/ produced in other processes (either chemical or fuel). Demand for ethylene, the largest volume and most important of the building-blocks, initially peaked in 1979 at 29.9 billion pounds before declining to a nadir of 24.5 billion pounds in 1983. This was the lowest production volume for ethylene since 1976, before the second petroleum price shock and resulting worldwide recession. Demand is projected by a group of industry analysts to begin a sustained growth period in 1986. The domestic industry would need to produce 36 billion pounds by 1990 to satisfy anticipated domestic demand. This would represent about a 2.5 percent average annual rate of growth. 2/

3.5 Capacity utilization

Figure 3-1 illustrates the capacity utilization rates of U.S. producers of primary olefins and aromatics.

1/ See Glossary of Terms.
2/ "Ethylene-Capacity Shortage Looms in Early 1990's, New Study Shows," Hydrocarbon Processing, July 1986, p. 17.

Figure 3-1
Capacity Utilization Rates



Source: U.S. International Trade Commission Publication, Synthetic Organic Chemicals, U.S. Production and Sales, 1981-85 editions and, SRI International Directory of Chemicals Producers, United States, 1982 through 1986 editions.

A comparison of capacity utilization rates of benzene (for chemical uses) was used in lieu of a comparison involving all of the primary aromatics, since benzene is often produced from an aromatics stream containing toluene and mixed xylenes as a feedstock. Figure 3-1 shows the increased rates of capacity utilization for the primary olefins, increasing from a period low of 67 percent in 1982 to a peak of 79 percent in 1985. 1/ However, the capacity utilization rate of facilities for the production of the benzene ran at consistently lower rates. This may be partially explained by the location and type of facilities used for the production of benzene and the other primary aromatics. Approximately 90 percent of the production of these materials takes place at facilities controlled by producers of petroleum products, and, in particular, motor gasoline. As the petroleum companies are producing relatively smaller quantities of the aromatics for use as octane enhancers (as the use of MTBE increases), relatively more of their production is directed towards the chemical uses. This could give the appearance that the utilization rate for chemical use of primary aromatics at these facilities is decreasing as more and more of the aromatics are produced for non-fuel uses.

Ethylene capacity utilization rates have also increased steadily, as shown in the following tabulation of operating rates based on nameplate capacity and on effective capacity (in percent): 2/

Item	1981	1982	1983	1984	1985
Nameplate capacity 1/	72	62	76	82	86
Effective capacity	81	84	97	99	98

1/ Derived from data in previous tabulations.

There are currently plans and to increase available ethylene capacity. Information supplied by the respondents to the Commission questionnaire indicated that, of the 29 companies reporting present ethylene capacity, 9 would be expanding their capacity during the next 3 years. Of the approximately 2,800 million pounds of planned expansions reported, 8 percent would be accomplished by additions to present facilities and the remainder would be by reactivating currently mothballed facilities and/or through "debottlenecking" current facilities, that is, improving the plant's throughput by changing those specific reaction processes that are currently the rate-determining steps of the entire production process. These changes may either be equipment or process related.

3.6 Domestic market

The major suppliers of primary petrochemicals in the domestic markets are the U.S. producers, particularly the petroleum companies. Chemical companies

1/ Data derived from: U.S. International Trade Commission, and SRI.
2/ "Ethylene-Capacity Shortage Looms in Early 1990's, New Study Shows," Hydrocarbon Processing, July 1986, p. 17.

producing primary petrochemicals tend to be net purchasers of the primary petrochemicals and, in many instances, have constructed plants that produced derivative chemicals near a specific secondary source of the primary olefins or aromatics. 1/ Table 3-1 shows U.S. production, imports, exports, and apparent domestic consumption for the primary olefins and aromatics.

Between 1981 and 1982, the apparent consumption of the primary olefins and aromatics decreased from 68.8 billion pounds to 58.1 billion pounds, representing a decline of 16 percent. At this time the effects of the 1979 petroleum price shock were having their greatest impact on both the U.S. and the world economies in the form of a prolonged recession. Slowed and declining demand for petrochemicals in end-use markets is exemplified by the decline in domestic production of automobiles. (See later section of this report on the automobile industry.) As the domestic recovery from the recession proceeded during 1982-84, domestic consumption of the primary olefins and aromatics increased by 25 percent to a volume of 72.7 billion pounds. In 1985, apparent consumption declined to 69.4 billion pounds compared with that in 1984, representing a 5-percent decrease.

Since 1981, consumption of ethylene and propylene has accounted for about 65 percent of the total consumption of the six primary petrochemicals. Benzene's share of this total has approximated 15 percent; while toluene and the mixed xylenes combined have averaged 16 percent of total consumption. 1,3-Butadiene's share of primary petrochemical apparent consumption has averaged 4 percent during the same period.

Imports account for a very small share of U.S. consumption, and, in many cases, are actually intracompany transfers of materials or exchanges of the primary olefins or aromatics for a downstream derivative.

3.7 Exports of primary petrochemicals and derivatives

U.S. exports of primary petrochemicals were valued at $371 million in 1986 (tables 3-2 and 3-3). The leading markets for these exports during 1986 were as follows:

Market	Value	Share of exports to total
	Million dollars	Percent
Mexico	114	31
Taiwan	60	16
Belgium	43	12
Japan	42	11

1/ Discussions with industry representatives.

Table 3-1
Building-block petrochemicals: U.S. production, exports of domestic merchandise, imports for consumption, and apparent consumption, 1982-86

Item	Production 1/	Exports	Imports	Apparent consumption	Ratio (percent) of imports to consumption
	1,000 pounds				
1982:					
Ethylene.....	24,501,346	2,137	145,671	24,644,880	0.59
Propylene....	12,534,972	44,049	499,615	12,990,538	3.85
Butadiene....	1,915,094	102,432	753,254	2,565,916	29.36
Benzene......	7,699,721	61,495	994,693	8,632,919	11.52
Toluene......	5,148,456	160,675	836,000	5,823,781	14.35
Xylene.......	4,998,598	1,976,980	412,080	3,433,698	12.00
Total......	56,798,187	2,347,768	3,641,313	58,091,732	6.27
1983:					
Ethylene.....	28,679,842	633	179,138	28,858,347	.62
Propylene....	13,958,546	56,379	484,603	14,386,770	3.37
Butadiene....	2,353,372	96,517	884,689	3,141,544	28.16
Benzene......	9,024,529	80,117	1,079,488	10,023,900	10.77
Toluene......	5,622,887	251,463	598,416	5,969,840	10.02
Xylene.......	5,518,150	1,598,698	450,878	4,370,330	10.32
Total......	65,157,326	2,083,807	3,677,212	66,750,731	5.51
1984:					
Ethylene.....	31,383,000	22,307	332,912	31,693,605	1.05
Propylene....	15,559,452	90,529	527,897	15,996,820	3.30
Butadiene....	2,452,131	144,925	872,694	3,179,900	27.44
Benzene......	9,646,164	139,644	1,273,665	10,780,185	11.81
Toluene......	5,249,313	287,708	597,839	5,559,444	10.75
Xylene.......	6,490,435	1,628,961	615,934	5,477,408	11.24
Total......	70,780,495	2,314,074	4,220,941	72,687,362	5.81
1985:					
Ethylene.....	29,846,726	47,912	230,989	30,029,803	.77
Propylene....	14,886,849	196,206	458,109	15,148,752	3.02
Butadiene....	2,340,484	187,188	831,975	2,985,271	27.87
Benzene......	9,389,805	83,184	1,093,996	10,400,617	10.52
Toluene......	5,073,965	203,156	1,131,847	6,002,656	18.86
Xylene.......	2/ 5,541,578	1,508,744	819,447	4,852,281	16.89
Total......	67,079,407	2,226,390	4,566,363	69,419,380	6.58
1982:					
Ethylene.....	32,811,217	975	286,413	33,096,655	.87
Propylene....	17,342,733	264,680	389,474	17,467,527	2.23
Butadiene....	2,645,635	179,949	452,504	2,918,190	15.51
Benzene......	10,211,188	63,589	1,138,370	11,285,969	10.09
Toluene......	5,798,419	193,408	996,746	6,601,757	15.10
Xylene.......	5,861,211	1,582,913	1,060,717	5,339,015	19.87
Total......	74,670,403	2,285,514	4,324,224	76,709,113	5.64

1/ Production data from Synthetic Organic Chemicals, U.S. Production and Sales, 1982-85 and Quarterly Report on Synthetic Organic Chemicals, December 1986, data for 1986 are preliminary figures.
2/ Estimated by Commission staff.

Source: Compiled from official statistics of the U.S. Department of Commerce, except as noted.

Although Mexico accounted for more than 99 percent of U.S. ethylene exports in 1985, exports to Mexico in 1986 declined to account for only 31 percent, while Canada and Japan each accounted for 25 percent of U.S. ethylene exports. Mexico was the major market for U.S. exports of propylene, 1,3-butadiene, toluene, and mixed xylenes. Canada was the major market for U.S. exports of benzene in 1986.

U.S. exports of the primary olefins and aromatics in 1985 accounted for approximately 3.3 percent of total U.S. production of these products. U.S. exports as a percent of production on a product-by-product basis is as follows (in percent):

Ethylene	0.2
Propylene	1.3
1,3-Butadiene	8.0
Benzene	.9
Toluene	4.0
Mixed xylenes	27.2

The following tabulations that contain, respectively, data supplied by the respondents to the Commission questionnaire concerning the value of their export shipments of primary petrochemicals and their derivatives, and total industry exports of primary petrochemicals and their derivatives (see tables 3-2-3-4 for details of the total industry exports) (in millions of dollars): 1/

Item	1982	1983	1984	1985	1986 1/
Primary olefins	38.1	32.8	39.1	57.5	31.7
Primary aromatics	114.9	72.7	67.7	31.3	24.0
Olefin derivatives	316.4	338.3	448.0	468.8	480.0
Aromatic derivatives	209.8	136.3	144.6	182.0	244.1
Total	679.2	580.1	699.4	739.6	779.8

1/ Estimated from partial-year data supplied in response to the Commission questionnaire.

Item	1982	1983	1984	1985	1986
Primary olefins	43.4	43.5	63.5	95.6	65.5
Primary aromatics	561.3	432.7	474.3	405.3	356.8
Major derivatives	2,944.4	2,932.1	3,181.5	3,057.0	3,344.5
Total	3,549.1	3,408.3	3,719.3	3,557.9	3,766.8

Most of these petrochemicals, particularly ethylene which is a gas under ambient conditions, are rarely exported over water because of handling, storage, and shipping difficulties and expenses. The most significant amount

1/ Compiled from official statistics of the U.S. Department of Commerce.

Table 3-2
Primary olefins: U.S. exports of domestic merchandise, by principal markets, 1982-86

Market	1982	1983	1984	1985	1986
	Quantity (pounds)				
Mexico	88,829,654	105,277,316	114,305,927	128,622,828	209,082,688
Canada	15,707,610	17,959,068	41,171,069	104,980,759	91,823,307
Indnsia	0	0	0	19,184,624	57,759,722
S Arab	5,382	0	20,920,509	34,956,639	34,428,256
Phil R	0	0	22,822,066	15,202,170	13,722,712
U King	5,972,881	2,403,342	5,581,555	9,023,609	12,298,986
France	7,263,754	2,980	0	0	10,557,729
India	11	0	341,959	6,375	7,471,050
Nethlds	7,389,030	40,940	10,369,361	4,167,628	4,485,413
Argent	2,800	0	13,119,364	0	3,691,996
All other	23,015,335	32,649,495	13,471,381	27,087,369	4,672,442
Total	148,186,457	158,333,141	242,103,191	343,232,001	449,994,301
	Value (1,000 dollars)				
Mexico	31,080	31,943	31,429	37,107	38,245
Canada	3,628	5,289	10,418	22,880	16,608
Indnsia	-	-	-	3,665	11,813
S Arab	4	-	5,439	8,865	8,148
Phil R	-	-	4,475	3,443	2,482
U King	1,385	470	1,002	1,686	2,220
France	1,389	1	-	-	1,879
India	1	-	93	1	1,502
Nethlds	1,379	8	1,887	788	961
Argent	1	-	2,886	-	701
All other	4,947	6,515	2,769	6,031	1,226
Total	43,813	44,226	60,400	84,465	85,786
	Unit value (per pound)				
Mexico	$0.35	$0.30	$0.27	$0.29	$0.18
Canada	0.23	0.29	0.25	0.22	0.18
Indnsia	-	-	-	0.19	0.20
S Arab	0.73	-	0.26	0.25	0.24
Phil R	-	-	0.20	0.23	0.18
U King	0.23	0.20	0.18	0.19	0.18
France	0.19	0.20	-	-	0.18
India	57.73	-	0.27	0.20	0.20
Nethlds	0.19	0.20	0.18	0.19	0.21
Argent	0.20	-	0.22	-	0.19
All other	0.21	0.20	0.21	0.22	0.26
Average	0.30	0.28	0.25	0.25	0.19

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table 3-3
Primary aromatics: U.S. exports of domestic merchandise, by principal markets, 1982-86

Market	1982	1983	1984	1985	1986
	Quantity (1,000 gallons)				
Mexico	56,735	38,531	52,740	64,849	60,934
China t	21,437	31,384	38,912	39,354	43,969
Japan	30,517	21,166	20,201	20,258	29,070
Belgium	23,237	17,467	26,956	30,410	27,709
Nethlds	36,575	17,977	6,853	17,811	18,488
Venez	7,200	6,673	13,614	9,326	12,554
Kor Rep	30,624	39,982	37,632	8,496	10,533
U King	12,415	26,928	17,260	8,561	10,100
Indnsia	30	6	49	23	5,683
Italy	18,168	15,437	13,550	13,678	8,842
All other	53,877	40,626	45,549	25,294	15,907
Total	290,815	256,176	273,317	238,060	243,790
	Value (1,000 dollars)				
Mexico	98,148	62,189	74,678	90,767	82,582
China t	31,607	53,770	67,812	64,377	59,922
Japan	51,609	36,287	34,324	31,575	41,292
Belgium	45,588	26,574	45,778	47,977	37,032
Nethlds	58,426	25,927	8,407	21,354	14,676
Venez	11,842	9,585	19,260	14,261	14,651
Kor Rep	46,058	52,965	51,675	12,729	13,637
U King	19,316	33,880	19,735	10,355	8,396
Indnsia	126	48	321	140	7,629
Italy	27,780	17,848	14,539	15,766	7,316
All other	89,737	65,588	61,812	38,445	18,007
Total	480,238	384,658	398,341	347,745	305,140
	Unit value (per gallon)				
Mexico	$1.73	$1.61	$1.42	$1.40	$1.36
China t	1.47	1.71	1.74	1.64	1.36
Japan	1.69	1.71	1.70	1.56	1.42
Belgium	1.96	1.52	1.70	1.58	1.34
Nethlds	1.60	1.44	1.23	1.20	0.79
Venez	1.64	1.44	1.41	1.53	1.17
Kor Rep	1.50	1.32	1.37	1.50	1.29
U King	1.56	1.26	1.14	1.21	0.83
Indnsia	4.19	8.05	6.51	6.05	1.34
Italy	1.53	1.16	1.07	1.15	0.83
All other	1.67	1.61	1.36	1.52	1.13
Average	1.65	1.50	1.46	1.46	1.25

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table 3-4
Derivatives: U.S. exports of domestic merchandise, by principal markets, 1982-86

(In thousands of dollars)

Market	1982	1983	1984	1985	1986
Canada------	281,462	355,850	368,354	329,034	340,004
Japan-------	335,002	330,485	334,944	304,147	314,954
Mexico------	265,488	293,575	285,682	326,746	308,771
Kor Rep-----	149,395	144,472	168,556	157,780	224,660
China M-----	237,823	97,066	249,559	223,879	184,094
Belgium-----	120,181	135,399	179,827	194,210	171,647
China t-----	92,822	148,471	119,489	97,269	165,202
Fr Germ-----	72,962	82,101	88,603	119,956	144,786
Hg Kong-----	74,794	71,657	74,802	65,663	116,066
Brazil------	66,235	61,701	71,197	77,144	110,521
Nethlds-----	109,015	71,268	98,173	138,660	91,661
Austral-----	71,318	72,531	100,901	90,174	87,266
U King------	89,087	100,586	93,465	76,691	83,138
Indnsia-----	95,148	86,996	72,107	49,575	76,413
Venez-------	80,553	56,549	82,214	49,696	73,701
All other---	803,103	823,364	793,605	756,340	851,649
Total---	2,944,386	2,932,070	3,181,476	3,056,964	3,344,535

Source: Compiled from official statistics of the U.S. Department of Commerce.

of U.S. trade is with the derivatives and not with the primary petrochemicals. The producers of the primary petrochemicals are as a group not the principal exporters of the derivatives made from these primary petrochemicals; rather, many of the derivatives are exported by those firms that use purchased primary petrochemicals to produce the derivatives or by export brokers and agents. During 1982-86, the questionnaire respondents' (i.e., primary petrochemical producers) share of total exports compared with U.S. Department of Commerce statistics of primary olefins. aromatics, and derivatives ranged from 17.6 percent in 1983 to 21.5 percent in 1985. Meanwhile, total U.S. exports of the derivatives of primary petrochemicals increased from $2.9 billion to more than $3.3 billion, or by 13 percent.

Another way of analysing export trade in relation to competitiveness is by examining the ratio of exports to sales of the items in question. The following tabulation shows the compiled export-to-sales ratio for producers of the primary olefins and aromatics that responded to the Commission questionnaire (in percent):

Source	1982	1983	1984	1985	1986
Primary olefins producers......	0.87	0.69	0.77	1.27	0.76
Primary aromatics producers....	5.30	3.27	3.29	1.42	1.59

These data indicate the far greater importance of direct export markets for the primary aromatics. Although the producers of primary olefins were fully utilizing production capacity during 1986, the primary aromatics producers did not reach a desirable operating rate during a period when their level of exports dropped sharply (from $68 million in 1984 to an estimated $24 million in 1986) and the ratio of exports to sales fell by more than 50 percent (from 5.30 percent in 1984 to 1.59 percent in 1986).

3.8 Imports of primary petrochemicals and derivatives

U.S. imports of primary petrochemicals in 1985 were valued at $777 million (table 3-5), but declined by 35 percent to $508 million in 1986. The primary sources of these imports were Canada (40 percent), the Netherlands (16 percent), and Japan (10 percent). In 1986, Canada accounted for nearly 100 percent of U.S. ethylene imports and accounted for 92 percent of propylene imports. Canada was also the main source for U.S. imports of toluene and mixed xylenes during 1986. Canada is the primary source for the imports of building-block petrochemicals primarily because of its proximity to U.S. facilities and the availability of ground and pipeline transportation infrastructure connecting facilities located in both nations.

Questionnaire responses show that the value of primary olefins and primary aromatics imports by multinational companies increased by 17 percent between 1982 and 1985. Canada and the Netherlands were the leading sources of these imports. Respondent data for the multinationals also show that in 1985

Table 3-5
Primary olefins and aromatics: U.S. imports for consumption, by principal sources, 1982-86

(in thousands of dollars)

Source	1982	1983	1984	1985	1986
Canada	347,076	265,334	268,760	268,173	185,831
Nethlds	113,963	136,594	145,787	122,402	80,533
Japan	37,312	16,190	22,938	65,224	50,070
Kor Rep	4	4,331	8,647	15,834	28,348
Brazil	11,064	57,437	65,261	55,152	27,849
Argent	32,906	31,089	29,396	43,507	27,584
U King	56,779	51,139	20,119	41,088	19,009
USSR	-	-	7,707	16,155	17,060
Portugl	8,729	8,064	8,129	10,024	14,858
Spain	12,828	19,925	25,840	24,956	10,506
All other	116,042	117,463	137,128	114,698	46,852
Total	736,702	707,566	739,711	777,214	508,499

Source: Compiled from official statistics of the U.S. Department of Commerce.

imports of primary olefins derivatives were three times the value of primary olefin imports.

During 1981-85, the ratio of U.S. primary petrochemical imports to apparent consumption increased from 4.8 percent to 6.6 percent with a 5-year average of 5.8 percent. 1/ On a product-by-product basis, the imports-to-consumption ratio during 1981-85 was 0.9 percent for ethylene, 3.4 percent for propylene, 25.0 percent for 1,3-butadiene, 10.8 percent for benzene, 12.3 percent for toluene, and 12.0 percent for mixed xylenes.

The 1,3-butadiene market had the largest import penetration of the primary petrochemicals, increasing from 13.9 percent in 1981 to 27.9 percent in 1985 after a peak year in 1982 when it reached 29.4 percent. During 1981-85, the ratio of imports to consumption for 1,3-butadiene annually averaged 25.0 percent. The primary sources of 1,3-butadiene during 1985 were the Netherlands (27 percent), the United Kingdom (14 percent), and Spain (10 percent).

During 1982-86, imports of the derivatives of the basic petrochemicals also increased from $391 million in 1982 to a high of $906 million in 1985, before declining slightly to $877 million in 1986 (table 3-6). The following tabulation shows estimates 2/ of the total net U.S. trade balance figures for derivatives of the basic petrochemicals with its major trading partners (in millions of dollars): 3/

Nation	1982	1983	1984	1985	1986
	-----------------	----------------(Million	dollars)-----	-----------------	
Brazil...........	53,439	45,909	28,795	51,612	87,446
Canada...........	79,556	116,109	22,695	-71,319	-97,724
Japan............	307,541	271,729	264,099	226,373	247,425
Republic of Korea.........	149,354	143,748	167,692	155,094	220,736
Mexico...........	256,268	261,697	233,965	276,944	260,002
Netherlands......	62,066	9,691	23,221	28,548	16,602
West Germany.....	49,996	31,133	28,348	67,540	97,672
All other........	1,594,921	1,477,144	1,602,080	1,416,350	1,635,139
Total........	2,553,141	2,357,160	2,370,895	2,151,142	2,467,298

1/ Compiled from official statistics of the U.S. Department of Commerce.
2/ There is no exact correspondence between the TSUS for imports and the Schedule B for exports of these items.
3/ Compiled from official statistics of the U.S. Department of Commerce.

Table 3-6
Derivatives: U.S. imports for consumption, by principal sources, 1982-86

(In thousands of dollars)

Source	1982	1983	1984	1985	1986
Canada------	201,906	239,741	345,659	400,353	437,728
Nethlds-----	46,949	61,577	74,952	110,112	75,059
Japan-------	27,461	58,756	70,845	77,774	67,529
Mexico------	9,220	31,878	51,717	49,802	48,769
Fr Germ-----	22,966	50,968	60,255	52,416	47,114
France------	29,625	29,980	43,891	33,390	42,031
U King------	10,337	20,743	28,157	40,135	32,338
Belgium-----	15,156	19,761	23,597	28,061	28,347
Italy-------	4,638	8,172	17,670	25,971	24,152
Brazil------	12,796	15,792	42,402	25,532	23,075
S Arab------	-	-	-	2,338	9,708
Colomb------	-	-	1,902	8,577	8,861
China t-----	458	4,478	6,095	11,451	8,253
Kor Rep-----	41	724	864	2,686	3,924
Argent------	4,618	17,212	10,496	5,334	3,726
All other---	5,074	15,129	32,078	31,890	16,623
Total---	391,245	574,910	810,581	905,822	877,237

Source: Compiled from official statistics of the U.S. Department of Commerce.

3.9 Government involvement

There are no U.S. tariffs on the six primary olefins and aromatics. However, under the Toxic Substances Control Act of 1976 (TSCA), the Environmental Protection Agency (EPA) is responsible for establishing standards for the use of topical chemicals. Some importers believe these regulations are a nontariff barrier which hinders imports. 1/

Some domestic producers regard these Government regulations as impediments to production. Additionally, as of January 1, 1987, the U.S. producers of primary olefins and aromatics began to pay the additional Superfund tax again 2/ at the rates shown in the following tabulation: 3/

Petrochemical	Tax rate (per ton)	Estimated tax rate as share of 1986 price (percent)
Ethylene	$4.87	1.68
Propylene	4.87	2.43
1,3-Butadiene	4.87	2.20
Benzene	4.87	1.82
Toluene	4.87	2.52
Xylene	10.13	4.78

A submission from the National Petroleum Refiners Association 4/ was critical of decisions on "domestic public policy objectives without full consideration of the impact of the policies on the worldwide competitiveness of the U.S. industry." The submission also stated that both "the refining and petrochemical manufacturing industries . . . are of vital importance to the U.S. economy and national security. It is therefore essential that government policies not disadvantage these industries relative to foreign competitiors."

The U.S. Government also sponsors petrochemical derivative export promotion through the Commerce Department, the State Department, and the Export-Import Bank. 5/

1/ U.S. International Trade Commission, Study of the Petrochemical Industries in the Countries of the Northern Portion of the Western Hemisphere, USITC Publication 1123, January 1981, p. C-5.
2/ The original Superfund legislation expired on Oct. 1, 1985.
3/ "Superfund Taxes: Some Winners and Some Losers," Chemical Week, Dec. 17, 1986, p. 6.
4/ Submission from National Petroleum Refiners Association, Feb. 25, 1987.
5/ U.S. International Trade Commission, op. cit., pp. C-28-C-29.

3.10 Factors affecting U.S. exports

Respondents to the Commission questionnaire to primary petrochemical producers cited certain international trade barriers that they felt adversely affected their ability to export both primary petrochemicals and their derivatives. The 11 barriers to international trade most often mentioned by the respondents were as follows: 1/

1. Government subsidies
2. State trading, Government monopolies, and exclusive franchises
3. Government laws and practices which discourage imports
4. Licensing requirements
5. Government procurement (procedures)
6. Discriminatory bilateral agreements
7. Exchange and other monetary or financial controls
8. Antidumping practices
9. Customs valuation
10. Restrictive business practices
11. Documentation requirements.

The countries most often associated with these various barriers to international trade were cited by the respondents to the Commission questionnaire in the following order:

1. Mexico
2. South American countries
3. European Community
4. Japan
5. Other Asian Pacific Rim nations
6. Canada

Although the responses to this question do not permit estimates of the severity of the various export barriers, certain observations regarding the data are possible. The first is that Mexico was cited for impeding trade approximately twice as often as any other country. Second, preshipment inspection was added as a potential barrier to international trade in reference to Indonesia, Venezuela, Bolivia, and Ecuador. Although not specifically stated in the questionnaire responses, the natural resource pricing advantages of the Mexican industry 2/ are believed to be the significant factor, along with the limited opportunities for foreign investment, in impeding the flow of international trade.

1/ There were 21 firms responding to this question in the Commission questionnaire.
2/ See App. D for discussion of the Mexican industry.

Chapter 4. Major World Petrochemical Producers

Following the boom in capacity in the mid to late 1970's, petrochemical producers have witnessed a period of excess capacity and low profit margins. However, declining crude petroleum prices in early 1986 resulted in higher profit margins, increased demand, dwindling inventories, and plants running at near full capacity. As a result, the number of reported petrochemical construction projects rose in 1986. The following tabulation shows global petrochemical projects in 1981, 1985, and 1986, for selected geographic areas: 1/

Country	1981	1985	1986
North America..........	94	29	14
Latin America..........	144	58	83
Asia/Pacific...........	176	159	142
Western Europe.........	70	16	37
Eastern Europe.........	94	28	22
Middle East/Africa.....	94	38	46
Total world........	672	328	344

The traditional world producers of petrochemicals, Western Europe, Canada, and Japan, discussed here are also among the major world consumers of petrochemicals. Industry sources estimate that lower feedstock costs could result in consumption in industrialized nations growing as fast as the Gross National Product (GNP) at least until the markets mature further. Also discussed are the energy-rich nations of Saudi Arabia and Mexico because they possess certain advantages vis-a-vis other nations in terms of petrochemical production. These nations have the crude petroleum and natural gas reserves on which to base their worldscale petrochemical industries as well as significant production capacity. Although there are many other nations with petrochemical production capacity or expansions planned, Brazil, China, and the U.S.S.R. have been singled out for discussion because of their reserves and/or potential in the world petrochemical market. The following tabulation shows the number of petrochemical projects for the nations and geographic areas discussed, in 1981, 1985, and 1986: 2/

Country	1981	1985	1986
Western Europe.........	70	16	37
Canada.................	34	12	5
Japan..................	35	7	6
Saudi Arabia...........	19	7	7
Mexico.................	64	18	32
Brazil.................	36	9	16
U.S.S.R................	27	11	8
China..................	31	28	30

1/ "Refining/Petrochemical Report," Oil & Gas Journal, Mar. 30, 1987, p. 54.
2/ Ibid.

4.1 Western Europe

Western Europe's proved reserves were estimated at 22 billion barrels of crude petroleum and 230 trillion cubic feet of natural gas, as of January 1, 1987. Norway and the United Kingdom together account for 89 percent of total crude petroleum reserves and 60 percent of the natural gas reserves. 1/

Distinctive features.--The Western European petrochemical industry, unlike that of the United States, primarily uses naphtha as a feedstock for the production of basic petrochemicals. In 1986, naphtha accounted for approximately 70 percent of Western European feedstock consumption, compared with close to 100 percent during the mid-1960's. The decrease in naphtha's share of feedstock consumption was mainly a result of increasing petroleum and petroleum products prices in the 1970's and early 1980's, and the increased flexibility designed into the newer Western European plants to allow for use of various feedstocks. Gas oil, LPG, and ethane supplied the remainder of Western Europe's feedstock needs in 1986.

One problem highlighted by the petroleum price shocks of the 1970's was industry overcapacity. Much of the new capacity came onstream as the 1979 petroleum disruption brought about the second petroleum price shock of the decade and, in turn, caused a slowdown in the world economy. 2/ According to industry sources, petrochemical demand and production in Western Europe began increasing again in 1983 and sustained that increase until the decline in petroleum prices beginning in 1986. 3/ Although a great deal of older capacity was shut down during the 1980's and the number of producers declined, some new and more efficient production capacity came onstream. 4/ However, the new capacity, mostly the result of joint ventures, has kept total capacity within Western Europe's goals for reducing and eliminating inefficient surplus capacity.

Industry structure.--The Western European petrochemical industry started up in the 1950's with the advent of the production of chemicals from petroleum fractions and some natural gas. Naphtha, readily available in Western Europe because petroleum products were mainly used for heating and fuel rather than for gasoline as in the United States, became the primary feedstock for the petrochemical industry in the area.

The Western European petrochemical industry consists of a broad spectrum of firms, ranging from multinational oil companies and chemical companies to state-owned companies. Although several of the multinational firms operating in Western Europe are based in the United States, the majority of production in the Western European petrochemical industry is domestically owned and

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1/ "Worldwide Report," Oil & Gas Journal, Dec. 22-29, 1986, p. 36.
2/ Ibid, pp. 2-3
3/ Dr. K. Mehta, "An Overview of the Petrochemical Sector in the European Community," OAPEC Bulletin, March 1968, p. 20.
4/ Draft chapter from a forthcoming book for Warwick University, p. 4.

controlled. Western Europe is said to have 12 of the world's top 20 petrochemical companies. 1/ Currently, approximately 40 percent of the Western European petrochemical industry is either state-owned or influenced. The French and Italian petrochemical industries, for example, which are dominated by state- holding companies, have each undergone extensive restructuring primarily under government sponsorship. 2/ The industry changes in France and Italy, and those in the United Kingdom and West Germany reflect the overall rationalization of capacity in the Western European petrochemical industry. 3/ The French conservative government, however, elected in March 1986, announced plans to reduce its holdings in the nationalized companies. 4/

Most of the industrial and corporate restructuring to date involved bilateral agreements such as portfolio exchanges and the creation of joint ventures, primarily among Western European firms and between Western European and U.S. firms. Two of the more recent joint ventures involve the production of polypropylene and of PVC and VCM. Portfolio exchanges have involved plant closures and transfers of ownership. 5/ All such agreements require the approval of the European Commission to prevent violation of the EC treaty, 6/ which contains certain competitive provisions that limit the number and type of agreements between firms. Current shuffling of facilities and production is generally approved in view of the overcapacity situation. Agreements between more than two parties, or that appear to lead to the formation of a cartel, are discouraged by the provisions in the treaty. The Treaty provisions could in some cases act as a restraint to further restructuring in the Western European petrochemical industry. Currently, however, most of the agreements have been approved.

Although there was significant investment in the industry in the late 1970's in response to increased demand for petrochemicals, investment has recently declined primarily because of the restructuring throughout the industry. Uncertainty concerning the future of petroleum prices, the deman for petrochemicals and continued consolidation of capacity, and imports from Middle Eastern and other energy-rich countries are expected to restrain future investments in the Western European petrochemical industry. Industry sources do expect modest investment for projects to improve efficiency. Research and development spending is also expected to increase.

Concentration within the Western European industry has increased in the last few years as a result of restructuring, particularly in France and Italy. The French and Italian petrochemical industries have regrouped their firms' production and orientation. Specialized "poles" were created, grouping commodity chemical production at particular firms and specialty chemical

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1/ p. 42.
2/ Jean Guinet, Petrochemical Industry, OECD Publications, 1985, pp. 120-122.
3/ Draft chapter, from a forthcoming book for Warwick University, p. 19.
4/ "French Chemical Producers Test a Business Formula," Chemical Week, Dec. 3, 1986, p. 18.
5/ Draft chapter from a forthcoming book for Warwick University, p. 23.
6/ Dr. Mehta, op. cit, p. 18.

production at others. 1/ The industry in these nations remains large enough, however, to prevent any one company from gathering a major share of the market. The top three producers in any of the major markets are said to hold no more than 51 percent of those markets. 2/

Production in the Western European petrochemical industry in 1984 was estimated to have amounted to approximately $67 billion. 3/ This was a decrease of approximately 20 percent compared with that in 1980. Western European imports and exports of petrochemicals in 1984 were valued at approximately $9.2 billion and $16.4 billion, respectively. Apparent consumption of petrochemicals in Western Europe in 1984 was valued at about $59.8 billion, representing a decrease of about 20 percent compared with that in 1980. Petrochemicals accounted for approximately 50 percent of total Western European chemical imports, as well as 50 percent of total Western European chemical exports in 1984. In 1984, imports of all countries of Western Europe amounted to about $9.2 billion of petrochemicals. Major sources of the imports in 1985 included the United States, other countries within Western Europe, and Saudi Arabia. Imports increased by 11 percent in 1984 and 7.5 percent in 1985. They are believed to have increased by 4.5 percent in 1986. 4/

In terms of the products covered in this study, polyethylene imports accounted for the largest percentage of total imports in 1985, by quantity. Imports of polyethylene into Western European countries amounted to approximately 2.2 billion pounds. Propylene, benzene, and toluene were the next largest imported petrochemicals, by volume, at 1.1 billion pounds, 1.0 billion pounds, and 727 million pounds, respectively. Ethylene imports, usually between Western European countries, amounted to approximately 651 million pounds. The import-to-consumption ratio for petrochemicals in Western Europe in 1984 was about 15 percent, compared with approximately 12 percent in 1980.

Petrochemical market growth during 1987-92 is expected to parallel the growth rates in the 1970's and amount to about "2.5-3.0 percent per GNP growth." 5/

Western European petrochemical profit margins declined in past years primarily because of the petroleum shocks of 1973 and 1979, overcapacity, and currency fluctuations. Currency changes affect the prices the raw materials and the petrochemicals differently, as the raw materials consumed in Western

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1/ Jean Guinet, op. cit., p. 122.
2/ Draft chapter from a forthcoming book for Warwick University, p. 21.
3/ Production recorded in terms of Western European turnover as presented in speech by Dr. Mehta, op. cit., p. 19; may encompass more than the basic products covered in this study.
4/ "Europe's Chemical Industry is Tackling Restructuring," European Chemical News, Sept. 15, 1986, p. 16.
5/ Ibid., and CEFIC/APPE Working Document, "The Impact of a Volatile Oil Price on Energy Costs to the Chemical Petrochemical Industry and on End-Product Pricing," p. 7.

Europe are generally purchased at prices related to the U.S. dollar, and the products are generally sold at prices related to the Deutschemark. 1/

Imports of petrochemicals from certain developing countries into Western Europe are currently eligible for duty-free entry under the EC's Generalized System of Preferences (GSP). In 1985, imports of methanol and polyethylene from Saudi Arabia exceeded their competitive need limit after 7 months. As a result, the EC imposed duties on both products. The EC reimposed the duties during the first week of 1986, assigning a duty of 12.5 percent on polyethylene and 13 percent on methanol.

The EC has also taken action in several unfair trade cases regarding alleged dumping and subsidies. During 1982, for example, the EC investigated such allegations concerning vinyl acetate monomer, styrene, certain xylenes, phenol, PVC, acrylonitrile, and other petrochemical derivatives and products. Of approximately 28 such cases, 8 items incurred an application of permanent duties, 1 item was assigned temporary duties, and 13 cases were suspended either following a pricing agreement or for lack of evidence. 2/

Export markets.--Exports of petrochemicals from Western Europe in 1984 were valued at approximately $16.4 billion. These exports accounted for approximately 15 to 25 percent of total production in 1984, 3/ whereas, U.S. exports account for approximately 10 percent of total U.S. production. The U.S. industry is comparable with the Western European industry in regard to volume of sales. The discrepancy in export shares indicates that the U.S. industry would probably face fewer problems than Western Europe if demand declined in traditional export markets. Demand in Western Europe's third-world export markets is expected to decline as "new producers" in the Middle East, Canada, Mexico, and other conventional energy-rich nations, displace Western European exports. 4/ Saudi Arabia, for example, is expected to send approximately 45 percent of selected petrochemicals to Western Europe, 2 percent to the United States, 26 percent to Japan, and 27 percent to other various Arab/African, Pacific Basin and Far East nations. 5/ In 1985, a Western European petrochemicals trade association estimated that sales of ethylene derivatives from Saudi Arabia to Western Europe amounted to approximately 330 million pounds with negligible amounts to the United States and Japan. 6/ Industry sources believe, however, that the decrease in the price of petroleum and increased consumption in the Middle East have blunted the full impact of the Saudi material on world markets. Traditional primary Western European export markets include the Middle East and Africa.

1/ Jean Guinet, op. cit., p. 65.
2/ Jean Guinet, op. cit., pp.140-141
3/ Speech by T.O. Hutchinson, op. cit., slide 10; these figures may include more products than defined as primary petrochemicals in this report; other sources estimate that Western European exports account for 40 to 50 percent of its annual output.
4/ Draft chapter from a forthcoming book for Warwick University, p. 4; "Europe's Chemical Industry is Tackling Restructuring", European Chemical News, Sept. 15, 1986, p. 16
5/ Ibid., p. 37.
6/ T.O. Hutchison speech, op. cit., slide #10.

Development of new export markets is considered to be essential to the Western European industry if it is to remain viable.

As is also the case for imports, polyethylene exports from Western European nations accounted for the largest share of total chemical exports, amounting to 2.1 billion pounds in 1985. Polypropylene, PVC, and styrene were the other individual petrochemicals accounting for the largest shares of exports, amounting to 819 million pounds, 525 million pounds, and 406 million pounds, respectively. Exports of ethylene, mostly to other Western European nations, represented the next largest export share, amounting to 354 million pounds in 1985.

Most of the petrochemical companies in Western Europe tend to experience better economies of scale as a result of increased capacity utilization because they are oriented toward production for export as well as for domestic consumption. Although there are no known programs of government-derived export assistance within the EC specifically directed towards petrochemicals, industry sources believe that individual states may have indirect measures, such as tax programs, to benefit producers exporting to non-Western European markets.

The prices for Western European petrochemical exports are primarily derived from the world market prices for these products. Prices may differ from those of domestic products as a result of petroleum pricing, supply and demand for the products, and currency fluctuations. Currency fluctuations are currently affecting the competitiveness of Western European petrochemicals with U.S. petrochemicals in the Far East. Transportation costs are also a factor. In 1984, the U.S. producers were reported to be benefiting from an f.o.b. cost advantage for polyethylene, compared with the Western European product, mainly because of lower feedstock costs associated with U.S. natural-gas-based ethane feedstocks. This advantage was practically eliminated, however, with the addition of transportation costs and duties. 1/

In general, differential pricing of exports compared with domestic production is said to be uncommon for the Western European petrochemical industry. Pricing is considered to be a strategic move to compete for long-term position. As such, the industry is more interested in establishing and building market volume than engaging in short-term pricing strategies.

Western European petrochemical producers are pursuing a strategy of increased investment overseas. Most companies have worldwide marketing organizations as well as overseas production capacity currently onstream. Western European firms are building or acquiring capacity in the United States, for example, to supply what are currently export markets in the United States and other locations. This strategy allows the company increased market presence, ready access to information concerning the local markets, and increased security of supply to the local markets.

1/ "Producers Must Tighten Their Belts in Europe," European Chemical News, Oct. 28, 1985, p. 13.

Factors of competition.--Naphtha, the primary feedstock for the Western European petrochemical industry, has accounted for a major portion of the production costs of petrochemicals. This is mainly a result of the increased prices for naphtha (through 1985) and all petroleum-based feedstocks in past years and the relative lack of flexibility in the Western European industry for chemical feedstocks.

In 1973, costs for energy-based materials accounted for about 45 percent of the total production costs of ethylene, increasing to 85 percent in 1980 and remaining around that level until 1983. As a result of the decline in world petroleum prices and the increase in flexibility previously described in the use of feedstocks, the price of the energy products decreased during the first six months of 1986. The price of naphtha fell by more than 50 percent during January-June 1986; however, naphtha prices are expected to increase over the next few years, mainly because of increased fixed costs associated with operating the refinery even if the price of petroleum remains depressed. 1/ The current lower prices, however, have increased the competitiveness of naphtha crackers in Western Europe vis-a-vis gas-based ethylene plants in Saudi Arabia. 2/ Increased efficiency of the facilities, as well as increased flexibility in utilizing lower priced feedstocks, could help maintain the higher level of competitiveness. According to a trade journal, production costs could be reduced by more than 20 percent if the Western European industry further increased its feedstock flexibility and the use of certain gas feedstocks. 3/

Overall labor productivity in Western Europe increased during 1980-84, primarily because of wide-scale employee reductions intended to increase productivity and cut labor costs. 4/ The increase in labor productivity, however, was less than the increase in total employment in 1985. In 1985, total employment increased in industrialized countries, excluding the United States, by 0.8 percent compared with 0.4 percent in 1984. During 1980-84, total employment remained relatively constant. 5/ The level of employment is expected to continue to increase in future years at a rate proportional to the

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1/ CEFIC/APPE Working Document, "The Impact of a Volatile Oil Price on Energy Costs to the Chemical Petrochemical Industry and on End-Product Pricing," pp. 2 and 5.
2/ "Petrochemicals and Plastics: Survey 1986," CEFIC, p. 7.
3/ "Western Europe's Petrochemical Industry is Subject of New BP Briefing Paper," Hydrocarbon Processing, February 1985, pp. 15 and 17.
4/ World Economic Outlook: A Survey by the Staff of the International Monetary Fund, International Monetary Fund, April 1986, p. 31; International Economic Indicators, U.S. Department of Commerce, December 1984, p. 61.
5/ International Economic Indicators, U.S. Department of Commerce, December 1984, p. 64.

size of the overall workforce. 1/ Labor costs are not expected to increase significantly during 1987-89. 2/

Total unit labor costs in manufacturing in Western Europe during 1980-85 declined (when examined in terms of U.S. dollars) after reaching a high in 1980. In terms of national currencies, however, the unit labor costs increased in those years, but at a decreasing rate each year. 3/ This declining rate of increase was attributed in part to the declining rate of increase in hourly compensation throughout the Western European industry. The rate of increase in hourly compensation decreased from 11.5 percent in 1980 to 5.3 percent in 1985. 4/ The slower increase of unit labor costs was also the result of increased productivity. Information particular to the petrochemical industry is not readily available.

The Western European petrochemical industry already has a well-established infrastructure. Built in reasonably mild environmental conditions and utilizing inputs that are readily available, the startup and maintainance costs of such infrastructure are generally lower than those in the Middle East, and comparable with those of the United States. The infrastructure in Western Europe is extensive and allows for the efficient transfer of materials throughout the EC and beyond. For example, a pipeline system exists solely to facilitate the transport of ethylene within Western Europe.

The Western European petrochemical industry already has a well-established infrastructure. For example, a pipeline system exists solely to facilitate the transport of ethylene within Western Europe.

Total capital expenditures by majority-owned foreign affiliates of U.S. companies in Western Europe are estimated to have been $17.0 million in 1986. Capital investment in the chemical industry is expected to continue to increase, buoyed by decreased petroleum prices and the status of the U.S. dollar. 5/ Approximately 40 percent of the Western European industry is state held. As such, capital for investment funding is primarily derived from the government. The remainder of the industry is financed through private funding, both foreign and domestic.

1/ World Economic Outlook: A Survey by the Staff of the International Monetary Fund, International Monetary Fund, April 1986, p. 31.
2/ Ibid., p. 33.
3/ International Economic Indicators, U.S. Department of Commerce, December 1984, p. 64; World Economic Outlook: A Survey by the Staff of the International Monetary Fund, International Monetary Fund, April 1986, pp. 33 and 189.
4/ International Economic Indicators, U.S. Department of Commerce, December 1984, p. 33.
5/ "Western European Capital Investment in Chemical Industry Remains Strong," European Chemical News, June 16, 1986, p. 6.

In the United Kingdom, capital expenditures in the chemical industry increased by 25 percent in 1985 to $1.9 billion and are believed to have increased in 1986 by about 8 percent. Approximately 50 percent of the investment during this period was believed to have been used for renovation of existing facilities. 1/ Capital expenditures in Italy, which were necessary to increase the ability to generate material for export purposes, are estimated to be in the range of $10 to 15 billion. Accumulating such capital, however, is not believed to be particularly easy for the Italian firms. 2/ France increased its investment to approximately $1.3 billion in 1985, mainly to modernize and improve production facilities. At least one firm is said to be looking to the government for additional capital. 3/

Transportation costs to North American and other European markets are generally higher for other areas of the world than for the Western European producers. This is particularly true for the producers in the Middle East. Much of the transportation costs involved in shipments overseas, such as to the United States, are moderated by the presence in the United States of subsidiaries of the Western European firms.

The level of technology employed in the Western European industry has increased as the restructuring of the Western European industry has involved the shutdown of older plants. The new plants that were brought onstream were more efficient. These plants utilize new process technologies, although much of the basic chemistry is the same, and have greater flexibility of feedstocks. The process technologies used in the newer plants are comparable with those recently built in other areas of the world. The large number of multinational firms operating in the Western European petrochemical industry, both those based in Western Europe and in other world areas, helps facilitate the transfer of technologies.

Adjustments to competitive pressures.--In terms of exports of petrochemicals from the Middle East, the Western European market in 1986-87 appeared to be absorbing the majority of the increased imports. Industry sources maintain that the Western European industry can remain competitive in this situation by continuing reductions of capacity and by exercising "price discipline." 1/ Currently, although the net raw material cost for Saudi ethylene production, for example, is said to be $67 per ton, compared with $240 per ton for Western European producers, the addition of freight, duty, and higher labor and capital costs, and the change in currency valuations is expected to allow Western European producers to maintain their competitiveness vis-a-vis the Saudi product. Similarly, the price at European locations of

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1/ "UK Chemical Industry Spending Up By Quarter," European Chemical News, Apr. 7, 1986, p. 14.
2/ "Italy's Chemical Trade Deficit Mars a Vintage Year," Chemical Week, Oct. 8, 1986, p. 22.
3/ "French Firms Still Trail EEC Rivals," European Chemical News, Jan. 20, 1986, p. 4; "CDF Chimie Seeks Government Cash," European Chemical News, July 28, 1986.
4/ "Producers Must Tighten Their Belts in Europe," European Chemical News, Oct. 28, 1985, p. 13.

U.S. polyethylene is said to be "virtually identical" with the price of the Western European polyethylene, once transportation and duties are added to the U.S. product. 1/

4.2 Canada

Canada's estimated proved reserves of crude petroleum were 6.9 billion barrels, as of January 1, 1987; natural gas reserves were estimated at 100 trillion cubic feet. 2/

Distinctive features.--The Canadian petrochemical industry is largely composed of modern plants and is primarily export oriented. 3/ This is attributable to the relatively small domestic consuming market and the available resources. According to industry sources, the Canadian industry must maintain and enlarge its export markets to continue operating at high enough rates of capacity to remain economically viable in the future. 4/ Capacity utilization in 1985 was 85 percent, representing an increase of 3 percent compared with that in 1984.

Industry Structure.--The Canadian basic petrochemical industry has significant foreign investment and many of the firms are affiliated with multinational firms. These firms have engaged in several domestic joint ventures. One such venture underway in Montreal is co-owned by the Quebec Government and a multinational. The joint-venture company, whose major products are ethylene, propylene, and butadiene, is currently undergoing restructuring estimated to cost approximately $30 million. The restructuring includes a shift of the ethylene production from an older plant to a newer, more efficient facility, and increasing the feedstock flexibility of the newer plant to allow increased use of natural gas liquid feedstocks. Natural gas liquids are expected to account for approximately 85 percent of the feedstock requirements. 5/

Another joint venture involves two multinational firms, the Canada Development Corporation (CDC), and a firm that was 100 percent owned by the CDC. 6/ The two multinational companies, which have since sold their shares to the Canadian partner, have, however, committed themselves to purchase the ethylene produced by the venture company until at least 1994. The venture company and the parent company have since combined operations. 7/

1/ Ibid.
2/ "Worldwide Report," Oil & Gas Journal, December 22-29, 1986, p. 36.
3/ Report of the Petrochemical Industry Task Force, February 1984, p. 7.
4/ The Canadian Petrochemical Fact Book, The Canadian Chemical Producers' Association, Winter 1982/83, p. 17; "Alberta Must Signal Its Long-Term Dedication," European Chemical News, Sept. 2, 1985, p. 14.
5/ "Changes at Canada's Petromont," Chemical Week, Aug. 13,1986, p. 28.
6/ "Petrosar Seeks Financial Help," European Chemical News, Dec. 24-31, 1984, p. 5.
7/ "Restructuring the Eastern Canadian Basic Petrochemical Industry," Hydrocarbon Processing, August 1986, p. 102-G.

In the overall Canadian chemical industry, which is made up of approximately 65 firms, 29 firms are reported to be affiliated with U.S.-based multinational firms. 1/ At least two of the firms in the Canadian petrochemical industry are government controlled. One of the two is 50-percent owned by a Quebec holding company.

The Canadian petrochemical industry is concentrated in the Provinces of Ontario, Quebec, and Alberta. In 1985, approximately one-half of the operating capacity was located in Alberta, 35 percent in Ontario (Sarnia), and the remainder in Quebec (Montreal). Firms in Sarnia and Montreal produce a wider range of ethylene derivatives than those in Alberta because the crude petroleum-based feedstocks in Sarnia and Montreal allow for a wider range of coproducts. 2/

The major share of the current reserves and production of crude petroleum and natural gas in Canada is concentrated in the Western Canada Sedimentary Basin. The discoveries of these major natural gas fields in Alberta fueled the creation of the petrochemical industry in that Province. Alberta, located in the Western Basin and with ready access to feedstock supplies, is now the primary basic petrochemical-producing province in Canada. The oldest petrochemical facililty, however, is located in Montreal. This location, although promising because of access to seaports and proximity to industrial markets in the eastern United States and Canada, 3/ entailed additional transportation costs for obtaining feedstocks from Western Canada or other sources.

During 1981-85, the Canadian petrochemical industry operated at a disadvantage compared with other nations' petrochemical industries in regard to feedstock costs, primarily as a result of the National Energy Program (NEP). Federal and Provincial petroleum and natural gas pricing regulations kept prices higher than world market prices, 4/ resulting in an estimated annual loss of $400 million during 1983-84. 5/ Taxes and royalties increased the Alberta border price for natural gas by 78 percent. 6/ The NEP, implemented in a time of escalating crude petroleum prices and growing Canadian nationalism, was intended to keep domestic Canadian prices for crude petroleum and natural gas below world levels. However, world crude petroleum price declines, combined with NEP practices, resulted in some Canadian domestic energy prices rising above world levels. This increased cost for Canadian feedstocks reduced the profit margins of the Canadian firms, in turn reducing these firms' competitiveness compared with other world-scale

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1/ World Trade Academy Press, Directory of American Firms Operating in Foreign Countries, Uniworld Business Publications Inc., 1984, pp. 257-358.
2/ "Investment Opportunities in Central Canada's Petrochemical Industry," Chemical Engineering Progress, March 1986, p. 11.
3/ Ibid.
4/ "Restructuring the Eastern Canadian Basic Petrochemical Industry," op. cit.
5/ "Canada's New Energy Pricing Agreement: A Boost for Petrochemicals," op. cit.
6/ "Alberta: Call for Flexible Gas Pricing," European Chemical News, Aug. 26, 1985, p. 10.

petrochemical producers. Foreign investment in the Canadian industry was restrained during this period as a result of the decreased profit margins and the growing degree of Canadian nationalism.

In 1984, with the election of the new Conservative government in Canada, refinery taxes for petrochemical feedstocks were reduced and deregulation of crude petroleum prices was implemented. Natural gas prices were deregulated later. In some cases, aid to some of the companies in the industry was implemented by the Government to avert closings. Since that time, the petrochemical industry's competitive situation is reported to have improved significantly. 1/ Passage of the Western Accord on March 29, 1985, removed all restrictions on trade in crude petroleum and refined products. Natural gas prices were deregulated in eastern Canada in early 1986. Following deregulation, Canada began importing crude petroleum from the United States at costs approximately equal to those on the U.S. gulf coast. 2/ Firms in the Provinces of Ontario and Quebec can now directly purchase natural gas from Alberta at significant cost savings. 3/ In 1985, however, the Canadian industry experienced unsatisfactory financial results. These results were attributed to the presence of new suppliers on the world market, as well as to the rationalization and restructuring experienced internationally. 4/

In 1985, five Canadian companies, the Canadian Government, and the Government of Alberta formed a consortium to develop a plan for a petrochemical complex in China. The complex was designed to produce ethylene, as well as several downstream products. The companies involved, as well as other such companies in Canada, are expected to benefit in at least two ways. One benefit would be the possibility of increased sales of technology to China. The second would be the possibility of supplying China's import needs in petrochemicals until the Chinese industry can supply its own domestic demand. 5/

Domestic Market.--Production of the entire Canadian petrochemical industry in 1985 was valued at $3.1 billion, an increase of less than 1 percent compared with that in 1984. 6/ The increase, which was larger in terms of Canadian dollars, was attributed to increased exports in 1985. 7/ Domestic consumption accounted for 53 percent of production in 1985. Overall Canadian consumption in 1985 was valued at $2.9 billion, compared with $3.1 billion in 1984.

Imports, which accounted for 44 percent of Canadian consumption in 1985, were valued at $1.3 billion compared with $1.2 billion in 1984. The slight increase in imports and the decrease in consumption were credited with the

1/ "Investment Opportunities in Central Canada's Petrochemical Industry," op. cit.
2/ "Restructuring the Eastern Canadian Basic Petrochemical Industry," op. cit.
3/ "Canadian Gas Cuts," European Chemical News, Feb. 10, 1986, p. 8.
4/ The Canadian Petrochemical Fact Book, 1985 update, op. cit.
5/ "Canadian Companies to Help Plan Chinese Petrochemical Complex," Chemical & Engineering News, June 24, 1985, p. 17.
6/ The Canadian Petrochemical Fact Book, The Canadian Chemical Producers' Association, 1985 update.
7/ Ibid.

decrease in the value of Canadian products sold in Canada. 1/ The United States accounted for an estimated 87 percent of the Canadian imports of benzene, toluene, and xylene (BTX) and an estimated 81 percent of the Canadian imports of ethylene, propylene, and 1,3-butadiene (olefins). Japan was the next largest source of the BTX imports (12 percent), and the European Community (EC) supplied 16 percent of the imports of the specified olefins. Exports of petrochemicals from Canada in 1985 were valued at $1.4 billion, representing an increase of 12 percent compared with that in 1984. The increase in exports bolstered Canadian petrochemical production. Exports accounted for 47 percent of Canadian production of petrochemicals in 1985, compared with 42 percent in 1984.

During 1981-85, the petrochemical balance of trade in Canada had a cyclical pattern. During 1981-82, the balance of trade increased to a high of $263 million. It decreased in 1983-84, reaching a negative $37 million in 1984. The balance of trade rebounded to $153 million in 1985.

Canada's tariffs are among the highest of all industrialized nations. 2/ Canadian tariffs on U.S. exports exceed the U.S. tariffs on comparable Canadian imports by as much as one-half in some cases. 3/ It is estimated that if all Canadian tariffs were reduced to the average level for industrialized nations, total net U.S. trade on all products could increase by more than $500 million annually. 4/ The current free-trade negotiations are seeking to bilaterally eliminate all U.S.-Canadian tariffs.

Canada's market protection mechanism include both tariffs and nontariff barriers. Two examples of nontariff trade barriers that existed in Canada during 1982-86 are the NEP and the investment barriers. The NEP has since been revised and energy prices have been deregulated. Investment barriers, however, are still being employed. 5/ Provisions under the Investment Canada Act, the revised energy policy, and other current legislative proposasl are said to interfere with new or expanded foreign investment. The Canadian Government can limit U.S. and other foreign investment and impose "voluntary" performance requirements. 6/ Two multinationals have allegedly refrained from starting up ethylene facilities in Canada because of provisions in the "Investment Canada Act." 7/ Canada has introduced legislation that would,

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1/ May include data on products other than those specifically considered in this study.
2/ Office of the United States Trade Representative, National Trade Estimate: 1986 Report on Foreign Trade Barriers, p. 47.
3/ "Trade Talks May Push Up Import Prices," CPI Purchasing, December 1986, p. 25.
4/ National Trade Estimate: 1986 Report on Foreign Trade Barriers, op. cit., p. 57.
5/ "Trade Talks May Push Up Import Prices," op. cit.; National Trade Estimate: 1986 Report on Foreign Trad Barriers, op. cit., p. 57.
6/ National Trade Estimate: 1986 Report on Foreign Trad Barriers, op. cit., p. 57.
7/ "Trade Talks May Push Up Import Prices," op. cit.

among other things, attemp to liberalize Canadian energy-sector ownership requirements. 1/ This matter is also being addressed in the context of the free-trade negotiations.

The Canadian Government, on both Federal and Provincial levels, has become involved in the domestic market on a number of occasions, in areas ranging from energy policies to company ownership. One of the earlier instances was the implementation of the NEP. The Government has also provided aid to financially troubled firms. A petrochemical firm in Montreal is expected to receive approximately $80 million to $100 million in grants from the Federal Government and the Province of Quebec during 1982-89. 2/ Another firm is expected to need Federal assistance for major investments. 3/ Although the Government denied such speculation in 1985, the company recently combined operations with its "parent" company, which was 100-percent owned by the CDC, a Government entity.

Other examples of government involvement include ownership/control of some fimrs and the deregulation of transportation. Government provisions are also in effect in regard to foreign investment in Canada, the procurement of goods in Canada, and the tariff system.

Export markets.--Exports accounted for 47 percent of total Canadian petrochemical production in 1985, whereas U.S. exports accounted for approximately 10 to 20 percent of total U.S. production. This indicates that the Canadian industry is far more dependent on export markets than is the U.S. industry. The export markets considered particularly important are the United States and the Pacific Rim nations. Consequently, Canadian firms are looking into investment opportunities in these areas. Major competitors for the Pacific Rim market are the producers in the United States and Saudi Arabia.

Exporting companies, in general, take advantage of higher economies of scale. Therefore, most of the companies producing these products in Canada are oriented towards production for export as well as for domestic demand. Capacity utilization for the industry increased from 82 percent in 1984 to 85 percent in 1985. The increase in capacity utilization, as well as in volume of production, was attributed primarily to increased exports.

The pricing of Canada's petrochemical exports appears to be comparable with products in Western Europe and the United States. Examples cited included exports of ethylene and linear low-density polyethylene (LLDPE) from Alberta in 1985. Exports of ethylene were reported to be priced several cents per pound lower than those of ethylene produced on the U.S. gulf coast at

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1/ National Trade Estimate: 1986 Report on Foreign Trade Barriers, op. cit.
2/ "Getting on With the Job of Running Petromont," Chemical Week, Nov. 26, 1986, p. 21.
3/ "Canada's New Energy Pricing Agreement: A Boost for Petrochemicals," op. cit.

costs comparable with natural gas. 1/ The Canadian price was reported to include full profit and debt servicing at all stages. 2/

Shipments of LLDPE from Alberta to Western Europe were priced, after duties were paid, within the same range as that of the Western European product. The exporting company quoted prices of $450-$470 per ton delivered to Western Europe, before adding duty costs, and $530-$560 per ton after duties were paid.

Factors of competition.--In 1985, it was estimated that the costs associated with producing a metric ton of ethylene in the United States totaled $420, compared with $340 in Canada, and $210 in Saudi Arabia. 3/ Alberta is considered to have an advantage when compared with other producing areas, both in Canada and worldwide, primarily because of its accessibility to the feedstocks and because of a general perception among U.S. consumers that Canadian products are of good quality and that the suppliers offer reliable service. 4/

The feedstocks consumed in the central Canadian petrochemical industry are delivered primarily via pipeline from Alberta. Several options are being considered to reduce feedstock acquisition costs to the central Canadian industry. One such option is the dedication of a pipeline to natural gas liquids (NGL's). A second is the swapping of Canadian natural gas for U.S.-produced LPG/NGL's in the Great Lakes and Northern Tier States. 5/ The central Canadian industry has also been substituting NGL's as much as possible for petroleum-based feedstocks, to maximize feedstock flexibility and minimize feedstock costs. 6/ The deregulation of pricing of Canada's energy resources has also reduced feedstock costs somewhat. In 1985, raw materials, not including intermediates, accounted for an estimated 52 percent of production costs, compared with 48 percent in 1984.

Labor costs accounted for an estimated 13 percent of production costs in 1984 and 1985. Total pay of all employees in the Canadian petrochemical industry in 1985 was valued at $549 million, representing an increase of 5 percent compared with than in 1984. Labor productivity increased by only 1.4 percent in 1985, compared with an 11.3 percent increase in 1984. 7/ Canada and the United States experienced significant reductions in their

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1/ "Alberta: Call for Flexible Gas Pricing," European Chemical News, Aug. 26, 1985, p. 10.
2/ Ibid.
3/ "U.S. Petrochemical Outlook Not So Dismal," Chemical & Engineering News, June 3, 1985, p. 14.
4/ "Alberta Must 'Fend Off Developing Industries'," European Chemical News, Sept. 9, 1985, p. 23.
5/ "Investment Opportunities in Central Canada's Petrochemical Industry," Chemical Engineering Progress, March 1986, p. 11.
6/ Ibid.
7/ World Economic Outlook: A Survey by the Staff of the International Monetary Fund, International Monetary Fund, April 1986, p. 189.

unemployment rates during 1983-85. 1/ Total unit labor costs in 1985 in all manufacturing industries in Canada increased during 1980-85 by 2.3 percent, after decreasing by 5.8 percent in 1984 and 2.4 percent in 1983. The increase was attributed in large part to the decline in labor productivity. Hourly compensation increased by only 3.8 percent in 1985, after increasing by 4.9 percent in 1984 and 4.3 percent in 1983. Information regarding only the petrochemical industry is not available.

Fixed capital expenditures in the Canadian petrochemical industry increased during 1980-82 to $1.0 billion, or by 225 percent during that period. Capital expenditures declined steadily during 1982-85, reaching a low of $161 million in 1985. Fixed capital expenditures were projected to increase in 1986 and then decline through 1988. 2/ Gross fixed assets declined in 1985 to $4.9 billion, after reaching a high of $5.3 million in 1984.

Capital costs account for a large share of production costs of petrochemicals. Capital costs in Canada are higher than those in the United States and Western Europe, primarily because of the colder climate and remoteness of some of the facilities. 3/ Construction costs in Canada are estimated to be 15 percent to 30 percent higher than on the U.S. gulf coast. Interest costs have also been higher. Overall interest rates for capital expenditures were higher during that period because of the expected 30 percent differential in the costs of plant construction compared with those in the United States. 4/

As of February 1984, annual transportation costs for the Canadian petrochemical industry were reported to be greater than $425 million. The average cost of transportation accounts for approximately 10 to 35 percent of the selling price of the product, depending on the particular market. 5/ Exports from Alberta to the U.S. west coast and the Great Lakes States incur transportation costs comparable with those of the producers on the U.S. gulf coast. 6/ Recent developments in the deregulation of the Canadian transportation industry are expected to have a positive effect on the Canadian petrochemical industry. 7/

Research and development (R&D) spending in 1984 in the Canadian petrochemical industry accounted for 1.1 percent of sales. The Canadian industry is said to have ready access to world technology, as well as areas of

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1/ Ibid., p. 32.
2/ The Canadian Petrochemical Fact Book, The Canadian Chemical Producers' Association, 1985 update.
3/ "Alberta Must Fend Off Developing Industries," European Chemical News, Sept. 9, 1985, p. 23.
4/ Report of the Petrochemical Industry Task Force, February 1984, p. 33.
5/ Ibid, p. 7.
6/ "Alberta Must 'Fend Off Developing Industries," European Chemical News. Sept. 9, 1985, p. 23.
7/ The Canadian Petrochemical Fact Book, The Canadian Chemical Producers' Association, 1985 update.

specialization in new technology within the industry. 1/ Although not one of the world's traditional petrochemical producing centers, the Canadian industry has invested a sizable amount in R&D and has developed into one of the leaders in the application of technology. 2/ A large share of the funding for the industry's R&D efforts comes from the companies themselves.

The exchange rate differential between the Canadian dollar and the U.S. dollar is reported to have resulted in increased Canadian penetration of the U.S. market. Although appreciating against other currencies until 1985, the Canadian dollar has been decreasing in value vis-a-vis the U.S. dollar for the last few years. During 1983-85, the value of the Canadian dollar declined from 81 cents to the 1985 value of 73 cents against the U.S. dollar. The Canadian inflation rates were reduced quite substantially and maintained at the lower levels throughout 1986. 3/

Financial performance.--The Canadian petrochemical industry incurred a net loss of $381 million after taxes in 1985. 4/ This was compared with a loss of $102 million in 1984, on a current dollar basis, and a loss of $101 million in 1983. The last year in which a profit was recorded was in 1981, when a profit of $165 million was posted after taxes. After-tax losses in 1985 were significantly larger than in previous years. This was primarily attributed to firms depreciating capital equipment and facilities valued at approximately $296 million, 5/ compared with $41 million in 1984.

Adjustment to competitive pressures.--The Canadian industry is facing competitive pressure in its domestic markets to reduce capacity in order to boost profit margins. Emphasis is also being placed on the efficient, low-cost transfer of feedstocks between the western Canadian producers and central/eastern Canadian petrochemical firms.

For Canadian petrochemicals to be competitive at the U.S. gulf coast, the ethylene cost advantage in Alberta must be emphasized to offset transportation costs. Producers in central Canada, in an effort to maintain low-cost feedstocks, are considering the "swapping" of Canadian natural gas for surplus U.S. LPG and NGL in the Great Lakes and Northern Tier States. 6/ Another adjustment to competitive pressures is the initiation of negotiations for free-trade between Canada and the United States. Enactment of free-trade legislation would be expected to give the chemical industry enough momentum to

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1/ Report of the Petrochemical Industry Task Force, February 1984, pp. 31-32.
2/ Ibid., p. 31.
3/ World Economic Outlook: A Survey by the Staff of the International Monetary Fund, International Monetary Fund, April 1986, p. 34.
4/ Based on data from companies' responses to a survey of the Canadian Chemical Producers Association; aggregate results are reported in The Canadian Petrochemical Fact Book, 1985 Update.
5/ The Canadian Petrochemical Fact Book, The Canadian Chemical Producers' Association, 1985 update.
6/ "Investment Opportunities in Central Canada's Petrochemical Industry," Chemical Engineering Progress, March 1986, p. 11.

remain competitive in international markets. 1/ Other firms in the chemical industry have been decreasing their commitment to commodity chemicals in order to reduce the capital intensiveness of their product lines. 2/

Structural changes include the eight new production units that were brought onstream during 1976-83, with a total capacity of 5.5 billion pounds of primary petrochemicals. These plants were constructed to replace older units that had been closed. During 1976-83, 27 such older units were closed, representing approximately 12 percent of total Canadian capacity, or about 2.8 billion pounds. As of February 1984, four plants with a combined capacity of 2.2 billion pounds that were shut down "temporarily" remained closed. Recently, ethylene operations at a plant in Montreal were shut down, eliminating 120 million pounds of annual capacity. This capacity was replaced, however, with a 450-million-pound-per-year ethylene unit that is operated at 95 percent of capacity in 1986. 3/ As of February 1984, at least 60 percent of the Canadian petrochemical industry investment was less than 5 years old. 4/

4.3 Japan

Japan's proved reserves of crude petroleum were estimated at only 57 million barrels and 1 trillion cubic feet of natural gas, as of January 1, 1987.

Distinctive features.--The Japanese petrochemical industry came into existence in 1955 when crude petroleum was substituted for coal as the main raw material of the chemical industry. The change was motivated by a desire to produce petrochemical products domestically rather than be dependent on imports. With Japan's overall high economic growth, there was increased demand for petrochemical products such as plastics and synthetic fibers. Domestic supply was provided by the construction of petrochemical facilities concentrated along the southern coastal areas of the island of Honshu. 5/

In Japan, the product emphasis of the crude petroleum refining industry has been on heating oils, with gasoline a secondary product. The reverse has been true in the United States. As a result, naphtha (a byproduct of the production of heating oils) has been readily available for chemical use in Japan and the olefin segment of the Japanese petrochemical industry developed using naphtha as an olefin feedstock.

1/ Ibid.
2/ "Canada's Chemical Producers Wait For A Thaw," Chemical Week, Apr. 16, 1986, p. 19.
3/ "Getting on With the Job of Running Petromont," Chemical Week, Nov. 26, 1986, p. 21.
4/ Report of the Petrochemical Industry Task Force, February 1984, p. 7.
5/ Interim Report of the Japanese Chemical Industry Sectional Meeting of the Industrial Structure Council, "The Petrochemical Industry and What Its Policies Should Be During the 1980's," Dec. 2, 1981, p. 4.

Industry structure.--In the 1950's, plastics and synthetic fibers quickly penetrated world markets. In Japan, each of the major industrial groups entered the market, sometimes with their long-established chemical producer (Sumitomo) and sometimes with a newly organized venture (Mitsui Petrochemical). 1/

In the 1980's the Government, through the Ministry of International Trade and Industry (MITI), established the Council for Petroleum Industry Cooperation (Council) and a plant construction approval standard to control investment, e.g., crackers for ethylene had to be larger than 100,000 tons per year. One direct consequence of this ruling was the "combinato," a complex in which several companies producing derivatives located in one area to take the output of a single cracker.

After 1973, the petrochemical industry entered a long period of recession. Following plans made earlier, Showa Denko and Ukishima Petrochemical brought new 300,000-ton ethylene crackers online. It was at this time that the companies first came under pressure as demand stagnated, imports increased, and naphtha prices strengthened. The second petroleum crisis in 1979 only heightened the problem as exports which had peaked at 20 percent of production in 1977 dropped to 12 percent in 1979, and imports rose from 0.7 percent to 4.3 percent of production. 2/ In this situation, Japan found itself with 13 major producers of ethylene and derivatives at 18 major petrochemical complexes.

Production growth was lower in the Japanese chemical industry in 1985 than for Japanese manufacturing industries as a whole. Output of basic petrochemicals grew 0.4 percent between 1984 and 1985. 3/ The new sources of petrochemical feedstock supply--the nations that have the natural resources--are the reasons for continued slow growth and overcapacity in the Japanese petrochemical industry. Other obstacles to entry include fuel and feedstock costs.

Domestic market.--During 1981-85, production of the six major primary petrochemicals increased from 23.5 billion pounds to 27.7 billion pounds, an average annual increase of 4.2 percent. Apparent consumption of primary petrochemicals in Japan during 1981-84 increased from 23.0 billion pounds to 27.2 billion pounds, an average annual increase of 5.7 percent. In 1985, consumption was 26.9 billion pounds, a 1.1-percent decrease from the 1984 level. During 1981-85, ethylene and propylene accounted for about 60 percent of the consumption of these six primary petrochemicals. Benzene's share of overall consumption was 17 percent during this period. Toluene and the mixed xylenes combined averaged 18 percent of total consumption for the six primary petrochemicals, and 1,3-butadiene's share was over 5 percent of consumption.

1/ Harvard Business School Press, "When Markets Quake," by Joseph L. Bower, p. 16.
2/ Ibid, p. 193.
3/ "Foreign Chemical Industries-Japan," Chemical & Engineering News, June 9, 1986, p. 77.

Once it was recognized that the Japanese petrochemical industry of the 1980's would have to dispose of excess capacity and eliminate excessive internal competition if it was to regain its health, the MITI acted to put these goals into practice. As a result, the Temporary Measures Law was drafted--with due consideration given to the requirements of the Anti-Monopoly Law. The heart of the Temporary Measures Law was a provision for the coordinated scrapping of surplus capacity. This provision was designed to help eliminate cutthroat competition. 1/

Japanese imports of the six primary petrochemicals totaled 357 million pounds in 1985. During 1981-85, total imports of the six primary petrochemicals ranged from a low of 272 million pounds in 1982 to a high of 459 million pounds in 1981. During this period, the imports-to-consumption ratio of Japan's six primary petrochemicals, decreased from 2.0 percent in 1981 to 1.3 percent in 1985. The average for the 5-year period was 1.5 percent. 2/

On a product-by-product basis, the average imports-to-consumption ratio during 1981-85 was as shown in the following tabulation (in percent):

Product	Ratio of imports to consumption
Ethylene.............	0.1
Propylene............	.7
1,3-butadiene........	9.0
Benzene..............	2.0
Toluene..............	1.3
Xylenes..............	2.8

The Japanese 1,3-butadiene market had the largest import penetration of the six primary petrochemicals for the period covered, 13.3 percent in 1981 and a low of 6.9 percent in 1982.

Export markets.--Japanese exports of the six primary petrochemicals in 1985 accounted for 4.1 percent of Japanese production of these products. The 5-year average of exports as a percent of production for this period was 3.2 percent. Average Japanese exports as a percent of production on a product- by-product basis during 1981-85 was as shown in the following tabulation (in percent):

1/ ECMRA/CMRA Conference, Venice, Italy, Oct. 17-18, 1983, "Restructuring the Japanese Petrochemical Industry, The Japanese Plan," p. 4.
2/ Data derived from Selected Petrochemical Statistics, Japan Petrochemical Association, October 1986, pp. 5, 7.

Primary products	Ratio of exports to production
Ethylene..............	0.3
Propylene.............	1.1
1,3-Butadiene.........	1.3
Benzene...............	7.7
Toluene...............	12.5
Xylenes...............	4.4

Japanese exports of the six primary petrochemicals totaled 1.1 billion pounds in 1985. The leading markets for these exports were other Asian nations, Western Europe, and the United States. According to data reported to the United Nations by Japan, Japanese exports of basic and intermediate organic chemicals were as follows in 1980 and 1985 (in billions of dollars):

Market	Exports in: 1980	1985
United States........	0.5	1.1
Western Europe.......	0.8	0.9
Rest of the world....	4.7	4.6
Total...........	6.0	6.6

Factors of competition.--As a country heavily dependent on imported oil, Japan benefited from the sharp drop in world crude petroleum prices in 1986. For basic petrochemical companies, which use both domestic and imported naphtha as their primary feedstock, lower crude petroleum prices translated into lower feedstock costs. 1/ In addition, the yen became much stronger compared with the U.S. dollar. The stronger yen makes dollar-denominated petroleum imports even less expensive.

Japan is increasingly challenging the United States in high technology areas. Advanced polymers (which are petrochemicals) is one area targeted for development by Japan's MITI under the general theme of "R&D Projects on Basic Technology for Future Industries." Since the early 1980's, Japan's Government and chemical industry leaders have forged a national strategy aimed at gaining world leadership in advanced materials in the 1990's. The strategy includes developing the necessary scientific and technological base, committing the required resources for a 10-year period, and striving to change educational and cultural practices that have hindered the growth of original and creative research. 2/ An assessment of Japan's R&D in high-priority, high-technology fields was produced by a panel of six chemists convened to evaluate Japanese work on advanced materials. The panel's report is one of a series produced by

1/ Earl Anderson, "Japanese Petrochemicals Face Tough Year," Chemical & Engineering News, May 19, 1986, p. 26.
2/ "Japan Aims for World Leadership in Advanced Polymers by 1990's," Chemical & Engineering News, Nov. 17, 1986, p. 35.

the Japanese Technology Evaluation Program (JTECH). The panel selected the following five key polymer areas, all of which involve the use of basic petrochemicals, for detailed examination:

High-strength/high-modulus polymers.
Engineering plastics and matrices.
Polymers for electronic applications.
Gas and liquid membrane separation technology.
Biopolymers.

In the area of high-strength/high-modulus polymers--aramids, polyimides, liquid crystalline polyesters, and ultrahigh-molecular-weight polyethylene--the Japanese have gained a strong foothold through joint ventures and innovative research. Although the Japanese are still behind the United States in basic R&D and product implementation, they are gaining ground and could pull even in the near future (1 to 10 years). Therefore, U.S. industry can expect strong competition for market share and a squeeze on profits. 1/

Japanese basic research on engineering resins and matrices for composites is currently behind that of the United States. However, two major programs under way since 1981 are accelerating research and could threaten the U.S. technology lead by the early 1990's. 2/

The Japanese are reportedly already even with the United States in advanced development of engineering resins, and make a broad spectrum of sophisticated products. If MITI programs are successful, Japanese firms may come to dominate the market in this area. The world market for polymeric materials for electronic applications is expected to grow from a few billion dollars currently to more than $10 billion a year. The United States is currently on an equal footing with Japan in basic research and is keeping pace. But the massive efforts Japanese industry is putting into R&D on packaging and encapsulant materials are expected to put them ahead in advanced development and product engineering. 3/

The United States and Japan are reportedly now even in key aspects of basic membrane research. Japan is behind the United States in most areas of biopolymer R&D, including artificial organs, biomaterials, controlled release, and targeted delivery.

Even though Japanese firms underwent financial difficulties in the 1970's and 1980's, they still built new, well-equipped R&D centers, and made major increases in R&D. Since the early 1980's, their government and industrial leaders have pursued a strategy of making Japan the world leader in advanced polymers by the 1990's and positioning it to lead in high-technology business

1/ Ibid.
2/ Ibid.
3/ Ibid.

areas that depend on advanced materials. This goal is considered vital to Japan's future economy, since the country has few raw-material resources. 1/

The chemical industry in Japan has several advantages in competing with the United States. Automation in the Japanese chemical industry has increased Japanese productivity per employee. Another advantage is the pattern of exploiting new opportunities through decentralization--splitting off affiliates and subsidiaries. Each such unit maintains its own R&D. Local management has the autonomy to make key decisions and commit resources, and can tailor the unit for maximum competitiveness in its product line. In the United States, management in recent years has been relying more on acquisitions and mergers and less on R&D to achieve growth. Most major U.S. firms still try to handle new ventures within their existing structure. 2/

A particular advantage for Japan is its Government's role as supporter of R&D and shaper of science policy in cooperation with industry.

Financial Performance.-- During 1985, three of Japan's largest petrochemical producers had the following sales and net earnings. 3/

Company	Sales	Net Earnings	Change from 1984 in: Sales	Change from 1984 in: Net Earnings
	---$ Million---		---Percent---	
Asahi Chemical	4,300	84.7	1.1	8.9
Mitsubishi Petrochemical	2,059	25.4	-4.8	-56.7
Mitsui Petrochemical	1,686	40.2	0.6	5.7

The substitution demand for petrochemical products in Japan is virtually saturated and is unlikely to outstrip GNP growth. Therefore, the Japanese petrochemical industry is likely to follow the country's car and electrical appliance sectors in investing overseas, including spending on specialty plastics, alloys and compounds, and on other high-value products. 4/

Capital investments in the chemical industry decreased from fiscal year 1975 to fiscal year 1978 and then began increasing in fiscal year 1979. 5/ By

1/ Ibid, p. 37, 38.
2/ Ibid, p. 38.
3/ "Japanese Specialty Chemicals: The Coming Wave," Chemical Week, July 9, 1986, p. 30.
4/ "Japanese Industry Looks Abroad For Investment," European Chemical News, Oct. 6, 1986, p. 30.
5/ The fiscal year 1979 began on Apr. 1, 1979, and ended on Mar. 31, 1980. Same time frame for all other fiscal years.

fiscal year 1985, capital investment in the entire Japanese chemical industry was about $8.0 billion. This represented a 12.2-percent increase over fiscal year 1984. In fiscal year 1986, investment in R&D in the fields of new materials and biotechnology continued to be brisk, amounting to approximately to $7.6 billion. 1/

Adjustments to competitive pressures.--Japanese petrochemical producers have undertaken severe capacity cuts in recent years in order to allow operating rates of their ethylene crackers to increase and to make way for imports of less expensive products from joint-venture projects in the Middle East (Eastern Petrochemical Co. and Saudi Methanol Co.). Exports to Japan from Saudi Arabia include ethylene glycol; ethylene dichloride (EDC); styrene monomer; linear, low-density polyethylene (LLDPE); and methanol. 2/

A rationalization program strictly enforced by MITI ensures that Japan is able to accommodate new levels of imports and to take advantage of their lower cost. MITI formed a cartel among the country's 11 ethylene producers, and these domestic companies have had to adjust output accordingly. From 1982 to 1986, these petrochemical producers cut ethylene capacity from 14.0 billion pounds to 9.6 billion pounds--a 31-percent decrease in capacity. Not surprisingly, capacity expansion of basic petrochemicals production is currently ruled out by MITI.

As noted earlier in the study, Japanese petrochemical producers are compensating for a stagnant commodities business by moving into new areas. Many are moving into higher value-added products such as specialty plastics, advanced ceramics, semiconductor materials, specialty metals, performance polymers, and biochemicals. 3/ Moving into higher value-added products is a long-term strategy requiring long-range basic research.

4.4 Saudi Arabia

Saudi Arabia is a nation with estimated proved reserves of 166.6 billion barrels of crude petroleum and 124 trillion cubic feet of natural gas, as of January 1, 1987. 4/ In 1986, Saudi Arabia produced about 4.7 million barrels of crude petroleum per day.

Distinctive features.--The Saudi Arabia Basic Industries Corp. (Sabic) is a quasi-State-owned corporation responsible for the development of capital-intensive industries (except petroleum). 5/ Saudi Arabia embarked on its petrochemical program in the mid-1970's in order to provide for the well-being

1/ "1985/1986 Annual Report," Chemical Industry in Japan, by Japan Chemical Industry Association, p. 23.
2/ "Japan Makes Room For Saudi Imports," European Chemical News, March 1986, p. 62.
3/ Ibid.
4/ "Worldwide Report," Oil & Gas Journal, Dec. 22/29, 1986, p. 36.
5/ Petromin is responsible for the development of crude petroleum reserves as well as the refining industry.

of its citizens. Industrialization was necessary to lessen the nation's dependence on crude petroleum exports as a source of revenue. Sabic's emphasis was on the development of a world-scale petrochemical industry based on natural gas which, up until then, had been flared. Saudi Arabia sought joint ventures with the world's leading crude petroleum and chemical companies so as to have access to their expertise and marketing channels.

The development of a petrochemical industry was also intended to provide opportunities for private sector investment in secondary and support industries that would not be under Government control as is the petroleum industry. The petrochemical ventures also provided for the creation of a skilled domestic labor force and for reducing the need for expatriate labor. However, now that the petrochemical industry is in place, Saudi objectives have turned toward the consolidation of production and privatisation of the industry. 1/

Industry structure.--Petrokemya is the only wholly owned Saudi petrochemical plant. This project had originally been a joint venture between Sabic and a major U.S. chemical company, however, the U.S. chemical company withdrew from the venture in 1982. The project, a 500,000-metric-ton-per-year ethylene plant, was continued by Sabic and completed in mid-1985. Even with the success of Petrokemya, Saudi officials plan to continue utilizing the joint-venture method in order to combine the technogical and marketing expertise of the overseas partners with Saudi Arabia's financial, raw material, and infrastructural resources. 2/

By the end of 1985, there were seven petrochemical companies with plants onstream in Saudi Arabia. Of these, six were joint ventures; three were joint ventures with U.S. crude petroleum or chemical companies, two with a Japanese company, and one with a Dutch/British petroleum company. The following tabulation shows the Saudi petrochemical companies producing ethylene and its derivatives onstream as of 1985: 3/

1/ "Uncertain Future Facing Saudi Petrochemicals," Manufacturing Chemist, February 1986, p. 19.
2/ Ibid.
3/ Ibid., other Saudi Arabian chemical projects not involving any of the six major building-block petrochemicals include production of methanol, ammonia, urea, melamine, and caustic soda.

Company	Location	Product	Capacity 1,000 metric tons per year
Saudi Petrochemical Co..... (Sadaf)	Al-Jubail	Ethylene	656
		Ethylene dichloride	454
		Styrene	295
		Ethanol	281
Arabian Petrochemical Co... (Petrokemya)	Al-Jubail	Ethylene	500
Al-Jubail Petrochemical Co. (Kemya).	Al-Jubail	LLDPE	260
Eastern Petrochemical Co... (Sharq)	Al-Jubail	LLDPE	130
Saudi Methanol Co.......... (Ar Razi)	Al-Jubail	Methanol	600
National Methanol Co....... (Ibn Sina)	Al-Jubail	Methanol	700
Saudi Yanbu Petrochemical Co. (Yanpet).	Yanbu	Ethylene	455
		Ethylene glycol	220
		LLDPE	210
		HDPE	90

The Saudi Industrial Development Fund (SIDF) is a Government agency established in 1974 in order to encourage foreign companies to participate in the Saudi development plan. Sixty percent of the funding for Sabic's petrochemical plants is derived from SIDF's low-interest, 16-year loans. Other incentives include a 10-year tax holiday for foreign joint-venture partners. 1/

Joint venture partners also enjoy a cost advantage in terms of natural gas feedstock. In exchange, the foreign partners agreed to market that portion of the production designated for export and to train Saudi workers to staff the petrochemical plants.

As stated previously, Saudi Arabia continues to seek foreign investment in its basic industries such as petrochemicals. About $12 billion has been invested in 7 world-scale petrochemical plants. 2/ U.S. companies have invested in Saudi petrochemicals with costs totaling $6 billion to $8 billion. 3/

All of the ethylene produced in the Saudi plants is consumed captively in the production of downstream products. The ethylene produced at the Yanpet

1/ "Saudi Petrochemicals Come Out Fighting," MEED, Nov. 23, 1985, p. 2.
2/ Ibid., p. 1.
3/ "Major Projects in the Middle East," European Chemical News, The Middle East and Southeast Asia Supplement, March 1986, pp. 50-52.

and Sadaf plants is sent to adjacent plants to produce ethylene dichloride, ethanol, polyethylene, and ethylene glycol. Petrokemya's ethylene production is used at Sharq to produce LLDPE.

Sabic's joint-venture agreements include provisions for marketing most of the quantities produced from its world-scale petrochemical plants. Eventually, Sabic will be responsible for marketing more of these products but no definite timetable was written into the joint-venture agreements. Sabic has established two wholly owned affiliates to market petrochemical sales worldwide.

Domestic market.--Saudi Arabia is a newly industrializing nation and domestic demand is estimated to absorb about 20 percent of their basic petrochemical production. Domestic demand for these petrochemicals is expected to be increasing at a rate upwards of 12 percent per year in the near future as consumer demand for plastics and other downstream products of basic petrochemicals increases. 1/

The Saudi Government generally does not emphasize the use of import restrictions or tariffs on petrochemicals. Instead, the Kingdom encourages the development of a strong domestic private sector. According to Sabic, the Kingdom imports plastics, both the raw materials and finished products, and about 75 percent of these imports are duty free, or face only a 4-to-7-percent duty. 2/

Saudi Arabia imports plastics that are not produced locally. The major sources of Saudi's imports are the United States, Japan, and Western Europe. In 1985, Saudi Arabia imported plastics and polymers valued at approximately $286 million, all of which entered the Kingdom duty free. 3/ The United States accounted for approximately 18 to 25 percent of these imports, 4/ Japan accounted for about 18 to 20 percent, and Western Europe accounted for about 20 to 25 percent. 5/

Saudi Arabia has a positive balance of trade, primarily as a result of its exports of crude petroleum. Petrochemical exports are a very significant factor in the Saudi economy.

Export markets.--During the second half of 1985, Saudi Arabia began to bring additional petrochemical plants onstream. The Kingdom's entrance into the world petrochemical market has been fraught with opposition from the traditional petrochemical producers, primarily the European Commission (EC). Approximately 50 percent of Saudi's petrochemical exports are slated for Japan

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1/ "Annual Petrochemical Issue," Oil & Gas Journal, Mar. 25, 1985, p. 76.
2/ "Saudi Petrochemicals Come Out Fighting," MEED, Nov. 23, 1985, p. 1.
3/ Ibid.
4/ During the first three quarters of 1986, Saudi Arabia's imports of butadiene from the United States were valued at $20.5 million.
5/ See the "Western Europe" section of this report for more details on Saudi-EC trade.

and the other Pacific Rim nations; the other 50 percent is slated for the EC and the United States. 1/

Europe is the main market for Saudi exports of polyethylene, accounting for up to 200,000 metric tons per year. Crude industrial ethanol 2/ is being exported from the multiproduct Sadaf complex to the United States for purification through an agreement with the joint venture's U.S. affiliate. Styrene is being shipped from Sadaf to Japan. Caustic soda has found markets in Australia and benzene in the Far East. 3/ About 50 percent of the methanol from Ar Razi is going to Japan while methanol from Ibn Sina is being exported to the United States, Europe and the Far East. 4/

Regional sales offices have been set up in Riyadh, London, New York, and Hong Kong, which together account for 20 percent of total petrochemical sales. The joint-venture partners market the remaining 80 percent of sales; however, Sabic hopes to eventually market 50 percent of the total. Europe was the primary market for Saudi exports in 1985-86; however, they faced problems with European tariffs and quotas and lost their GSP status.

Sabic's production and marketing philosophy is to operate its plants at maximium output and sell its products worldwide in markets giving the best netback possible. Sabic is seeking to diversify its markets and lessen its dependence on the major world consumers. Regional markets around Saudi Arabia are considered to be high-growth areas. Africa, a traditional market of European producers, is expected to be a growing market for Saudi petrochemical exports.

Factors of competition.--Saudi Arabia's petrochemical industry is based on natural gas that is produced in association with crude petroleum and was formerly flared as a waste product. Sabic has stated that the price of natural-resource-based feedstock is set by the Saudi Arabian Government. 5/ According to Sabic, the projected market distribution for petrochemicals produced in Saudi facilities is intended to be 10 percent for the Saudi domestic market, 20 percent for the United States, 22 percent for Europe, 20 percent for Japan, and 28 percent for the rest of the world. 6/

The practice of setting internal natural resource prices by Petromin began, to a limited degree, with its creation in 1962 and continued expanding until Petromin assumed full control during the 1970's. 7/ Petromin is reported to be viewed as a profitmaking company in the course of negotiations with potential buyers for its natural gas feedstock. Petromin apparently

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1/ "Saudi Petrochemicals Come Out Fighting," MEED, Nov. 23, 1985, p. 3.
2/ Saudi Basic Industries Corporation, Information pamphlet published by SABIC Publications Department, 1986.
3/ "Uncertain Future Facing Saudi Petrochemicals," Manufacturing Chemist, February 1986, p. 19.
4/ Ibid.
5/ "The Saudi's Are Coming!," CPI Purchasing, March 1985, pp. 46-48.
6/ Mr. Abdulaziz al-Zamil, Middle East Economic Survey, Feb. 8, 1982, p. 4.
7/ Ibid.

prices its natural gas or petroleum-based feedstock at levels deemed necessary to recoup its own costs for (1) the process of preparation or, for the associated natural gas, separation from the crude petroleum and processing, and (2) the amortized costs of the Saudi Master Gas System. 1/ There does not appear to be any obligation assumed by the purchaser of the feedstock (natural-resource-based) materials to price their downstream products at less than world levels.

It is primarily this low price for natural-gas and natural-gas-based feedstocks that has led to the large expansion in facilities to produce petrochemicals made from the olefins, products of the natural-gas-based feedstocks. Few secondary petrochemical facilities use aromatic-based feedstocks such as benzene, toluene, and the xylenes. It is possible that as Saudi Arabia expands its refining capacity, more aromatic-based feedstocks for petrochemical conversion will become available. This could mean additional capacity to produce a whole range of petrochemicals based on benzene, toluene, and xylene.

An important area in which Sabic has been successful is in its move toward "Saudi-isation" 2/ of its workforce. An average of 47 percent or 8,000 workers in the petrochemical industry are Saudi citizens; the technical, maintainence, and operational staff of the plants are 80 percent Saudis. 3/ The training of Saudi workers sent to the United States for periods of 18 to 20 months has been costly.

At the Sadaf plant, the cost per worker to train the Saudis was about $150,000. 4/ The trainees are committed to work for the company for at least as long as their training period. The following tabulation shows the approximate staffing at certain plants: 5/

Plant	Total employees	Saudi employees
Sadaf	1,500	600
Sharq	400	300
Ibn Sina	200	130
Kemya	375	300
Ar-Razi	240	175
Petrokemya	400	240

1/ Based on conversations with U.S. and other nations' industry representatives.
2/ "Saudi Petrochemicals Come Out Fighting," MEED, Nov. 23, 1985, p. 3.
3/ Ibid.
4/ Ibid.
5/ Ibid., p. 4.

Between 1970 and 1985, Saudi Arabia invested almost $268 billion in its petrochemical industry. Of this, about $125 billion was spent on the development of the infrastructure needed by the petrochemical industry. Government investment in infrastructure, through loans, totaled over $58 billion in 15 years, of which loans to Sabic and Petromin were $13.1 billion. 1/ As a result, Saudi Arabia has a well-developed, technologically advanced infrastructure to transport petrochemicals between plants and to ports for export.

Saudi Arabia's petrochemical industry expansion plans are hinged upon revenues generated by the export of crude petroleum. Despite several years of declining crude petroleum export revenues, Saudi's petrochemical industry is still a growing factor in the world petrochemical market. The 1986 petroleum price plummet has reinforced the viability of the move away from dependence on crude petroleum exports for revenue to the development of downstream production.

Financial performance.--Expenditures of $12 billion and the involvement of the world's leading crude petroleum and chemical companies in joint ventures with Sabic have resulted in the completion of plants with an annual capacity of more than 5 million metric tons per year. Sabic has $4 billion budgeted for expansion plans through 1990, as part of the fourth 5-year plan. Sabic's sales in 1986 are expected to reach $240 million as it builds up its marketing network. 2/ More than 70 percent of Saudi Arabia's petrochemical sales enter the export market. As a result, Sabic's profit level has risen. In 1985, profits were $40 million--4.2 times its 1984 profit and 7.3 times its 1983 profit. 3/

Adjustments to competitive pressures.--After recordbreaking building schedules employing innovative modular techniques with units shipped in from Japan and South Korea, the end of 1985 saw the effective completion of the first phase of the country's chemicals strategy. On opposite sides of the Kingdom, two vast new complexes have been created at Al-Jubail on the Persian Gulf and at Yanbu on the Red Sea with a full range of industrial and social facilities. Flanked by new ports, the cities house major petrochemical facilities including three crackers, three polyethylene plants, and two methanol units.

Now, with all of the key components in place, the emphasis is on finding the returns that the plants' low-cost economics were meant to ensure. As the world's major chemical producers build up their specialty chemical businesses, Sabic and its partners' investments have placed them in the commodity petrochemical area. Such an outcome was always implicit in the plan to use

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1/ "Saudi Petrochemicals Investing in Change," A speech given by Mr. Hisham Nazer, Saudi Arabian Minister of Planning, before the CMA Annual Conference, Oct. 22, 1985, p. 10.
2/ "Uncertain Future Facing Saudi Petrochemicals," Manufacturing Chemist, February 1986, p. 17.
3/ "Middle East Petrochemicals Flow to Western Europe Despite Tariffs," Oil & Gas Journal, June 23, 1986, p. 15.

natural gas to provide low-cost feedstock for units such as ethylene plants, at prices which would ensure a significant comparative advantage when compared with plants in Europe and North America.

4.5 Mexico

The Mexican petrochemical industry is based on an abundance of crude petroleum and natural gas feedstocks. Mexico has estimated proved reserves of 54.7 billion barrels of crude petroleum and 76.5 trillion cubic feet of natural gas, as of January 1, 1987. 1/ Crude petroleum production in 1986 averaged approximately 2.5 million barrels per day. 2/

Distinctive features.--Petroleos Mexicanos (Pemex) is the Mexican State-owned petroleum company formed in 1938 to maintain petroleum industry productivity after Mexico nationalized the industry and expropriated foreign investments. The ownership of Mexico's petrochemical industry is divided between Pemex and private companies; however, by law, only Pemex can produce olefins and aromatics. In the past, only Pemex could produce first-order derivatives such as polypropylene, since these products were defined as "basic" or primary petrochemicals, and private companies produced the next levels of downstream derivatives. However, in October 1986, the Mexican Government issued a resolution that redefined primary and secondary petrochemicals. The new redefined list allows the secondary petrochemical industry to produce several products which had previously been reserved for Pemex, among the more important of which is polypropylene. 3/ The Government has also made it possible for secondary petrochemical producers to import raw material requirements directly.

Industry structure.--Under Mexico's new Petrochemical Development Plan (PDP), 36 petrochemical products were reclassified from "basic" to "secondary petrochemicals." The principal objectives of the PDP are as follows:

(1) To develop an integrated petrochemical industry with permanent access to selected products markets abroad and to supply the domestic market at competitive prices;

(2) to make efficient use of petrochemicals, energy, and scarce resources;

(3) to reduce the sector's trade deficit in the short term and establish foundations to make the petrochemical industry a net foreign exchange earner;

1/ "Worldwide Report," Oil & Gas Journal, Dec. 22/29, 1986, p. 37.
2/ Ibid.
3/ "Optimism Returns to Mexico's Petrochemical Industry," Chemical & Engineering News, Nov. 17, 1986, p. 14.

(4) to strengthen the technological structure of the industry; and

(5) to promote geographic deconcentration and regional development. 1/

As stated previously, by law, only Pemex can produce basic petrochemicals and some first-order derivatives including polyethylene. The following tabulation shows the 34 petrochemicals still classified as "basic" petrochemicals: 2/

Basic petrochemicals	
Acetaldehyde	Hexane
Acetonitrile	Isopropanol
Acrylonitrile	Methanol
Alpha-olefins	Methyl-tertbutyl-ether
Ammonia	n-Paraffins
Benzene	Olefins
Butadiene	Ortho-xylene
Carbon black feedstock	Para-xylene
Cumene	Pentane
Cyclohexane	High-density polyethylene
Dichloroethane	Low-density polyethylene
Dodecyl benzene	Propylene
Ethanol	Propylene tetramer
Ethyl benzene	Styrene
Ethylene	Toluene
Ethylene oxide	Vinyl chloride
Heptane	Xylene

The PDP also calls for a strengthening of Pemex's basic petrochemical investment program. Pemex is supposed to satisfy domestic demand generated by the secondary petrochemical sector, but has not done so in recent years.

In an effort to reactivate investment from the private sector in the petrochemical industry, the following 36 petrochemicals were reclassified from "basic" to "secondary:" 3/

1/ Pemex Information Bulletin, No. 37, October 1986, p. 4.
2/ Ibid.
3/ Ibid.

Secondary petrochemicals

Acetic acid	Hydrocyanuric acid
Acetic anhydride	Isopropene
Acetylene	Lauryl alcohol
Acrolein	Methyl chloride
Acrylic acid	Methylene chloride
Aliphatic solvents	Naphthalene
Allyl alcohol	Nonane
Allyl chloride	Oxo-alcohols
Aromin 150	Polybutylene
n-Butanol	Polypropylene
Butyraldehyde	Propylene chlorohydrin
Carbon tetrachloride	Propylene dichloride
Chloroform	Propylene oxide
Chloroprene	Tetrachloroethane
Ethyl chloride	Trichloroethane
Ethyl hexanol	Trichloroethylene
Ethylene chlorohydrin	Vinyl acetate
Ethylene dibromide	Vinyl toluene

Foreign investment in the secondary petrochemical industry is encouraged, especially in light of the new PDP; foreign ownership is restricted to 40 percent with the other 60 percent being held by the Government. Foreign investment in the Mexican secondary petrochemical industry has accumulated at an average rate of about $700 million per year.

Domestic market.--The Mexican petrochemical industry produces more than 900 products under about 450 petrochemicals permits in a sector in which about 150 major companies participate. Mexico's petrochemical industry experienced production growth rates of about 27 percent per year from the early 1960's (through the late 1970's) when several units came onstream. 1/ However, with economic and financial problems coupled with plunging world crude petroleum prices during 1986, Mexico has been lacking the capital needed for petrochemical plant expansions. 2/

Demand for petrochemicals in Mexico has grown at an average annual rate of about 12 percent since the 1960's, reaching 13 million metric tons in 1985. 3/ Demand is forecasted to reach 30 million metric tons, growing at an

1/ Fernando Gutierrez Saldivar, "Competitiveness of the Mexican Chemical and Petrochemical Industry," as presented at the Second Annual Congress of the North American Continent, Las Vegas, Nevada, 1980, pp. 10-14.
2/ "Petrochemicals May Fare Better as Feed Costs Dip and Processes Are Improved," Oil & Gas Journal, Apr. 7, 1986, p. 48.
3/ Compiled from data derived from Petroleos Mexicanos, Memoria De Labores 1985.

average annual rate of 4 to 6 percent during the 1986-2000 period. 1/ It is estimated that during the next 15 years, investments of $500 million per year in the petrochemical industry would have to be made in order to meet domestic demand. 2/

On August 24, 1986, Mexico became a member of the General Agreement on Tariffs and Trade (GATT). Under the GATT, Mexico will eliminate, as much as possible, its import-licensing requirements and import quotas. Mexico also "bound" all of its import duties at a ceiling of 50 percent. In practice, Mexico applies tariff rates lower than the ceiling, with the highest duty rate currently applied being 45 percent. In an action not directly related to GATT, Mexico announced in April a tariff reform program that will result in a top duty of 30 percent by October 1988. 3/

Since 1985, import-licensing requirements for all basic petrochemicals have been eliminated and 97 percent of the secondary petrochemicals imported have been exempted from import licensing requirements. 4/ Previously, tariffs for basic petrochemicals (olefins and aromatics) averaged about 5 percent with only Pemex being allowed to import these products. However, under the new PDP, secondary petrochemical producers can import olefins and aromatics feedstocks directly. Tariffs for imports of secondary petrochemicals produced in Mexico range from 22.5 to 37 percent. These rates are being decreased in order to reach levels of 20 to 25 percent by October 1988. 5/

Mexico relies heavily on imports of basic petrochemicals to meet domestic demand. Although capacity is adequate, Pemex has not been able to produce enough basic petrochemicals from existing plants. During January-September 1986, Pemex produced only 62 percent of its planned output of xylenes and 88 percent for benzene. 6/ Although Mexico has the capacity to produce 17.4 million metric tons of petrochemicals per year, production was 10.9 million metric tons in 1984 and 11.4 million metric tons in 1985. 7/

Mexican imports of petrochemicals increased from 869,322 metric tons in 1984 to 1.2 million metric tons in 1985. 8/ Mexican petrochemical imports are estimated to be about 1 million metric tons in 1986. 9/ The United States is the principal supplier of petrochemicals to Mexico.

1/ "Mexico's Petrochemicals Industry in Crisis," European Chemical News, Apr. 21, 1986, p. 6.
2/ Ibid.
3/ "Mexico's Accession to the GATT Will Benefit U.S. Business and the World Trading System," Business America, Oct. 13, 1986, p. 10.
4/ Pemex Information Bulletin, No. 37, October 1986, p. 5.
5/ Ibid.
6/ "Mexico's Pemex Continues Building Petrochemical Plants," Chemical & Engineering News, Dec. 1, 1986, p. 16.
7/ Petroleos Mexicanos, Memoria Des Labores 1985, pp. 96 and 104.
8/ Ibid., p. 124.
9/ Pemex Information Bulletin, No. 37, October 1986, p. 6.

Historically, Mexico has had a negative chemical trade balance. The following tabulation shows Mexico's petrochemical trade balance in 1984 and 1985: 1/

Year	Imports	Exports	Trade balance
	Millions of dollars		
1984	441.7	128.5	-313.3
1985	571.5	76.2	-495.4

The United States is the major source of petrochemical imports to Mexico as well as the major market for Mexican exports, primarily as a result of the proximity of the two nations. Bilateral agreements exist between the United States and Mexico for the purchase of goods. For example, from August 1981 to August 1986, the U.S. Department of Energy (DOE), under a contract between the United States and Mexico, purchased 50,000 barrels per day of crude petroleum for the U.S. Strategic Petroleum Reserve (SPR). During September, October, and November 1986, DOE purchased 4 million barrels of crude petroleum. A new 1-year contract has been negotiated, which commenced on December 1, 1986, to purchase 65,000 barrels per day (plus or minus 10 percent) of Mexican Isthmus crude petroleum for the SPR. 2/

Export markets.--Mexico is not a major exporter of petrochemicals. Mexican exports of petrochemicals are shown in the following tabulation (in metric tons): 3/

Year	Petrochemical exports
1984	576,145
1985	339,526
1986 1/	273,750

1/ Estimated.

Mexico exports certain basic petrochemicals, primarily to the United States. The following tabulation shows Mexican exports of selected basic petrochemicals (in metric tons): 4/

1/ Petroleos Mexicanos, Memoria Des Labores 1985, pp. 121 and 124, and Pemex sources.
2/ Pemex Information Bulletin, No. 37, November 1986, p. 4.
3/ Petroleos Mexicanos, Memoria Des Labores 1985, p. 121, and Pemex Information Bulletin, No. 37, October 1986, p. 6.
4/ Petroleos Mexicanos, Memoria Des Labores 1985, p. 121.

Item	1984	1985
Ethylene...............	29,544.3	60,332.3
Benzene................	13,477.4	7,696.6
Toluene................	7,308.4	-

The major objective of the PDP is to use basic and secondary petrochemicals to produce higher valued finished products for the export market. Considering Mexico's lack of adequate production to satisfy domestic demand coupled with the nation's shortage of capital, it is unlikely that Mexico will invest in basic or secondary petrochemical plants to be fully devoted to the export market.

Factors of competition.--Since Pemex is the only entity in Mexico involved in all phases of crude petroleum and natural gas exploration, development, and production, petroleum refining, and the manufacture of many petrochemicals, it is difficult to ascertain domestic prices for natural gas and crude petroleum. These materials are usually transferred between different Government entities at unknown prices. In general, however, it is believed that these transfers occur at below world level prices, but not below the cost of production, which is estimated to be in the range of $3.00 to $6.50 per barrel. 1/

The Government of Mexico maintains a two-tier industrial pricing policy for petroleum products (including No. 6 fuel oil) and natural gas. These fuels are generally sold to domestic industrial consumers at a price below international market prices and are usually sold for export at international market prices. The National Industrial Development Plan (NIDP) states that fossil fuel prices have traditionally been lower than international prices in order to allow for the strengthening of industry by giving it "a substantial margin of production via input." 2/

In outlining guidelines for the future, the Mexican National Energy Program states that, for hydrocarbons, "domestic price levels will be maintained lower than those abroad, except in the case of imported products or of those containing a high proportion of imported inputs." 3/

1/ U.S. Department of State, Telegram No. 2047 from the American Embassy in Mexico, January 1985, p. 2.
2/ Mexico, Industrial Development Plan, 1979-1982-1990 (Abridged English Version), p. 30-34.
3/ Mexico, National Energy Program, 1984-1988, p. 95.

The following tabulation shows ranges of prices for heavy fuel oil (#6) and natural gas to Mexican industrial consumers during 1982-86: 1/

Year	Natural gas	Heavy fuel oil (#6)
	U.S. dollars per thousand cubic feet	U.S. dollars per gallon
1982 1/	0.45	0.038
1983 1/	1.06	.093
1984 2/	1.63	.140
1986 3/	1.68	.134

1/ As of Dec. 1, 1982, and 1983.
2/ As of Oct. 1, 1984.
3/ As of Nov. 1, 1986. October 1986 prices for natural were $1.70 per thousand cubic feet and $0.135 per gallon for heavy fuel oil (#6).

Petrochemical prices are targeted at 80 percent of the international prices in order to remain competitive. 2/ Prices for petroleum products and petrochemicals are uniform throughout Mexico and apply equally to all industrial consumers, whether the complaints are foreign, domestic, or joint ventures. 3/ However, it is believed that superimposed on these prices are discounts allowed to ventures that locate in certain areas of Mexico, which the Government wants to develop.

In late 1980, the World Bank approved a $150 million loan to Ferrocarriles Nacionales de Mexico, which operates 70 percent of Mexico's 20,200 kilometer rail system, to rehabilitate and expand Mexico's railroad network. Mexico's highway system consists of approximately 207,000 kilometers of roads, of which only about 30 percent are paved. Along with upgrading railways and highways, Mexico has planned port expansions. Mexico has a pipeline system totaling about 13,000 kilometers. Expansions have included a 1,344 kilometer line from the Reforma crude petroleum and natural gas fields in Chiapas to the industrial area in Monterrey. This project also included a line to McAllen, TX, to handle gas exports to the United States.

Mexico's petrochemical plants are world scale and based on process technologies used internationally. Mexico's problems in producing adequate supplies of petrochemicals are not technological but financial. Lack of capital has led to Pemex giving priority to the production of gasoline, which can be exported, as opposed to the production of basic petrochemicals.

1/ Data for 1982, 1983, and 1984, were derived from the U.S. International Trade Commission, Potential Effects of Foreign Governments' Policies of Pricing Natural Resources, USITC Publication No. 1696, May 1985, p. 31. Data for 1986, derived from Pemex Information Bulletin, No. 37, November 1986, p. 2.
2/ U.S. Department of State, Incoming Telegram, ITC-01, January 1985, p. 1.
3/ Ibid.

In spite of relatively high economic growth, 1985 was a difficult year for the Mexican economy. Inflation was almost 64 percent and the budget deficit equaled 9.5-10 percent of GDP. Both greatly exceeded original targets and 1984 levels. The Government's demand for credit rose sharply, causing a marked increase in domestic interest rates and lower credit flows to the private sector from the domestic banking system. Minimum wages fell in real terms for the fourth consecutive year.

Real growth in the Mexican economy at 4 to 5 percent followed a level of 3.7 percent in 1984 and negative growth rates in 1982 and 1983 of 0.5 percent and 5.3 percent, respectively. This growth was spread over most sectors of the economy including manufacturing, agriculture, and commerce.

Financial performance.--The Mexican economy's high inflation and exchange-rate problems have had an impact on the financial position of Pemex. In 1985, Pemex's external debt was $15.8 billion dollars. The following tabulation shows Pemex's financial position in 1985 and an estimate for 1986 (in billions of dollars): 1/

Source	1985	1986 1/
Assets:		
Current	6.0	3.3
Fixed	30.6	27.2
Total	36.6	30.5
Liabilities:		
Current	2.4	2.7
Long-term	15.3	14.2
Total	17.7	16.9
Equity	18.9	13.6

1/ Estimated

Note.--The Mexican exchange rate was 371.70 pesos per 1 U.S. dollar in 1985.

In late 1986, Mexico requested a standby agreement with the International Monetary Fund (IMF). In August 1986, Mexico received a bridge loan for $1.6 billion, of which $1.1 billion was provided by European and Latin American Central Banks and the U.S. Treasury; $500 million was provided by 54 commercial banks. 2/ In September, Mexico's creditors accepted a rescheduling of medium-term credits with maturities between September 1986 and March 1988, including 60 percent of the interest due from the first of such dates to the end of 1987, and with a new amortization schedule beginning in January 1992 and ending in July 1996.

1/ Pemex Information Bulletin, No. 37, October 1986, pp. 6 and 7.
2/ Ibid.

Adjustments to competitive pressures.--Pemex will spend an estimated $2.5 billion during the next 6 years to add new capacity to its petrochemicals industry (in thousands of metric tons per year): 1/

Location/product	Planned expansions Capacity	Completion date
Morelos:		
Ethylene	500	1988
Propylene	350	1988
Ethylene oxide	200	1988
Polypropylene	100	1989
Butadiene	100	1988-91
Acrylonitrile	50	1988-91
Isopropanol	75	1988-91
High-density polyethylene	100	1988
Low-density polyethylene	80	1990
Acetaldehyde	150	1989
Pajaritos:		
Vinyl chloride	200-300	1/
Salina Cruz:		
Benzene	275	1/
Toluene	120	1/
o-Xylene	30	1/
p-Xylene	200	1/
Heavy aromatics	29	1/
San Martin Texmelucan:		
Acrylonitrile	50	1987
Ciudad Madero:		
Cumene	20	1/
MTBE	30	1/
Salamanca:		
Olefins	50	1991
Linear paraffins	60	1991
Tula:		
Olefins	50	1991
Linear paraffins	60	1991
Lazaro Cardenas:		
Ammonia	445	1989
Camargo:		
Ammonia	445	1990

1/ In planning stage.

1/ "Mexico's Pemex Continues Building Petrochemical Plants," Chemical & Engineering News, Dec. 1, 1986, p. 16.

If Pemex is able to obtain the necessary funds needed to fulfill its current petrochemical investment plans and complete the projects on schedule, the company will make a big dent in Mexico's petrochemical import bill. It also will be able to provide the secondary petrochemical industry with the raw materials needed to become serious exporters.

4.6 Other Latin American nations

Like Mexico, other Latin American nations possessing hydrocarbon reserves have built or are building petrochemical industries. Estimated proved reserves of crude petroleum and natural gas as of January 1, 1987, for Latin America are as follows: 1/ 2/

	Crude Petroleum (million barrels)	Natural Gas (million cubic feet)
Argentina.................	2,270	23,000
Bolivia..................	149	4,840
Brazil...................	2,250	3,200
Chile....................	290	4,200
Colombia.................	1,290	4,000
Puerto Rico..............	0	0
Venezuela................	25,000	59,000

However, the 1986 plunge in crude petroleum prices is expected to result in delayed petrochemical industry expansions.

Distinctive features.--Although Argentina and Venezuela (a member of Organization of Exporting Countries (OPEC)) possess the largest reserves of natural gas, only Brazil has increased its capacity to produce ethylene during 1982-86, as shown in the following tabulation (in 1,000 metric tons): 3/

	Ethylene Capacity				
	1982	1983	1984	1985	1986
Argentina.............	253	253	253	253	253
Bolivia...............	230	230	230	230	230
Brazil................	1,242	1,347	1,407	1,427	1,428
Chile.................	60	60	60	60	60
Colombia..............	115	115	115	115	115
Puerto Rico...........	413	413	413	413	413
Venezuela.............	150	150	150	150	150
Total.............	2,463	2,568	2,628	2,648	2,649

1/ Mexico is discussed separately in this report, and, therefore, not included here.
2/ "Worldwide Report," Oil & Gas Journal, Dec. 22-29, 1986, p. 36.
3/ "Ethylene Report," Oil & Gas Journal, Sept. 3, 1984, p. 59, and Sept. 1, 1986, p. 40.

Industry structure.--Brazil's petrochemical industry began in the mid-1950's. However, large-scale projects did not come onstream until 1972 with the inauguration of the First Petrochemical Pole in Sao Paulo. The Second Petrochemical Pole in Bahia came onstream in 1978 and the Third Petrochemical Pole in Rio Grande do Sul began production in 1982. These petrochemical poles were created to foster the development of second generation petrochemical projects. The Brazilian Government controls petrochemical feedstocks through the State-owned and -operated petroleum company, Petrobras.

The second generation projects were based on a tripartite development model that provided that the Brazilian Government would not be less than that of a foreign stockholder. Petroquisa, a subsidiary of Petrobras, manages the Government interest. Although foreign investment is encouraged, joint ventures require a minimum of 51-percent Brazilian equity (Government and private) in any project. As a result, about one-third of a project's interest belongs to the Government through Petroquisa, about one-third to a private Brazilian company, and the remaining one-third to a foreign investor. Petrochemical raw materials (crude petroleum and natural gas) are provided by Petrobras and petrochemical prices are controlled by the Conselho Interministerial de Precos (CIP). 1/

Domestic market.--Domestic demand for petrochemicals in Brazil increased from 17 percent to 30 percent in 1986 compared with 10 percent to 12 percent in 1985. 2/ Currently, Brazil's petrochemical industry is operating at or near full capacity in order to satisfy domestic demand and maintain exports. The following tabulation shows the capacity and operating rate for several petrochemicals in 1985: 3/

Product	Production (1,000 metric tons)	Percent of capacity
Ethylene	1,310	94
Propylene	405	122
Butadiene	220	86
Benzene	516	96
Toluene	184	96
Mixed Xylenes	214	104

Much of Brazil's ethylene capacity is from ethanol dehydration plants, and some of the aromatics are from coke ovens. However, Brazil's petrochemical industry is primarily based on naphtha. As a result of its

1/ U.S. Department of State, Airgram, "Brazil's Petrochemical Industry," Mar. 28, 1984, p. 5.
2/ "Brazil Plans Petrochemical Expansion Programme," European Chemical News, Nov. 24, 1986, p. 25, and "Latin American Petrochemical Demand Surges Ahead," European Chemical News, Dec. 1, 1986, p. 4.
3/ William D. Gersumky,"Impact of the Alcohol Program on the Brazilian Petrochemicals Industry," presented before the World Chemical Congress of Marketing and Business Research, September 1986, exhibit III.

successful fuel ethanol program, which has largely displaced gasoline in fuel markets, there has been a significant change in the product mix from Brazil's refineries. Therefore, naphtha for chemical conversion is plentiful--about 10 million metric tons. 1/

As a result of increased domestic demand coupled with sustaining export markets, Brazil removed import tariffs for certain products such as PVC. Import tariffs on some items were as high as 45 percent. 2/

Export markets.--In 1985, exports accounted for about 6 percent of total ethylene production, or about 79,000 metric tons. Exports of propylene were 23 percent of production, or 93,000 metric tons. Exports of aromatics accounted for 20 to 40 percent of total production. 3/ Brazil's major markets are other Latin American nations and Asia, particularly China.

Factors of competition.--Brazil's fuel ethanol program allows for naphtha's availability for use as a petrochemical feedstock. Available feedstock plus technological advances provided by its foreign joint-venture partners have resulted in a world scale petrochemical industry for Brazil. However, Brazil's exchange rate problems could hamper its petrochemical expansions. As of December 1, 1985, the U.S.-Brazilian exchange rate was US$1.00 = NC$10,440. 4/ The following tabulation shows the Brazilian exchange and inflation rates for 1983 through 1985: 5/

	1983 1/	1984 1/	1985 1/
Exchange rate:			
New Cruzieros per U.S. dollar	979.0	3,168.0	10,440.0 2/
Inflation (percent)	211.0	223.8	235.1 3/

1/ Yearend values.
2/ As of Dec. 31, 1985.
3/ IGP as of December 1985.

Financial performance.--Brazil's economic growth rose to 8.3 percent in 1985 and the positive trade balance reached $12.5 billion. Although Brazil remains one of the world's most indebted nations, the total external debt had been declining somewhat in real terms and, until late February 1987, Brazil

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1/ "Strong Growth Ahead for Brazil's Petrochemical Industry," Chemical & Engineering News, Sept. 29, 1986, pp. 14 and 15.
2/ "Latin American Petrochemical Demand Surges Ahead," European Chemical News, Dec. 1, 1986, p. 4.
3/ "Strong Growth Ahead for Brazil's Petrochemical Industry," Chemical & Engineering News, Sept. 29, 1986, p. 14.
4/ U.S. Department of Commerce, International Marketing Information Series, Foreign Economic Trends and Their Implications for the United States, Brazil, FET 86-40, April 1986, p. 2.
5/ Ibid.

had remained current on interest payments to its commercial bank creditors. The following tabulation shows some key economic indicators for Brazil: 1/

	1983 1/	1984 1/	1985 1/
National accounts:			
GDP (in billions of current U.S. dollars)....	209.5	212.3	235.0
GDP growth (percent in constant cruzieros)......	-3.2	4.5	8.3
Per capita GDP (in current U.S. dollars)....	1,648.0	1,611.6	1,724.0
Balance of payments (in billions of U.S. dollars):			
Trade balance.............	6.5	13.1	12.5
Net interest payments......	-9.6	-10.1	-10.2
Gross foreign debt.........	91.6	102.4	100.3
Gross foreign reserves.....	4.6	12.0	11.6

1/ Yearend values.

Adjustments to competitive pressures.--With Brazil's economy growing rapidly, new petrochemical capacity will be necessary to meet future demand. Expansion plans include an additional 100,000 metric tons of LDPE and 150,000 metric tons of PVC; however, this may not be enough to satisfy expected thermoplastics demand of 1.5 million metric tons in 1990 and 2.3 million metric tons in 1995. 2/ However, as previously mentioned, naphtha feedstock is available for further expansion.

4.7 Nonmarket economy (NME) countries

The majority of the reserves of natural resources in the NME countries is concentrated in four countries. The U.S.S.R. and China account for a large share, with the remainder located in Poland and Romania. The reserves in Romania, however, are nearly exhausted. 3/ The U.S.S.R. is the main source of most of the natural resources consumed by countries participating in the Council of Mutual Economic Assistance (CMEA). As of January 1,1987, the U.S.S.R. had estimated proved reserves of 59.0 billion barrels of petroleum and 1.6 trillion cubic feet of natural gas. As of January 1, 1987, China also had estimated proved reserves of 18.4 billion barrels of petroleum and 30 billion cubic feet of natural gas. 4/

1/ Ibid.
2/ "Strong Growth Ahead for Brazil's Petrochemical Industry," Chemical & Engineering News, Sept. 29, 1986, p. 15.
3/ East European Economic Handbook, Euromonitor Limited, 1985, p. 23.
4/ "Worldwide Report," Oil & Gas Journal, Dec. 22-29, 1986, p. 37.

<u>Distinctive features</u>.--Most of the petrochemical industries in the NME countries are developled per the framework designated in the country's "five-year plan" governing overall economic growth within the country. The majority of the current five-year plans emphasize growth in the chemicals sector, particularly in regard to petrochemicals.

<u>Industry structure</u>.--The petrochemical industries in the NME countries are predominantly, if not completely, state-owned or controlled. Ongoing economic reforms in both China and the U.S.S.R. are encouraging the formation of joint ventures, particularly with Western countries in an effort to expand foreign trade and investment in each of the countries.

In 1985, 1300 joint ventures in all areas of the economy were approved in China, equaling the total approved in the last 5 years. <u>1</u>/ New reforms promulgated as of April 1986 have resulted in the establishment of the first wholly owned foreign subsidiary in China. Prior to this, projects had to be operated as joint ventures. The new company will be involved in the production of compounds to seal metal cans for foods and beverages. <u>2</u>/ China has also increased imports of advanced technology from the rest of the world.

The U.S.S.R. has developed legislation allowing for direct trade between Western partners and certain Soviet production enterprises, bypassing the Ministry of Foreign Trade. <u>3</u>/ The new policy allows for a maximum of 49 percent ownership by Western countries participating in joint ventures. These countries in return will be able to extract their return after the U.S.S.R. has withdrawn hard currency profits from export. <u>4</u>/ An additional benefit to the Western firms that is considered possible is the potential flow of technology from the Soviet firms to the Western firms in the joint ventures. <u>5</u>/

A major factor in the development of the petrochemical industries in the NME countries was the ready availability of natural resources for use as feedstocks and fuels. In the case of the Eastern European countries, the U.S.S.R., Poland, and Romania provided the majority of the fossil fuels consumed. China has apparently been able to supply most of its needs from its own reserves of crude petroleum and natural gas. Growth in the petrochemical industries has also been spurred by the continued expansion in downstream products, particularly plastics.

Construction costs are significant components of the total costs associated with the development and expansion of these petrochemical

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<u>1</u>/ "China's New Five-Year Plan," ibid.
<u>2</u>/ "Grace Sets Up New Subsidiary in Shanghai," <u>Chemical Marketing Reporter</u>, Feb. 23, 1987, p. 5.
<u>3</u>/ "U.S.S.R. Encourages New Joint Ventures," <u>European Chemical News</u>, Nov. 24, 1986, p. 10; "Planning a Soviet-U.S. Venture," <u>Chemical Week</u>, Sept. 24, 1986, p. 19.
<u>4</u>/ "UK Chemical Firms urged to Seek Trade in USSR," <u>European Chemical News</u>, Jan. 26, 1987, p. 11.
<u>5</u>/ Ibid.

industries, particularly in remote regions in the U.S.S.R. and China. Although construction costs in parts of Western Siberia are approximately 10 to 80 percent higher than those in Moscow, such costs for Eastern Siberia range between 7 to 8 times higher than those in Moscow. 1/

The degree of foreign involvement is increaseing within the petrochemical industries in the NME countries. The five-year plans of both the U.S.S.R and China encourages incresed foreign investment, primarily in the form of joint ventures, as well as increased imports of equipment. The benefits from such reforms include decreased reliance on imports as the domestic industry is expanded, and increased flows of foreign currency to the NME countries.

China and the U.S.S.R. have each been trying to increase their supplies of foreign currency. 2/ In the case of the U.S.S.R., the decline in the price of crude petroleum worldwide resulted in decreased earnings from exports to the West. 3/ As of January 1986, it was believed that the U.S.S.R. would prefer to import from its CMEA partners, with whom it could conduct barter deals, exchanging crude petroleum for other goods. 4/ The new decree concerning joint ventures in the U.S.S.R. was said to be effective January 1, 1987. 5/ Other Eastern European countries experiencing shortages of hard currency have negotiated countertrade deals with Western firms. 6/

Information concerning foreign ventures pursued by a number of the NME countries is not widely available in the public domain. It was reported in March 1985 that a Chinese company, which handles petroleum, natural gas, rubber, fertilizers, and basic chemicals, planned to establish joint ventures in China and abroad. 7/ Negotiations are also underway to build a $200 million petrochemical project in China, involving bidders representing companies in France, Italy, and Japan. 8/ It would involve a buy-back provision for the products, in spite of China's current shortage of domestic production of petrochemicals, to repay loans within four or five years. 9/ The complex would include a 130,000-metric-ton-per-year ethylene plant, fed by a mixture of ethane, LPG, and naphtha.

1/ East European Economic Handbook, Euromonitor Limited, 1985, p. 3.
2/ Vigor Fung, "Deadlocked Demand: Indonesian Tycoon's Refinery Venture in China Is Stalled by a Host of Obstacles," Asian Wall Street Journal Weekly, Mar. 17, 1985, p. 20; East European Economic Handbook, Euromonitor Limited, 1985, p. 35.
3/ "Soviet Union Rethinks PVC, Nylon Projects," European Chemical News, Jan. 23, 1986, p. 21.
4/ Ibid.
5/ "U.S.S.R. Encourages New Joint Ventures," European Chemical News, Nov. 24, 1986, p. 10.
6/ East European Economic Handbook, Euromonitor Limited, 1985, p. 19.
7/ "China Boosts Chemicals Trade," European Chemical News, Mar. 25, 1985, p. 11.
8/ "Firms Compete for a $200 Million Chinese Buy-Back Contract," European Chemical News, Dec. 22/29, 1986, p.18.
9/ Ibid.

Domestic market.--According to an industry source, production of ethylene in China in 1984 amounted to 648,000 metric tons, compared with 653,700 metric tons in 1983. Ethylene capacity in 1983 amounted to 721,000 metric tons and was projected to increase by 930,000 metric tons per year during 1986-90. 1/ Four new plants, each adding approximately 300,000 metric tons of annual capacity, are scheduled to be constructed during 1986-90.

Production of all petrochemicals in China in the first six months of 1986 increased to $1.7 billion, or by 5.7 percent, from the similar period in 1985. This output represented 57 percent of the planned total for 1986. The increase occurred in spite of continuing shortages of crude petroleum and power and transport difficulties. 2/

Production of ethylene in the U.S.S.R. amounted to 2.5 million metric tons in 1984, or 83 percent of total ethylene production in Eastern Europe. In 1985, Soviet production of ethylene amounted to 2.7 million metric tons. 3/ Soviet ethylene capacity in 1984 and 1985 amounted to 3.5 million metric tons. Capacity utilization during 1981-85 ranged from 65-80 percent. Prior to 1980, capacity utilization was said to generally be at installed capacity. 4/ As of April 1, 1985, plans were underway to construct four new turnkey petrochemical facilities. One of the four was geared to olefins and was expected to increase ethylene capacity by 250,000 metric tons per year. Falling petroleum prices resulted in the cancellation of two planned projects and a scaling down of the olefins and terephthalic acid/polyester fibers facilities. In July 1986, the olefins project was cancelled for financial reasons, mainly attributable to increased investment necessary since the events at the Chernobyl nuclear reactor. 5/

Chinese imports of chemicals were valued at $4.1 billion in 1984. 6/ China must import a large share of the petrochemicals it consumes domestically. Chinese consumption of petrochemicals could increase in the future if China develops an auto industry. 7/ China's major import partners in 1983 were Japan, Hong Kong, the United States, and West Germany.

1/ "China Unveils Ambitious Chemical Proposals," European Chemical News, Oct. 27, 1986, p. 23.
2/ "China Petrochemicals Production Rise", European Chemical News, Aug. 11/18, 1986, p. 8.
3/ Matthew J. Sagers and Theodore Shabad, "Soviet Petrochemical Industry" draft copy of a chapter in a forthcoming volume, Gorbachev's Economic Plans, edited by John Hardt and Jean F. Boone, to be published in Spring 1987 by the Joint Economic Committee.
4/ Ibid.
5/ "Soviet Union Scraps Plans for Olefins Complex," European Chemical News, June 2, 1986, p. 22.
6/ "China Boost Chemicals Trade," European Chemical News, Mar. 25, 1985, p. 11.
7/ "Canadian Companies to Help Plan Chinese Petrochemical Complex," Chemical and Engineering News, June 24, 1985, p. 18.

Soviet imports of chemicals in 1984 were valued at $2.49 billion in 1985. 1/ These imports increased by about 16 percent from those in 1984. The major sources of Soviet imports of all products in 1984 were CMEA countries.

Export markets.--Exports of chemicals by Eastern European countries are largely directed to other countries within Eastern Europe, as well as to the U.S.S.R. Hungary, for example, has imported most of its petroleum from the U.S.S.R. in exchange for ethylene in past years. 2/ The U.S.S.R. and the Eastern European countries have maintained a trade surplus with Western countries that began in 1982. Countries such as Romania, for example, are said to be forced to maintain such a surplus in order to obtain hard currency to pay for imports such as crude petroleum from the Middle East. 3/

Soviet exports of chemicals were valued at $1.89 billion in 1985. 4/ The Soviet trade balance for chemicals in that year was valued at a negative $594.8 million. Exports increased by about 2 percent from those in 1984. Approximately 80 percent of Soviet exports to Western countries in 1985 was accounted for by crude petroleum and natural gas. Chemical raw materials and manufactured goods are slowly gaining a larger share of these exports. 5/

Chinese exports of chemicals in 1985 were valued at $6.3 billion. 6/ Chemicals accounted for approximately 20 percent, or $10 billion, of China's total foreign trade in 1985. China's major export markets in 1983 were Japan, Hong Kong, and the United States. Crude petroleum and coal are the major products exported to Japan.

Factors of competition.--As most of the Eastern European petrochemical industries obtain their crude petroleum from the U.S.S.R., the pricing of Soviet crude petroleum to CMEA members has remained relatively constant in recent years, independent of the world price. 7/ Sales, however, vary, depending on the availability of the crude petroleum, world prices, and the Soviet need for hard currency. If the U.S.S.R. exports more to Western countries to obtain foreign currency, Eastern European countries are supplied with less crude petroleum. 8/ This generally results in increased Eastern European imports from the Middle East, if the country involved has hard currency available, which, in turn, probably results in decreased imports from Western countries. 9/

1/ "Soviet Chemical Trade Up," European Chemical News, Sept. 1,1986, p. 8.
2/ East European Economic Handbook, Euromonitor Limited, 1985, p. 142.
3/ Ibid., p. 29.
4/ "Soviet Chemical Trade Up," op. cit.
5/ "Flexibility Key to Trade With Comecon," European Chemical News, Oct. 28, 1985, p. 15.
6/ "China Boosts Chemicals Trade," European Chemical News, Mar. 25, 1985, p. 11.
7/ East European Economic Handbook, Euromonitor Limited, 1985, p. 92.
8/ Ibid., p. 92.
9/ Ibid., pp. 26-27, p. 284.

Labor productivity is expected to increase during the next five years in most of the NME countries. 1/ Labor productivity in the Soviet chemical industry increased by 10 percent during the first 6 months of 1986. 2/

Transportation costs represent a significant portion of spending in the NME petrochemical industries. Some NME countries are currently upgrading their transportation facilities. 3/ China, for example, is attempting to improve its transportation network by constructing new berths in its port facilities and by adding new track to its railway system. More than 90 percent of China's foreign trade moves by water and China's ports are heavily dependent on railways to distribute cargo. 4/ Prices in the various transport sectors in China are set by administrative order from the relevant authority. 5/ These prices, although difficult to interpret in a nonmarket economy, can be maintained higher than cost. 6/

The petrochemical industry is currently undergoing reforms in many of the NME countries in accordance with reforms implemented under their five-year programs. Much of the reform involves intensive development of the industry, i.e., modernization and retooling of existing facilities, rather than extensive development. Research and development expenditures are expected to increase. 7/ Goals include raising output through higher productivity as well as the development of greater autonomy for individual enterprises. Much of the modernization and construction currently completed in the NME petochemical industry has involved equipment and technology imported from Western countries. This situation is expected to continue during the next five years, particularly in view of the fact that both the U.S.S.R and China are encouraging joint ventures. 8/ In the U.S.S.R., for example, foreign partners in such ventures are allowed to contribute in the form of equipment, technology, or capital. 9/

Financial performance.--Data on current economic indicators are not available for most of the petrochemical industries in NME countries. Data are available, however, for Eastern Europe and the U.S.S.R. for overall economic indicators. The net material product of Eastern European nations increased by

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1/ World Economic Outlook: A Survey by the Staff of the International Monetary Fund, International Monetary Fund, April 1986, p. 166.
2/ "Soviet Industry Beats Targets," European Chemical News, Aug. 4, 1986, p. 9.
3/ "Sweeping Economic Reforms are Aimed at Quadrupling Production," Chemical and Engineering News, Dec. 17, 1984, p. 60.
4/ Potential Effects of Foreign Governments' Policies of Pricing Natural Resources, USITC, Publication 1696, May 1985, p. 115.
5/ Ibid.
6/ Ibid.
7/ "Soviet Union Sets Ambitious Goals for Next 15 Years," Chemical and Engineering News, Dec. 16, 1985, p. 48.
8/ "UK Chemical Firms Urged to Seek Chemical Trade in U.S.S.R.," European Chemical News, Jan. 26, 1987, p. 11, "China's New Five-Year Plan," China Reconstructs, July 1986, p. 24.
9/ "U.S.S.R. Encourages New Joint Ventures," European Chemical News, Nov. 24, 1986, p. 10.

an estimated 7.5 percent in 1985, compared with 4.5 percent in 1984. The decline was primarily attributed to a hard winter followed by drought in some countries. 1/ The increase in the Soviet net material product was estimated to amount to 3 percent in 1985, unchanged from that in 1984. Gross fixed investment for the U.S.S.R. and Eastern Europe in 1985 increased by an estimated 2.5 percent, compared with 2.5 percent in 1984 and 5 percent in 1983. 2/ Current account balances for Eastern Europe and the U.S.S.R. declined to an estimated $500 million in 1985 from $7 billion in 1984. The projected balance for the region in 1986 is a negative $5 billion. Net debt for Eastern Europe and the U.S.S.R. in 1985 was estimated at $72 billion, representing an increase of 17 percent from that in 1984.

Adjustments to competitive pressures.--The petrochemical industries in the NME countries are currently being modernized. Also, some new construction is underway. Hard-currency shortages are expected to be a prime factor in future plans for the NME petrochemical industries. Investment in the petrochemical industries in NME countries is expected to increase during 1986-1990. In China, approximately $6.2 billion will be invested, representing an increase of 64 percent from 1980 to 1985. 3/ Foreign investment in the Chinese petrochemical industry was valued at $534 million in 1982 and 1983, compared with $4 million in 1981. Foreign investment in the Chinese petrochemical industry reached a high of $1.22 billion in 1979. 4/ Repayment of capital expenditures for the projected construction is expected to be in the form of buy-back provisions and, in a departure from traditional financing practices, by the issuance of bonds. In an effort to raise $138.9 million for a 300,000-metric-ton-per-year ethylene plant, a branch of a Chinese bank has been authorized to issue bonds. An additional $272 million is to be obtained through foreign investment. Until now, traditional financing has included central government allocations and low-interest loans. 5/

1/ World Economic Outlook: A Survey by the Staff of the International Monetary Fund, International Monetary Fund, April 1986, p. 161; percentages quoted in terms of constant dollars.
2/ Ibid.
3/ "Chinese Chemicals Revamp," European Chemical News, May 12, 1986, p. 6.
4/ "China: The Advancing Petrochemical Industry," Chemical and Engineering Review, Feb., 1985, pp. 13-20.
5/ "China Takes A New Tack in Financing," Chemical Week, Dec. 3, 1986, p. 24.

Chapter 5. View of U.S. Industry's Competitiveness and Implications for U.S. Producers

In this section of the report those factors believed to directly influence the competitiveness of the U.S. primary petrochemicals industry are discussed and analyzed. This is followed by a summary of the Commission questionnaire respondents' assessments of the primary petrochemical industry's competitiveness and the relative importance of the competitive factors.

5.1 Competitive factors involved in development of world market share

Feedstocks for petrochemicals in the United States have been subject to regulations to varying degrees since the mid-1950's when the Federal Power Commission was empowered to regulate the price of natural gas crossing State boundaries. 1/ The intent was to obtain a balance between the users' desire for low prices and the producers' desire to realize an adequate profit. On the other hand, the U.S. Mandatory Oil Import Program, instituted in 1958, restricted crude petroleum imports so that U.S. consumers were in actuality paying about one-third more for petroleum than consumers in Western Europe. 2/ However, these price differences were of no major importance to the U.S. petrochemical industry until the first "crude petroleum price shock" in late 1973, because until then, the costs of the gas-based and petroleum-based petrochemical feedstocks were only about 1 cent per pound and represented a small share of the overall costs for the production of primary petrochemicals. Fixed cost, essentially capital investment, was the major cost factor at that time. The cost of labor in the petrochemical industry was not then and is not now very significant; many petrochemicals, and primary petrochemicals in particular, are produced in large, automated plants. In summation, the cost structure for petrochemicals in the early 1970's was about 75 percent fixed costs (mostly capital, but also including labor, overhead, maintenance, and research) and 25 percent variable costs (raw materials and energy). 3/

The "crude petroleum price shocks" of 1973 and 1979 altered the economics of the petrochemical industry. By the early 1980's, the costs of feedstocks had increased by a factor of 10. The relative importance of the cost elements of the industry reversed; variable costs (principally feedstock and energy) then accounted for 75 percent of all costs. 4/ This reversal afforded CERN's, such as Saudi Arabia and Mexico, the opportunity to become major players in the global petrochemical industry. The CERN's had historically flared (or discarded) large volumes of natural gas produced in association with crude petroleum. The CERN's lacked domestic markets and could not economically compete in the world natural gas market because of the high costs of moving

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1/ U.S. International Trade Commission, <u>Potential Effects of Foreign Governments' Policies of Pricing Natural Resources</u>, USITC Publication 1696, May 1985, p. D9.
2/ M. M. Schweitzer, "Petrochemicals: Strategies for Change for an Industry in Transition," unpublished staff paper of United States Trade Representative, Feb. 3, 1982, p. 2.
3/ Ibid.
4/ Ibid., and K. D. Loos, Arthur D. Little, Inc., "The Changing Chemical Cost Structure," <u>Chemical Purchasing</u>, September 1983, p. 25.

natural gas across oceans. However, when crude petroleum prices increased, the CERN's took advantage of low-cost feedstocks and offered those feeds to multinational and new domestic companies at a fraction of the price that these feedstocks were commanding in the United States, Western Europe, or Japan. This gave primary petrochemical producers in the CERN's a large feedstock (and energy) price advantage vis-a-vis other world primary petrochemical producers. This feedstock/energy price advantage decreased in 1986, following the decrease in crude petroleum prices. The ratio of fixed to variable costs again changed, and at the beginning of 1987 approached a 50/50 balance. 1/

As mentioned previously, natural gas and petroleum regulations continued in the United States after 1973, and in some ways the domestic petrochemical industry benefited. The Emergency Petroleum Allocation Act of 1973, as amended, led to a two-tiered system of price controls for domestic crude petroleum, which continued until January 1981. 2/ In 1980, according to an industry analyst, these controls gave the U.S. petrochemical industry an estimated advantage of 11 percent in composite petroleum and natural gas costs compared with the rest of the world. 3/ In 1981, before decontrol, the average refinery acquisition cost of U.S.-produced crude petroleum was $24.23 per barrel, whereas that for imported crude petroleum was $33.89 per barrel. In 1982, following decontrol, the difference in these average values declined to less than $3 per barrel. A program partially and gradually to decontrol natural gas prices was contained in the Natural Gas Policy Act of 1978. 4/ Three types of domestic natural gas were defined; "high-cost" natural gas (a special case of new gas as defined in Section 107 of the Natural Gas Policy Act of 1978) was decontrolled in 1979; "new gas" (gas produced from wells begun after Feb. 19, 1977), accounting for about 30 percent of the flow to interstate pipelines, was decontrolled in January 1985. The remainder, "old gas" (gas produced from wells active before the enactment of the Natural Gas Act of 1978) was effectively decontrolled by a Federal Energy Regulatory Commission (FERC) ruling in May 1986. 5/

5.2 Changing feedstocks

It was previously noted that naphtha (petroleum-based) is the dominant feedstock chosen for the production of ethylene by the global industry, followed by ethane (gas-based), which is growing in importance. However, at the current time, much of the U.S. ethylene production capacity, once

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1/ Chem Systems, "Revitalized Petrochemicals Face New Uncertainties," European Chemical News, Feb. 23, 1987, p. 9.
2/ U.S. International Trade Commission, Summary of Trade and Tariff Information . . . Crude Petroleum, USITC Publication 841, Control No. 4-10-23, July 1983, p. 8.
3/ W. W. Reynolds, Shell Oil Co., "Feedstocks for Chemicals," Chemical Purchasing, November 1982, p. 73.
4/ Potential Effects of Foreign Governments' Policies of Pricing Natural Resources, USITC Publication 1696, May 1985.
5/ Elizabeth Tucker, "FERC Votes to Allow Prices of 'Old' Natural Gas to Rise," Washington Post, May 30, 1986, pp. F1 and F4.

primarily based on ethane, now has dual-fire capabilities so that the industry can vary feeds according to the prevailing world economic price and supplies. With the great increase in feedstock costs, and the varying demand for co-products of naphtha- or gas-oil-derived ethylene (e.g., propylene, butadiene, and benzene), it has become advantageous for a producer of ethylene to be able to vary feedstocks. Therefore, in the past 10 to 12 years, major U.S. and European ethylene plants based on naphtha or gas oil have been modified (or originally designed) so they can shift to ethane or use any of a number of feedstocks derived from the heavy liquids when cost factors so dictate. 1/ (Plants designed for gas-based feedstocks can usually easily switch between ethane and propane feeds, but generally have not been designed with the option to use naphtha or gas oil.)

In 1986, when the U.S. price of crude petroleum was about $15 per barrel, or about 6 cents per pound, ethane was being sold at a lower price and naphtha for a slightly higher price. In earlier years, naphtha usually was sold for about the same price as crude petroleum, at least partially because the addition of tetraethyl lead to naphtha was sufficient to convert it to motor gasoline with an adequate octane rating. But with the enforced removal of lead from gasoline, and since naphthas have a low octane rating, naphtha's value to petroleum refiners has decreased. This has made such gasoline-boiling-range feeds more attractive and available to the petrochemical (ethylene) industry, instead of to the fuel industry. 2/ Similarly, U.S. and foreign availability of ethane (derived from natural gas) has been enhanced by the discovery of new natural gas reserves and by the adoption of improved (cryogenic) technology to separate more ethane from the recovered gas. During 1967-81, though recovery of total natural gas liquids held constant as a percentage of the "marketed" natural gas, recovery of ethane more than quadrupled. 3/

In 1978, feedstocks for ethylene in the United States were 70 percent "light" materials (ethane, propane, and other natural gas liquids) and 30 percent heavy liquids (naphtha and gas oil). (See Glossary of terms.) By 1985, the heavy liquids' share had decreased to 22 percent. But by the third quarter of 1986, the heavy liquids' share of total feedstocks used had returned to the 1978 level of 30 percent, as naphtha prices fell. Industry sources estimate that by 1990 the heavy liquids' share will increase to 36 percent or more. 4/

1/ "Olefin Producers are Revamping for Feedstock Flexibility to Reduce Operating Costs," Chemical Engineering, June 11, 1984, pp. 22-29; "Feedstocks for Chemicals," Chemical Purchasing, November 1982, p. 61; and Chemical Engineering Progress, February 1984, p. 24.
2/ "Naphtha Displaced from Leaded Gasoline," Hydrocarbon Processing, August 1985, p. 17; and Chemical Engineering Progress, February 1984, p. 24.
3/ "Booming Natural Gas Liquids Industry," Oil & Gas Journal, July 13, 1981, p. 72.
4/ M. G. Marbach, Shell Oil Co., "Aromatics," Papers presented to Chemical Marketing Research Association, May 1986, pp. 41-54; and "U.S. Inventories of Olefins Expand," Chemical Week, Nov. 12, 1985, p. 46.

Western Europe used naphtha almost exclusively in its ethylene crackers during the 1960's and 1970's. But by mid-1986, only 76 percent of their feed was naphtha, with the balance being gas oil, liquefied petroleum gas (LPG), and ethane. This ability to vary feedstocks provides the Western European petrochemical industry some relief from the susceptibility to drastic changes in price of one particular feedstock (naphtha). Considerable flexibility has also been designed into European crackers to shift from one feedstock to another. 1/ In contrast, the newer producers of ethylene in the Middle East, Mexico, and other energy-rich countries only use ethane to produce ethylene because of its comparative low price.

The typical product slate for the various feedstocks for olefins is as shown in the following tabulation (in pounds produced per 100 pounds ethylene): 2/

Item	Ethane	Propane	Light naphtha	Gas oil
Ethylene	100	100	100	100
Propylene	4	40	46	69
Butylenes	1	3	12	31
Butadiene	3	7	14	26
Benzene, toluene, and xylene	-	7	27	42
Fuel products	22	81	98	221
Feedstock required	129	238	297	488

These relations are not fixed, because for propane, naphtha, and gas oil it is possible--by increasing the temperature and shortening the residence time of the feed in the cracking furnace--to increase the yield of ethylene while decreasing the amounts of coproducts produced. 3/ These parameters are often changed to maximize the production of the product(s) most in demand at the time.

In the United States, most of the primary aromatics are produced in petroleum refineries for use as fuel, and constitute about one-quarter of the motor gasoline produced. The much smaller quantity of aromatics used as petrochemical raw materials is also mainly produced in petroleum refineries; about 20 percent is produced as coproduct from ethylene plants (1985 data),

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1/ "European Community-Middle East Trade Zone," Chemical Marketing Reporter, Oct. 6, 1986.
2/ "Ethylene Feedstocks," Chemical Business, June 29, 1981, p. 20; Chemical Business, Apr. 5, 1982, p. 33; DeWitt & Co. release, 1985; Chemical & Engineering News, Mar. 12, 1984, p. 37; and European Chemical News, Oct. 27, 1986, p. 18.
3/ "Ethylene Feedstocks," Chemical Business, June 29, 1981, p. 20; Chemical Business, Apr. 5, 1982, p. 33; DeWitt & Co. release, 1985; Chemical and Engineering News, Mar. 12, 1984, p. 37; and European Chemical News, Oct. 27, 1986, p. 18.

and about 2 percent is recovered from coal tar. 1/ Large amounts of propylene and butylenes are also coproducts of petroleum refineries.

Potential petrochemical feedstocks are often diverted from the petrochemical uses; ethane can be (and often is) left in natural gas for its fuel value; propane and butane constitute the LPG market and are also converted to alkylate and other gasoline components; naphtha is "reformed" or isomerized to aromatics and other higher octane hydrocarbons; gas oil is cracked and distilled to gasoline, jet fuel, diesel fuel, heating oil, and other fuels; and the aromatics are added directly to the unleaded gasoline pool as octane enhancers. These fuel uses are much larger in volume than the petrochemical uses of feedstocks and are a significant factor determining their prices owing to the much larger fuels market.

The Arab oil embargo of 1973 led to a well-remembered gasoline shortage and a short-lived shortage of petrochemicals during part of 1974. The petrochemical industry was quickly given a preferred position in the allocation program to obtain petroleum and natural gas fractions, 2/ but shortages still resulted from a buildup of inventories by fearful customers, insufficient plant capacity for a number of major petrochemicals, and exports of petrochemicals to other countries at world prices to maximize earnings. Following the Iranian revolution of 1979 there was another gasoline shortage, but petrochemicals were largely unaffected. Since 1979, large new reserves of crude petroleum and natural gas have been developed in many countries. Whereas the crude petroleum production of the Organization of Petroleum Exporting Countries (OPEC) dropped from a peak of 32 million barrels per day in 1979 to only 17 million barrels per day in 1985, that of other free-world countries rose from 22 to 28 million barrels per day during 1979-85. Canada and Mexico both increased their capacity to supply natural gas and crude petroleum, and the United States is well along with its program to build up a strategic inventory of crude petroleum. U.S. production of crude petroleum steadily increased during 1979-85 from 8.6 million barrels per day to more than 9.0 million barrels per day. 3/ Natural gas production in the United States declined from 19.7 trillion cubic feet in 1979 to 16.4 trillion cubic feet in 1985. 4/ In addition, the Departments of Commerce and Energy have worked jointly on a statistical program to alert Government policy-makers to the specific domestic feedstock and building-block petrochemical needs and the procedures to be implemented in case of another interruption of petroleum exports to the United States.

Other than crude petroleum imports, the United States is not now dependent on imports of materials for use as petrochemical feedstocks. U.S. imports of petrochemical feedstocks, sourced mainly from Canada and Latin

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1/ M. G. Marbach, op. cit.
2/ Federal Energy Administration testimony, Hearings on Materials Shortages before the U.S. Senate Subcommittee on Investigations, Committee of Government Operations, Oct. 9 and 10, 1974, p. 131 of Pt. 2.
3/ U.S. Department of Energy, Monthly Energy Review, December 1986, March 1986, p. 46.
4/ Ibid, p. 63.

America, are negligible. In 1985, less than 1 percent of the quantity of imports of crude petroleum and natural gas were imported for chemical conversion. In 1984-85, imports of building-block petrochemicals accounted for less than 3 percent of the U.S. consumption of these products, including their use as raw materials for gasoline (aromatics) as well as for petrochemicals. 1/ It is not likely that the United States would become dependent on imported feedstocks or building-block petrochemicals.

5.3 Capital investment

For any industry, requirements for capital investment depend mostly on the growth rate of the industry and the rate of technological change. Investment requirements of the capital-intensive petrochemical industry are mostly for plant construction. Even in the 1950's when the U.S. industry was growing most swiftly, the availability of capital was not a problem. Retained earnings were sufficient for all capital investment made during that period. Several of the largest chemical companies had almost no debt at all. In the more recent years of slower growth, there has still been no apparent shortage of capital. Several large petrochemical companies have used some of their available capital to repurchase stock and retire debt. In addition to retained earnings, funds required for leveraged buyouts, acquisitions, and manufacturing facilities have been readily available from financial institutions.

5.4 New technology

Previous to and during the 15 years following World War II, the petrochemical industry discovered and developed hundreds of major new chemicals, such as synthetic fibers, plastics, synthetic rubber, detergents, pesticides, and plasticizers. But, from a review of the petrochemical production statistics collected annually by the U.S. International Trade Commission, 2/ it is apparent that the rate of commercialization of new products greatly decreased since 1960. Since that time, the major technological achievements have been in the area of process improvements to reduce production costs--an accomplishment obscured by the ten-fold rise in prices of petroleum and natural gas. Some of the improvements involve energy conservation, discovery of new catalysts that minimize byproducts and require less demanding reaction conditions (lower pressures and temperatures), new synthesis routes based on lower cost raw materials, and general process improvements to increase plant efficiency. In the field of specialty petrochemicals, continuing innovations in the formulations of existing chemicals have led to advances in older areas such as engineering plastics, as well as the development of newer classes of products such as electronics chemicals, oilfield chemicals, plastics alloys, and synthetic lubricants. Some examples of the new technologies are as follows:

1/ M. G. Marbach, op. cit., and official statistics of the Department of Commerce.

2/ U.S. International Trade Commission, Synthetic Organic Chemicals; U.S. Production and Sales, annual.

1. In 1972, on the average, the petrochemical industry consumed 1.5 barrels of fuel for every barrel of feedstock processed. By 1980, conservation measures reduced that ratio to about 1.1. 1/ For ethylene crackers, energy consumption decreased by more than 50 percent during 1970-86, and improved technology increased the yields of ethylene in the cracking furnaces. 2/

2. Several new polypropylene production technologies were developed. One, employed by a joint venture of U.S. and Italian companies, uses new catalysts and technology and reportedly has cut plant investment by 56 percent and energy consumption by 80 percent compared with older processes. Another company claims even better economies. 3/

3. Polyethylene and polypropylene: The Unipol process, developed by a U.S. company, greatly simplified the technology and lowered the cost of producing these plastics. Operations using the new process began in 1968 for high-density polyethylene (HDPE), in 1977 for low-density polypropylene (LDPE), and in 1984 for polypropylene (PP). More than 40 process licenses were granted since that time. About 25 percent of the world's 1986 polyethylene production was produced in Unipol reactors. 4/ About seven similar processes were subsequently developed by other U.S. and foreign firms. 5/

4. Olefins: New technology makes it possible to convert propylene to a mixture of ethylene and butylene, or vice versa, depending on market demand. 6/

5. C12-C14 alcohols for detergents are now made from ethylene by a highly selective process that minimizes production of by-products. 7/

6. Recent developments in technology have made possible polymer alloys, blends of plastics that, in most cases, were previously incompatible. 8/

1/ Chemical & Engineering News, March 1984, p. 8.
2/ ECN Process Review, October 1986, p. 6.
3/ R. M. Hendricks, Himont Inc., "Polypropylene: An Overview," Papers presented to Chemical Marketing Research Association, May 1986, p. 55.
4/ Chemical & Engineering News, Mar. 3, 1986, p. 15.
5/ "All the Polyethylenes," Chemical Marketing & Management, spring 1986, pp. 45-49.
6/ European Chemical News, June 16, 1986, p. 14.
7/ Ibid.
8/ Ibid.

5.5 Internationalization of the petrochemical industry

As described in several recent reports of the U.S. International Trade Commission, 1/ the traditional petrochemical-producing areas of the world--the United States, Western Europe, and Japan--are now competing with CERN's, which, with low-cost crude petroleum and natural gas, have recently built and are continuing to build world-scale petrochemical industries. Leading the new and expanding participants are Saudi Arabia, Indonesia, Kuwait, Canada, Mexico, the U.S.S.R., and the People's Republic of China (China). In these nations, the upgrading of their low-cost petroleum and natural gas into higher value petrochemicals has been given a high degree of importance. A significant share of the CERN's production is intended for export. Some industry analysts believe that sometime after 1990, the United States, Japan, and certain Western European nations may become net importers of petrochemicals. In some of these energy-rich nations, particularly Saudi Arabia and Canada, many of the newer installations are joint ventures with U.S., Western European, and Japanese companies. At a recent conference a high level Saudi Arabia Government official stated that the "downstream industrialization is one area where Saudi-U.S. partnership can be developed even further." 2/

The main contribution of the U.S. and other joint-venture partners of the developing countries is their technology and know-how, and their world marketing position and expertise. Most of Saudi Arabia's 12 large and recently constructed petrochemical ventures are joint ventures with U.S., Japanese, Taiwanese, and South Korean partners. The four U.S. partners include three energy companies and one chemical company (the latter acquired by a West German chemical company in 1986). These partners supplied the technology and marketing assistance, and also trained the Saudi Arabian personnel. The Saudi Arabian contribution to the ventures included guaranteed low-priced feedstocks, low-interest loans, and newly constructed infrastructure. 3/

In overall terms, most U.S. petrochemical companies have eschewed the joint-venture route to overseas investment in the past in favor of wholly owned affiliates, except in some developing countries where only a minority position is allowed. The advantage of a joint venture is that it allows producers to expand their marketing position for a given product with a smaller investment. Duplicate facilities can be shut down, overheads reduced, and research and development (R&D) expenses can be shared. However, joint

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1/ U.S. International Trade Commission, The Probable Impact on the U.S. Petrochemical Industry of the Expanding Petrochemical Industries in the Conventional-Energy-Rich Nations, USITC Publication 1370, April 1983; and The Shift from U.S. Production of Commodity Petrochemicals to Value-Added Specialty Chemical Products and the Possible Impact on U.S. Trade, USITC Publication 1677, April 1985.
2/ H.E. Hisham Nazer, "The Royal Commission for Jubail and Yanbu and the Petrochemical Industry in Saudi Arabia," Twelfth International Petrochemical Conference, National Petroleum Refineries Association, San Antonio, TX, Apr. 5-7, 1987, p. 6.
3/ Saudi Basic Industries Corporation report, 1986, pp. 1-35.

ventures typically have a limited lifespan because,. with the passage of years, the situations and interests of the partners tend to diverge. In many such cases, one of the partners may buy out the other.

Process technology for petrochemical compounds has generally been freely available for licensing since the early 1960's. 1/ Prior to that time, the leading companies tended to keep their technology secret. The change came because of companies' desire to earn extra revenue and also because certain engineering and construction firms succeeded in penetrating the veil of patents and technology to become successful via their own process research. In 1977, the U.S. chemical industry received $633 million in royalties from foreign companies; by 1984 royalties had nearly doubled to $1.2 billion. Licensing has become a very inexpensive route to new products, especially for new producing countries; via licensing, the cost of acquiring fully developed production technology has been estimated to be as low as 2 to 10 percent of internal technology development costs. 2/

The 1950's and 1960's were noted for the rise of multinational firms, particularly U.S. firms expanding into Western Europe as it recovered from World War II. By 1970, U.S. chemical companies direct investment abroad was about $13 billion (gross fixed assets, mostly petrochemical), which was more than one-third of their domestic plant investment of $36 billion. No other U.S. industry approached this total. Petrochemical investments by U.S. petroleum companies would also add a significant amount to the total. 3/ The U.S. petrochemical industry was motivated by the desire for growth into new markets abroad and, in the early 1960's, by its (erroneous) fear that U.S. supplies of natural gas liquids were running out and that long-term U.S. growth would require shifting to naphtha feedstocks. Because naphtha (with lead) was needed for gasoline in the United States, but was in surplus in Europe, there seemed then to be little hope that the United States could remain cost competitive with Europe. 4/ All this changed after 1979. Falling profits and the tremendous investment in petrochemicals in energy-rich developing countries led the U.S. chemical industry, as well as other traditional producers, to deemphasize commodity petrochemicals and to concentrate efforts on other products, particularly "specialties." Several large U.S. chemical firms sold many of their European operations, and others cut back on foreign investment. In contrast, foreign (mostly European) companies invested heavily in the U.S. chemical industry during this period, mostly by acquisition. In the past few years such acquisitions exceeded $8 billion, more than half of that was for facilities producing first and 3 second-stage petrochemicals.

1/ "Process Technology Available for Licensing," ECN Chemscope, October 1986, pp. 14-74.
2/ "Is it Smart to License Out Technology?" Chemical Week, Apr. 9, 1986, p. 30.
3/ U.S. Senate, Implications of Multinational Firms for World Trade and Investment and for U.S. Trade and Labor, February 1973, pp. 390 and 407. This study was performed by the U.S. Tariff Commission, now the U.S. International Trade Commission.
4/ M.M. Schweitzer, quoting from an Arthur D. Little study, op. cit., pp. 1-2.

5.6 Questionnaire respondents' strategies for responding to competitive challenges

The following sections contain information taken from the Commission questionnaire concerning the strategies of the U.S. producers in the context of the current global market situation, and, in some cases, the anticipated situation for the near future.

Respondents' view of their industry's competitiveness. In response to the question as to whether the U.S. industry was in a declining competitive position relative to other major producers of building-block petrochemicals in the global market, the respondents to the Commission questionnaire replied by a margin of 17 to 13 that U.S. industry competitiveness was declining. However, the majority of those believing that the level of competitiveness was declining supplied as a major reason the competitive advantage held by the conventional energy-rich nations in terms of feedstock/fuel price and availability. Respondents stating that the level of U.S. competitiveness was, in their opinion, either stable or increasing, almost unanimously cited the industry restructuring and rationalization that had occurred since 1984 (and is still continuing) as contributing to the stabilization of the global petrochemical market. Almost all of the optimistic respondents felt that other U.S. competitive advantages, such as technology and product development (of value-added products) would more than compensate for the feedstock/fuel disadvantage. They indicated little concern about increasing prices for these feedstock/fuel materials in the near future; most respondents felt that the feedstock/fuel price level had either stabilized or would be subject to decline in the event of an OPEC collapse.

Other statements made by respondents that are representative of U.S. industry sentiment were that worldwide, the lead phase-down already seen in the United States would continue and force price increases to the purchasers of the aromatics, as these materials would be drawn increasingly away from the chemicals market into the fuels market.

Other respondents felt that the U.S. industry remains vulnerable to imports of the value-added materials. Others accented that only Mexican and Saudi Arabian producers enjoy a true cost advantage in such materials compared with U.S. producers, and that any threat has been minimized by U.S. rationalization that has already taken place. Other respondents have emphasized the vulnerability of the ethylene-based derivatives; although the technology advantage resides in the United States, the United States risks losing the competitive advantage if crude petroleum prices were to rise again. Respondents also cited specific factors, such as the Superfund Tax, with rates ranging from 1.7 percent to 4.8 percent, that they believe gives them a competitive disadvantage compared with foreign competition.

Those domestic firms that believe that the U.S. industry is either in a stable position or increasing its level of competitiveness have stated that the domestic industry is becoming much more of a global industry than it had been in the past, locating its own facilities in nations with comparative natural resource advantages. They also believe that there will be the need for increasing capacity in the near future; 1/ however, there is little rush to build entirely new facilities. 2/ Instead there will be "debottlenecking" and expansions of present facilities to supply the anticipated increased demand.

Respondent companies' ranking of marketing techniques and strategies. Respondents to the Commission questionnaire provided information regarding their marketing techniques and strategies, as well as the strategies they believe their domestic and foreign competitors favor. The following tabulation summarizes these results: 3/

	Domestic Firm	Domestic Competition	Foreign Competition
Company orientation: 1/			
Pricing policies	H	H	H
Product quality	H	H	M
Technical service	H	M	M
Advertising	M	M	M
Quantity discounts	M	M	M
Sales techniques:			
Captive sales force	H	H	M
Non-affiliated distributors	S	M	M
Export techniques:			
Under own license	M	M	M
By broker	M	M	S
Intracompany movements	S	S	S
Barter/Countertrade	S	S	S

1/ "H" indicates a heavy reliance; "M" a moderate reliance; and "S" a slight reliance.

This information shows the importance the domestic industry places on pricing policies, product quality, a captive sale force, and technical service; other strategies and techniques appeared to receive little attention. The foreign competition, on the other hand, is believed by the respondents to rely almost exclusively on pricing policies to market their products.

Respondent companies' ranking of strategies for responding to foreign competition.--Respondents were requested to rank in order the concentration of their individual firm's strategies and efforts to respond to foreign

1/ "Shortage Predicted for U.S. Ethylene Supply," Oil & Gas Journal, July 7, 1986, p. 30.
2/ The cost for the construction of a world-scale ethylene unit is estimated to now be approximately $1 billion. "A Make-Do Decade for Petrochemcials," Chemical Business, March 1987, p. 13.
3/ In response to the Commission questionnaire, 34 firms indicated their firm's orientation.

competition, both in the context of "next year" and the "next 2-5 years.". The following tabulation provides a summarization of the results obtained from the respondent firms: 1/

Rank	Response Strategies
Next year:	
1	Reduce production and transportation costs.
2	Accent pricing and/or financing terms.
3	Reduce overhead costs.
4	Reduce raw/intermediate material costs.
5	Accent production changes: quality, design, diversity, etc.
Next 2-5 years:	
1	Reduce production and transportation costs.
2	Accent pricing and/or financing terms.
3	Reduce overhead costs.
4	Reduce raw/intermediate material costs.
5	Increase investment in plant and equipment.

The most significant difference between the strategies as ordered for "next year" vis-a-vis the "next 2-5 years" is the appearance of the strategy that anticipates the need for increased production capacity in the future--the expenditure of additional capital on new plant and equipment or the improvement of the efficiency of existing plants and increasing the capacity of current plant and equipment (debottlenecking). These replies picture an industry looking to move forward aggressively.

Respondent companies' ranking of their objectives for both their company and their primary petrochemicals divisions.--Respondents to the Commission questionnaire also ranked their firm's specific objectives, both for the entire company or division and for the building-block petrochemicals specifically. The results are as follows: 2/

1/ There were 31 firms responding to the question in the Commission questionnaire.
2/ There were 32 firms responding to this question on the Commission questionnaire.

Rank	Objective
Company/Division orientation:	
1	Improve profit center net
2	Increase return on equity
3	Increase return on sales
4	Improve production efficiency
5	Assure company/division survival
6	Expand sales
Product orientation:	
1	Improve profit center net
2	Increase return on equity
3	Assure company/division survival
4	Improve production efficiency
5	Increase return on sales
6	Improve capital productivity

This information suggests that both perspectives are quite similar and both adhere to the widely reported short-term focus of the majority of the companies in the domestic petrochemical industry. It is interesting to note that many companies apparently still seek to expand sales, while those divisions more closely related to the primary petrochemical product lines are more investment oriented and seek to improve capital productivity.

Respondent companies' ranking of detailed responses to foreign competitors.--The respondents were also asked to rank order (from a detailed list of prompts) a set of special strategic responses to foreign competition. The results of their responses are as follows: 1/

1/ There were 33 firms responding to this question on the Commission questionnaire.

1 Concentrate on maintaining price competitiveness match competitor price terms.
2 Concentrate on product for market niches where firm has competitive advantage.
3 Hold to basic business strategy; no adjustment required.
4 Improve product quality.
5 Reduce energy consumption.
6 Reduce supervisory/managerial layering.
7 Increase production of up-scale or higher value-added products.
8 Increase transportation cost-saving efforts.
9 Make capital-savings improvements in production processes.
10 Trim non-production employment.
11 Concentrate on product for market niches where competition is less intense.
12 Improve.expand product service and/or support.
13 Modernize present plant and equipment.
14 Invest in new plant and equipment to cut costs and improve productivity.
15 Intensify R & D efforts to develop new products.
16 Cut employment to reduce labor costs.
17 Invest in more labor-saving equipment to cut costs.
18 Cut production costs by reducing material processing waste.
18 Improve financing and other financial terms of purchase.
20 Diversify product mix and models to strengthen market position.

The responses to this particular question indicate an initial tendency toward the cost-cutting techniques and confirms the earlier data that indicated the short-term outlook of much of the domestic industry. However, prominent among the strategies selected was the improvement of product quality, the search for market niches, and other related strategies that entail an expenditure of capital in the present in order to assure a competitive market position in the future. Such strategies indicate a renewal of interest in longer term remedies and a commitment to view competitiveness as a longer term goal not necessarily achievable quickly.

Chapter 6. Evaluation of U.S. Industry Competitiveness

In order to assess the level of competitiveness of the U.S. petrochemical industry vis-a-vis other major world producers, the Commission used questionnaires 1/ to solicit directly from primary petrochemical companies their viewpoints on the factors that have been previously described. Table 6-1 shows the compiled data received from the respondents to the questionnaire, concerning the factors that the U.S. producers have regarded as having the greatest impact on their competitiveness in the market for both building-block petrochemicals and their derivatives. There were two specific "past" time periods designated in the questionnaire for separate responses, so that periods of radically different competitive situations in the world market could be represented. As such, the responses given concerning the time period designated 1984-85 are differentiated from the responses for the period 1986 as periods of a relatively higher feedstock/fuel costs (1984-85) and relatively lower feedstock/fuel costs (1986). In addition, data compiled from responses regarding future competitive conditions (next 1-3 years) are also provided based on each respondent's own estimation of the conditions expected to be encountered during this period.

6.1 Industry ratings of competitiveness factors

One of the most important general factors that impacts the competitiveness of all industries is the relative cost structure of the industry. In particular for the primary petrochemical industry, the cost of feedstocks and fuel (feedstock/fuel price) is the almost unanimous choice of the respondents as the factor that has the greatest direct impact on their competitiveness for building-block petrochemicals, both in the domestic market and in the global market. The second factor cited for both "past" time periods, as well as anticipated for the future, was the price of competitive primary product imports, which would supplant U.S. production currently being supplied to both U.S. and foreign markets. Environmental regulations, feedstock/fuel availability, taxes, and import quantity were clearly viewed as important competitiveness factors by the questionnaire respondents. For the derivatives, the three most important factors were the same as for the primary olefins and aromatics; however, factors such as environmental regulations, import quantity, and import quality are viewed by the respondents as having a greater impact on the derivatives market than for the basic petrochemicals, while taxes are viewed as being less of a factor. Other factors such as safety regulations and research and development were viewed as much more important factors in relation to the competitiveness of the derivatives than to that of the basic petrochemicals, as the development of new markets is extremely important in a more direct way to the producers of the derivatives.

The severity of competition from foreign competitors was described by the respondents as exhibiting its most visible impact on the petrochemical

1/ A description of the methodology used in the questionnaire is found in app. C.

Table 6-1.--Petrochemicals: Evaluation of competitiveness factors 1/

Competitive Factors	1984-85 Ranking	1986 Ranking	Future Ranking
Building-block petrochemicals:			
Feedstock/fuel price	1	1	1
Import price	2	2	2
Environmental regulations	3	4	3
Feedstock/fuel availability	4	3	4
Taxes	5	6	6
Quantity of primary petrochemical imports	6	5	5
Quality of primary petrochemical imports	7	7	9
Tariffs	8	9	7
Safety regulations	9	8	8
Intra-company transfers	10	10	10
Research and development	11	12	11
Antitrust measures	12	13	12
Investment restrictions	13	14	13
Nontariff measures	14	11	15
Profit repatriation	15	15	17
Barter/Countertrade	16	16	14
Intellectual property rights	17	17	16
Corrupt Practices Act	18	18	18
Primary Petrochemical Derivatives:			
Feedstock price	1	1	1
Import price	2	2	2
Environmental regulations	3	3	3
Import quantity	4	4	5
Feedstock availability	5	6	4
Import quality	6	5	6
Taxes	7	8	9
Tariffs	8	7	8
Safety regulations	9	10	7
Research and development	10	9	10
Intra-company transfers	11	11	11
Antitrust measures	12	12	12
Investment restrictions	13	13	13
Non-tariff measures	14	16	14
Intellectual property rights	15	14	16
Profit repatriation	16	15	17
Barter/Countertrade	17	17	15
Corrupt Practices Act	18	18	18

1/ 25 firms responded to this question from the Commission question- naire concerning building-block petrochemicals; 28 responded concerning primary petrochemical derivatives.

Source: Compiled from data submitted in response to the questionnaires of the U.S. International Trade Commission.

industry's profitability. The following tabulation indicates the order of the potential effect on areas of the industry, according to the respondents: 1/

Rank	Industry area
1	Profitability
2	Capacity utilization
3	Market share
4	Cash flow
5	Employment
6	Productivity/output
7	Product survival
8	Ability to finance capital investment

6.2 Production cost factors 2/

Responses to the Commission questionnaire concerning the costs of production of each of the six building-block petrochemicals being considered yielded the following statistics for ethylene production in 1986 (in cents per pound): 3/

Product/cost item 1/	Average	Minimum	Maximum
Feedstock costs:			
Feedstock............	13.15	6.09	28.6
Byproduct credits.....	6.80	.7	23.0
Net feedstock cost......	6.43	1.9	13.0
General operating costs:			
Utilities............	2.37	.08	5.3
Catalysts/chemicals...	.29	.1	1.9
Labor...............	.57	.12	3.3
Maintenance..........	.73	.36	1.23
Overhead.............	.78	.01	2.39
Transportation.......	.92	.03	3.0
Other...............	1.21	.1	3.85
Total cost............	11.98	6.2	21.2

1/ There were 20 firms reporting ethylene production cost data in the Commission questionnaire.

1/ There were 32 firms responding to this question in the Commission questionnaire.
2/ A comparison of various producer-country's feedstock cost situation is contained in ch. 2.
3/ The data presented here include responses that transfer, or allocate the costs of production to the primary products of a certain process, not necessarily the specific product being considered. Therefore, there are certain minimum and maximum costs listed that appear to be unrealistic. These costs arise from the "actual" costs of the process being allocated to another product (either a fuel, one of the other basic petrochemicals, or another petrochemical product).

As can be seen from the data, there is a wide variability in the range of the costs as allocated by the respondents. However, the total costs for the production of all of these items decreased significantly during 1984-86.

The range of costs for the production of ethylene for the U.S. industry in 1984 was estimated to be between 20 and 27 cents per pound (of ethylene produced) f.o.b. the U.S. gulf coast, 1/ compared with a range of costs in late 1986 from the questionnaire responses of between 6 and 29 cents per pound, with an average cost of approximately 12 cents per pound. During this period, the range of net cost for feedstock declined from 11 to 14 cents per pound in 1984 to 2 to 13 cents per pound in late 1986. 2/ In 1984, feedstock costs accounted for up to 52 percent of total production costs. Net feedstock costs increased to 62 percent of production costs in 1986 despite lower average feedstock prices, presumably as a result of successful efforts to reduce other production costs.

Ethylene byproducts credits are an important factor in determining ethylene production costs. The prices at which byproducts can be sold are important to the economics of ethylene production and directly influence how the unit is operated. If byproducts are in excess supply, or suffer from price depression, efforts will usually be made to minimize byproducts production.

A significant portion of the byproducts produced are fuel products even when the feedstock is ethane. The ability to market or to use these fuel byproducts in plant operations gives petroleum companies an advantage compared with chemical companies and is one of the reasons why major petroleum companies have a large share of the primary olefins production capacity.

In the current world energy market, the advantage afforded to the petroleum companies that produce ethylene is emphasized, as the increased use of gas oil/naphtha feedstocks generates far more byproducts than does the use of ethane feedstock.

In the cases of both propylene and butadiene, the importance of byproduct credits to the cost of production is also evident. Net feedstock costs for propylene ranged from 22 to 65 percent of the total cost of production, and from 21 to 40 percent for butadiene, as shown in the following tabulation (in cents per pound: 3/

1/ U.S. International Trade Commission, Potential Effects of Foreign Government's Policies of Pricing Foreign Resources, USITC Publication 1696, May 1985, p. 81.
2/ Ibid., p. F-53.
3/ Derived from responses to the Commission questionnaire.

Product/cost item	Average	Minimum	Maximum
Propylene: 1/			
Feedstock costs:			
Feedstock..................	10.56	5.1	15.01
Byproduct credits..........	5.62	2.55	13.02
Net feedstock cost...........	7.44	1.90	12.06
General operating costs:			
Utilities..................	1.37	.05	5.03
Catalysts/chemicals........	.13	.01	.25
Labor......................	.20	.03	.52
Maintenance................	.41	.05	.81
Overhead...................	.65	.01	2.39
Transportation.............	.98	.03	2.00
Other......................	1.12	.03	3.85
Total cost..................	11.37	8.50	15.56
1,3-Butadiene: 2/			
Feedstock costs:			
Feedstock..................	8.02	1.55	13.55
By-product credits.........	5.00	4.41	5.59
Net feedstock cost.........	6.35	1.55	13.55
General operating costs:			
Utilities..................	1.93	.08	3.20
Catalysts/chemicals........	.28	.14	.80
Labor......................	.91	.23	1.88
Utilities..................	1.93	.08	3.20
Catalysts/chemicals........	.28	.14	.80
Labor......................	.91	.23	1.88
Maintenance................	.43	.04	.81
Overhead...................	1.19	.01	2.50
Transportation.............	.55	.03	1.71
Other......................	1.06	.00	3.85
Total cost..................	21.82	7.25	33.83

1/ 9 firms reported propylene cost data in response to the Commission questionnaire.
2/ 20 firms reported 1,3-butadiene cost data in response to the Commission questionnaire.

Production costs for the aromatics are typified by the benzene cost structure, 1/ which, among various producers, ranged from $0.60 to $1.23 per gallon. Feedstock costs ranged from $0.43 to $0.95 per gallon and accounted for up to 78 percent of the production costs.

1/ Often the other primary aromatics are used to produce benzene. Also, benzene and other aromatics production is partially allocated to production costs of fuels, thus the wide range of costs described in this section.

Toluene production costs ranged from $0.58 to $0.79 per gallon, while those of mixed xylenes range from $0.51 to $0.75 per gallon. Feedstock costs were again a major component of total production cost accounting for between 77 percent and 93 percent of the total cost, as shown in the following tabulation: 1/

Production/cost item	Average	Minimum	Maximum
	-------cents per gallon-------		
Benzene: 1/			
Feedstock....................	59.53	43.00	95.30
General operating costs:			
Utilities..................	7.25	2.10	13.67
Catalysts/chemicals........	.67	.14	2.00
Labor......................	1.49	.35	4.12
Maintenance................	1.39	.20	4.00
Overhead...................	3.58	.20	13.92
Transportation.............	2.97	.30	5.10
Other......................	2.93	.02	11.94
Total cost..............	75.78	59.76	122.65
Toluene: 2/			
Feedstock....................	61.29	51.40	74.50
General operating costs:			
Utilities..................	4.17	2.10	6.40
Catalysts/chemicals........	.34	.01	.90
Labor......................	.94	.16	1.96
Maintenance................	.38	.18	.70
Overhead...................	.87	.20	1.40
Transportation.............	3/	3/	3/
Other......................	.61	.20	1.61
Total cost..............	68.10	58.13	79.40
Mixed xylenes: 4/			
Feedstock....................	65.16	51.40	99.99
General operating costs:			
Utilities..................	5.58	1.47	15.80
Catalysts/chemicals........	.43	.01	1.61
Labor......................	.91	.16	1.96
Maintenance................	.68	.18	1.75
Overhead...................	2.92	.20	9.17
Transportation.............	3/	3/	3/
Other......................	1.16	.03	4.10
Total cost..............	75.42	57.15	130.00

1/ 12 firms reported benzene cost data in response to the Commission questionnaire.
2/ 6 firms reported toluene cost data in response to the Commission questionnire.
3/ There were no enough responses to this item to provide publishable data.
4/ 8 firms reported mixed xylenes production costs in response to the Commission questionnaire.

1/ Derived from responses to the Commission questionnaire.

6.3 Relation of product price to feedstock price and exchange rates

Variations in prices of the primary olefins and aromatics are directly related to variations in the cost of feedstock. Figure 6-1 shows the relationship between the average annual price of the predominant primary olefin (ethylene) and aromatic (benzene), 1/ and the average price paid for crude petroleum in the United States. 2/ The strong correlations observed between crude petroleum cost and ethylene prices (+0.89) and benzene (+0.84), respectively, are not surprising given the high percentage of petrochemical cost attributed to feedstocks.

The pricing of crude petroleum in dollars may limit the extent to which exchange-rate movements influence pricing of petrochemicals; however, there may be exchange-rate effects on other cost components along with demand pressures from petrochemical producers in other countries 3/. Multiple regression analysis was employed to examine the separate influences of exchange rates 4/ and feedstock cost on benzene and ethylene prices using annual data from 1977-86, with the following results: 5/

--almost 95 percent of the variation in ethylene prices was explained by variations in crude petroleum prices and exchange rates, with a 10-percent increase in feedstock prices (other factors constant) leading to a 6.3-percent increase in ethylene prices and a 10-percent increase in the real value of the dollar, resulting in a 4.3-percent reduction in ethylene prices;

--over 90 percent of the variation in benzene prices was explained by variations in crude petroleum prices and exchange rates, with a 10-percent increase in feedstock prices (other factors constant) leading to a 6.0-percent increase in ethylene prices, but no statistically significant price effect of changes in the real exchange rate.

1/ Compiled from U.S. International Trade Commission, Synthetic Organic Chemicals, U.S. Production and Sales, annual reports, 1977-1985.
2/ Refiner acquisition cost, U.S. Department of Energy, Monthly Energy Review, December 1986, March 1987, p. 97.
3/ Factors that create or contribute to these effects are the trading, in Western Europe, of crude petroleum in U.S. dollars, and chemicals is Deutschemarks; and the feedstock variability available to many U.S. producers but not as widely possible in Western Europe.
4/ Multilateral-trade-weighted real value of the U.S. dollar, calculated by the Board of Governors of the Federal Reserve System based on dollar exchange rates with 10 major industrial countries, Economic Report of the President, January 1987, p. 365.
5/ The estimated regression equations, based on 10 annual observations and correcting for autocorrelation of residuals are ("ln" is the natural logarithm, base e, and values in parentheses are "t-statistics"):

$$\ln(\text{ethylene price}) = \underset{(4.8)}{2.9} + \underset{(9.6)}{0.63} \ln(\text{petroleum price}) - \underset{(3.0)}{0.43} \ln(\text{exchange rate}),$$

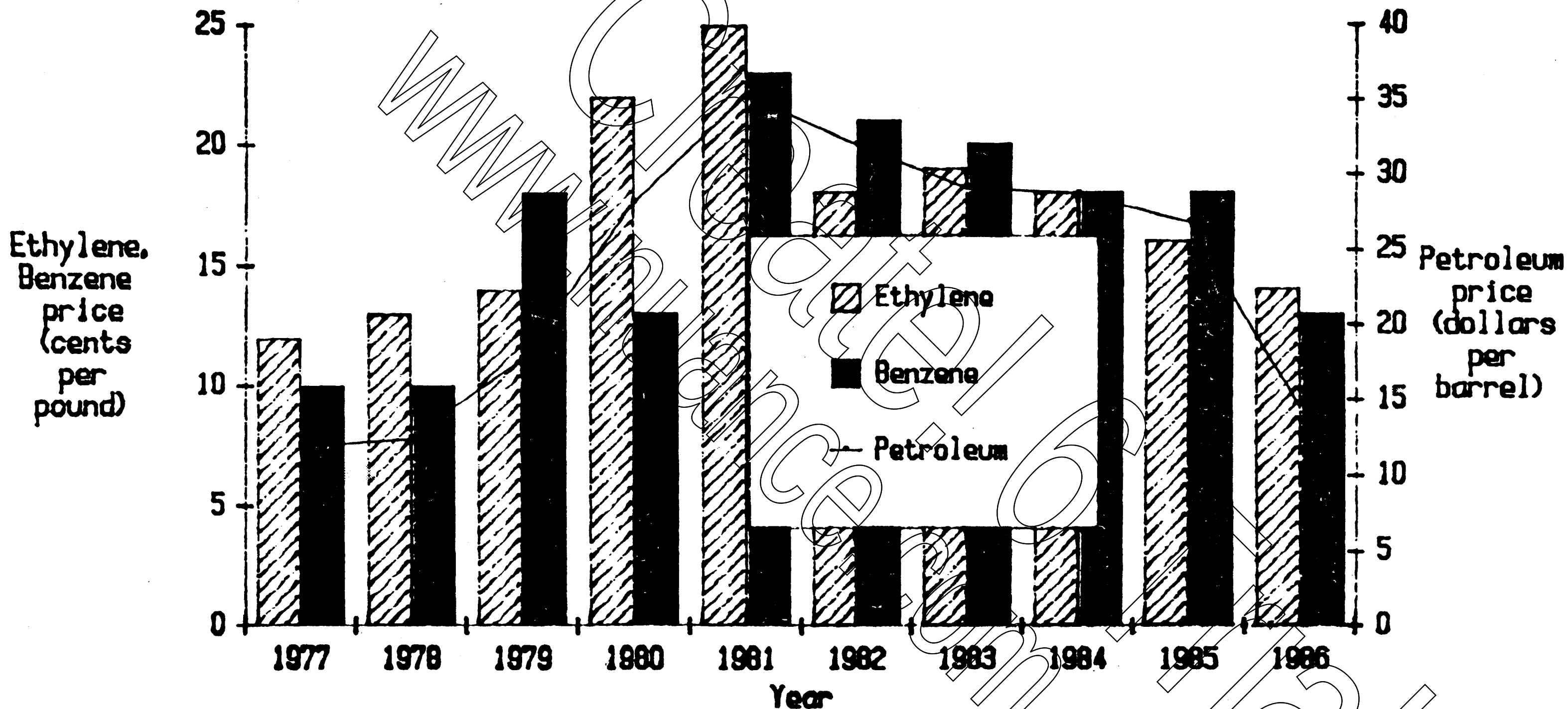
R2 = .94;

$$\ln(\text{benzene price}) = \underset{(0.1)}{0.13} + \underset{(5.9)}{0.60} \ln(\text{petroleum price}) - \underset{(0.8)}{0.17} \ln(\text{exchange rate}),$$

R2 = .90.

Figure 6-1

Ethylene, Benzene, and Petroleum Price Variations



Source: Compiled from official statistics of the U.S. Department of Commerce and the USITC, Synthetic Organic Chemicals; U.S. Production and Sales, 1977-85, and staff estimates.

6.4 Investment and research and development (R&D) expenditures

Future competitiveness is also affected by the amount of investment in the domestic industry. Therefore, information regarding such factors as capital expenditures for new plant and equipment and R&D expenditures was requested from the respondents to the Commission questionnaire. The responses are summarized in the following tabulation (in millions of dollars): 1/

	1982	1983	1984	1985	1986 1/
Capital Expenditures:					
Primary olefins....	260.3	121.7	99.0	126.4	109.4
Primary aromatics..	63.2	124.4	86.8	41.6	30.7
R&D Expenditures:					
Primary olefins....	14.7	12.4	11.9	10.3	7.3
Primary aromatics..	5.2	4.6	4.0	4.3	2.0

1/ Estimated from partial-year data.

There has been a decrease in capital expenditures as reported by the respondents to the Commission questionnaire. Annual expenditures related to the primary olefins fluctuated during 1982-86, with an overall decrease of nearly 60 percent from the high level in 1982 to 1986, with a low point in 1984. Expenditures for the primary aromatics decreased by 51 percent during 1982-86. During that period, capital spending for the entire U.S. chemical industry increased by 37 percent, from $12.7 billion in 1982 to $17.4 billion in 1986. 2/ Budgeted capital spending worldwide for 13 major chemical companies was reported to have increased to $6.0 billion in 1986, still 15 percent below the spending peak in 1981. 3/

One possible explanation of the decrease in capital expenditures for the questionnaire respondents is the decline in demand and emergence of excess capacity in the early 1980's. This made possible the cannibalization of equipment from shutdown capacity. In many situations, necessary materials or parts may be removed from plants permanently shut down to supply the needs of operating plants instead of purchasing new parts. This cannibalization process is limited by both the availability of suitably sized and/or designed

1/ Of the firms responding to the questionnaire, 14 reported R&D expenditures for primary olefins, while 8 reported R&D expenditures for primary aromatics. Capital expenditures for primary olefins were reported by 21 firms, while 15 firms reported capital expenditures for primary aromatics.
2/ Data for 1982 compiled from official statistics of the U.S. Department of Commerce, data for 1986 from "Facts and Figures of the Chemical Industry," Chemical & Engineering News, June 9, 1986, p. 52.
3/ Ibid, p. 53.

older parts in good condition and the ability of the operating plant to meet increasing demand without restarting some of the shutdown capacity. 1/

R&D expenditures provide an indication of the efforts to develop new products and improve technology. The amount of expenditures on R&D for the primary olefins declined each successive year during 1982-86; the overall decrease during the period was 51 percent. R&D expenditures on the primary aromatics declined by 62 percent. The industry's major R&D emphasis is not on the primary olefins and aromatics, but instead involves the development of new downstream derivatives and markets. 2/ The following tabulation shows R&D spending as a percentage of sales for both the questionnaire respondents and an industry estimate for all chemicals (in percent): 3/

Year	Industry estimate for all chemicals	Directed toward-- Primary olefins	Primary aromatics
1982..........	3.7	0.34	0.24
1983..........	4.0	.26	.21
1984..........	4.2	.24	.19
1985..........	4.8	.23	.20
1986 1/.......	4.8	.17	.13

1/ Questionnaire results based on partial-year data.

R&D spending as a percent of sales for the chemical industry in general has been steadily increasing throughout this period, while that specifically for the primary olefins and aromatics has trended steadily downward. This clearly highlights the emphasis of the industry toward new product and market development to provide outlets for their own primary petrochemical production.

6.5 Employment

The following tabulation shows the average wage rates for the respondent producers of building-block petrochemicals.

1/ This cannibalization process takes advantage of the value of the updated pieces of equipment in plants often 20 years old or older. Also, as opposed to other manufacturing industries, chemical plants are not useless when shut down.

2/ Such R&D increases demand for the primary olefins and aromatics.

3/ Questionnaire data derived from previously cited sales and R&D figures. Industry estimate from Chemical & Engineering News.

Item	1982	1983	1984	1985	1986 1/	Average annual rate of increase 1982-86
	------------Per hour------------					Percent
All workers.............	$11.89	$12.62	$12.44	$12.47	$12.91	2.1
Production and related workers engaged in the production of--						
Primary olefins.......	12.93	14.35	14.79	14.50	15.11	4.0
Primary aromatics.....	2/	11.27	9.34	9.31	9.11	-4.5

1/ Based on partial-year data.
2/ Insufficient data reported in the questionnaires to derive an average wage rate for this time.

During this period wages generally increased for all workers by about 8.5 percent during the entire 5-year period. The decline in wage rates reported by producers of primary aromatics may be related to either the cutback in employment occurring primarily in higher wage categories or a function of the way respondents allocated the share of production workers that were included in this category. 2/ U.S. Department of Labor statistics for specific segments of the U.S. chemical industry are in close agreement with the questionnaire results, as shown in the following tabulation of hourly wage rates for production and non-supervisory workers in the chemical industry and for all manufacturing: 3/

Source	1982	1983	1984	1985
All manufacturing................	$ 8.49	$8.83	$9.18	$9.52
Chemicals and allied products....	9.96	10.58	11.08	11.57
Industrial organic chemicals 1/..	11.85	12.73	13.43	13.99

1/ Includes primary olefins and aromatics.

Not only has the wage rate for the chemical industry in general exceeded the U.S. average wage scale for all manufacturing, production workers for the industrial organic chemicals segment, including those working in the

1/ Questionnaire data derived from previously cited sales and R&D figures. Industry estimate from Chemical & Engineering News, op. cit., p. 54.
2/ Production workers engaged in the production of primary aromatics are also engaged in the production of fuels in many of the respondents' facilities.
3/ Of the responding firms, 33 reported total employment, 26 reported employment related to the primary olefins, and 17 reported employment related to the primary aromatics.

production of the primary olefins and aromatics, have historically been at the high end of the chemical industry wage scale.

The total number of employees for the respondents are shown in the following tabulation along with those engaged in the production of the primary olefins and aromatics: 1/

Source	1982	1983	1984	1985	1986 1/	Percentage change, 1985 over 1982
All workers...............	25,709	25,028	25,166	24,363	23,377	-5.2
Production and related workers engaged in the production of:						
Primary olefins.........	9,557	9,810	8,979	8,425	7,999	-11.8
Primary aromatics.......	1,465	1,409	1,445	1,438	1,408	-1.8

1/ Based on partial-year data.

The data in this tabulation reflect the industry's response to the decline in demand during the early 1980's. Employment in the primary olefins decreased by the greatest amount during 1982-86, as primary olefins facilities bore the brunt of the industry rationalization. Where excess capacity was shut down, there were also decreases in the number of employees. Even though production expanded in the mid 1980's, employment continued to decline. Many of the cutbacks in employment came in the white-collar workforce, as several companies offered widely publicized "early out" retirement packages so as to cut back somewhat on the higher paid end of the workforce.

These cuts in employment in primary petrochemicals have resulted in a stagnant employment situation for the entire U.S. chemical industry. Overall domestic chemical and allied products industry employment statistics of the U.S. Department of Labor show the following: 2/

1/ Chemical & Engineering News, op. cit., p. 62.
2/ Chemical & Engineering News, op. cit., p. 61; 1986 data are not available.

Source	1982	1983	1984	1985	Percent change 1982-85
	---------Thousands--------				
All employees:					
All manufacturing................	18,781	18,434	19,412	19,426	3.4
Chemicals and allied products....	1,075	1,043	1,048	1,042	-3.1
Industrial organic chemicals.....	171	163	164	164	-4.1
Production workers:					
All manufacturing................	12,742	12,530	13,310	13,214	3.7
Chemicals and allied products....	599	579	582	576	-3.8
Industrial organic chemicals.....	86	84	83	84	-2.3

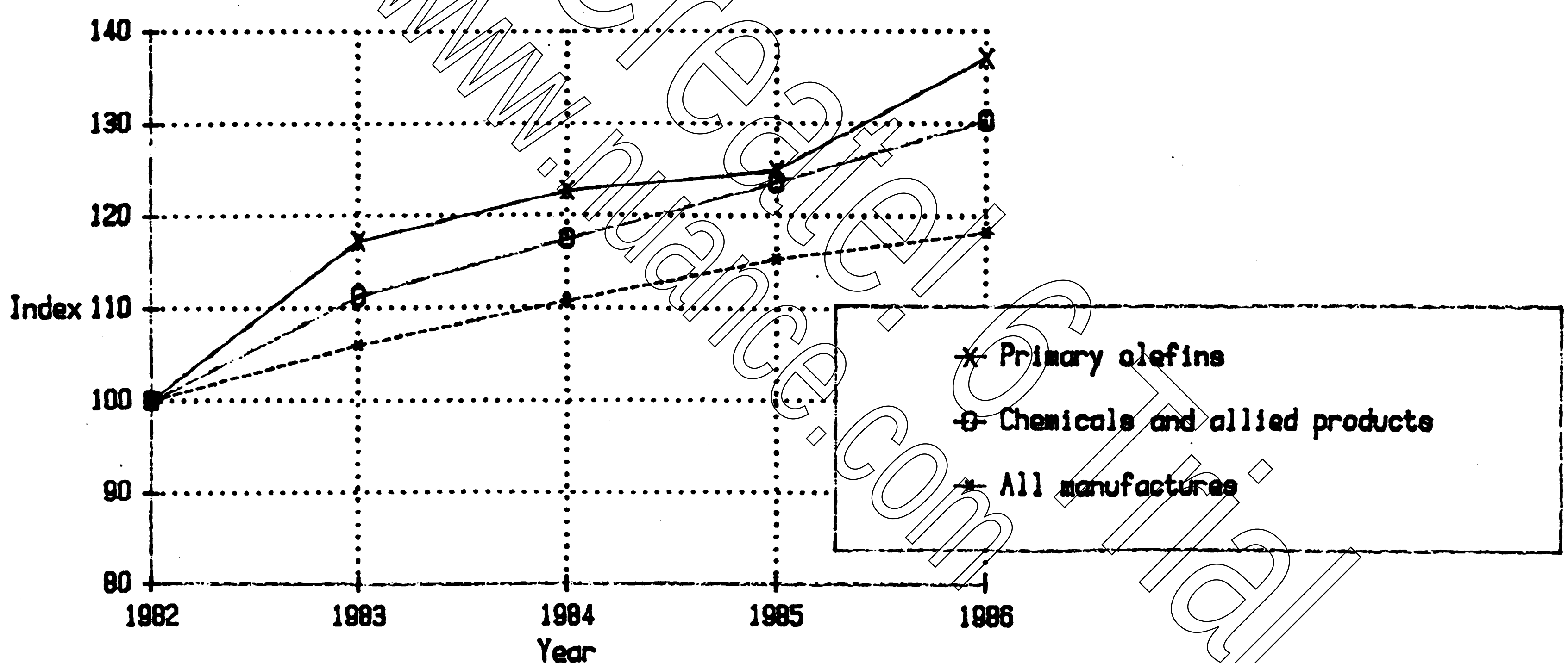
It is interesting to note that although personnel numbers were reduced to cut costs and as a result of restructuring, the questionnaire data indicate that wage rates were not uniformly reduced; this would also have reduced costs. 1/ One explanation is that union contracts helped maintain wages but it is also possible that companies did not want to further adversely impact employee morale in light of the personnel reductions.

6.6 Industry productivity

Figure 6-2 shows the relationship between productivity of the primary olefins as calculated from responses to the Commission questionnaire 2/ and the Federal Reserve Board productivity index 3/ for all manufacturing and for chemicals and allied products. 4/ Productivity has increased throughout the manufacturing economy at a steady pace during 1982-86; meanwhile, productivity of the chemicals and allied products industry increased from 1982 to 1986 at a faster pace. Productivity of primary olefins 5/ increased at an even more rapid, though more erratic pace than the other two measures. This index calculated for the respondent producers of primary olefins, shows a slowdown in the rate of increase of productivity during 1983-85. This slowdown may be associated with the rationalization of primary olefins capacity during that period. The slowdown may also be attributed to an adjustment in production levels related to previous year's overproduction. A further significant increase in productivity took place in 1986 related primarily to the rapidly declining costs of feedstocks.

1/ With the apparent exception of production workers for primary aromatics.
2/ Production volumes from U.S. International Trade Commission Synthetic Organic Chemicals, U.S. Production and Sales, 1981-85 editions; annual number of hours from Commission questionnaire with 28 respondents.
3/ Economic Report of the President, January 1987.
4/ "Chemical Industry Productivity Continued to Rise in 1986," Chemical & Engineering News, Mar. 9, 1987, p. 9, indexed to 1982=100.
5/ Insufficient data to compute a productivity index for primary aromatics.

Figure 6-2
Industry Productivity Indexes



Source: Compiled from official statistics of the U.S. Department of Commerce and from responses to the Commission questionnaire.

6.7 Primary petrochemical industry evaluation of its own companies

Before analyzing the raw data supplied in the Commission questionnaire to obtain values for measures of competitiveness, the respondents were asked to give a self-evaluation of their own (firm's) competitiveness. The following tabulation shows the results: 1/

Item	Highly Competitive	Competitive	Non-competitive	Percent highly competitive or competitive
Domestic market:				
Primary olefins......	5	17	3	88
Primary aromatics....	7	11	4	82
Primary derivatives..	7	21	3	90
Foreign market:				
Primary olefins......	1	5	7	46
Primary aromatics....	1	5	4	60
Primary derivatives..	3	16	4	83

According to the results displayed in the above tabulation, several firms now active in the production and marketing of primary petrochemicals and their derivatives believe they are actually noncompetitive in domestic, as well as foreign markets. None of these "noncompetitive" respondent firms are multinational in nature. Although several firms that believe they are highly competitive and many firms that believe they are competitive in the domestic market, far fewer firms believe that they can compete in foreign markets. 2/

6.8 Profitability

Net sales and net profits as summarized from the data reported by the respondents to the Commission questionnaire are shown in the following tabulation (in millions of dollars): 3/

1/ There were 33 firms responding to this question from the Commission questionnaire.
2/ The strategies that the firms indicate they will use to increase their competitiveness are presented and analyzed in Ch. 4.
3/ There were 29 firms that responded to this question from the Commission questionnaire.

Item	1982	1983	1984	1985	As of Aug. 31,--	
					1985	1986
Net sales:						
Primary olefins....	4,349	4,783	5,049	4,519	2,945	2,724
Primary aromatics..	2,169	2,226	2,058	2,199	1,423	979
Net profits:						
Primary olefins....	-115.7	-108.6	65.9	-133.7	-46.6	298.3
Primary aromatics..	39.3	59.3	45.0	30.9	28.7	61.8

The building-block petrochemical industry's net profit picture has recently improved, although only in 1984 did the respondents report a positive net profit for both primary olefins and aromatics ($66 million and $45 million, respectively), for the period 1982-85. However, a dramatic net profit turnaround occurred in 1986 based on the 8-month data obtained from the respondents. The data for the first 8 months of 1986 show a $298 million net profit versus a net loss of almost $47 million for respondents producing primary olefins during 1985, even though the value of sales declined in 1986. The respondent producers of primary aromatics reported a similar situation as their profits from production of primary aromatics increased to $62 million despite a 31-percent decline in the value of sales. The improved performance was due primarily to increased capacity utilization and lower costs, and probably to some derivatives market shakeout. The negative profitability data for the primary olefins and aromatics in earlier years may also be partially attributable to low transfer prices that may have been associated with the sale of these materials to associated companies or for intracompany transactions.

Over the 1982-86 period covered, the primary aromatics outperformed the primary olefins (for the questionnaire respondents) by a wide margin, as for each year the primary aromatics showed a net profit. Sales of each fluctuated and showed no clear trend, although both primary olefins and primary aromatics showed markedly improved net profits for the first 8 months of 1986 compared with the first 8 months of 1985.

6.9 Technologies

The respondents to the Commission questionnaire have indicated a major competitive advantage for the domestic industry in terms of both process and equipment technologies. The following tabulation highlights the questionnaire responses as to the location of the technology competitive advantages: 1/

1/ There were 20 firms responding to this question from the Commission questionnaire.

Item	Your firm	Domestic competitior	Foreign competitor	Percent domestic advantage
Process technologies:				
Primary olefins............	7	6	3	81
Primary aromatics..........	1	3	0	100
Derivatives of--				
Primary olefins..........	4	7	3	79
Primary aromatics........	2	3	2	71
Equipment technologies:				
Metallurgy.................	2	0	1	67
Glass technology...........	0	0	0	-
Ceramics technology........	0	0	0	-
Design of:				
Pumps....................	1	1	0	100
Reactor vessels..........	2	0	1	67
Condensers...............	1	0	1	50
Drivers..................	0	1	0	100
Pipelines................	1	1	0	100

The preceeding tabulation indicates that domestic firms believe they hold competitive advantages in production processes both for the primary petrochemicals and their derivatives. With regard to the equipment technologies, the responses indicated that there was not a significant difference in the technologies, either among the domestic competitors or between them and the foreign competition.

6.10 Company financial data

In addition to the data from the questionnaires, statistics have been compiled from the Datext 1/ Financial Service concerning the financial status of the U.S. firms that produce building-block petrochemicals.

Table 6-2 gives the average, minimum, and maximum values of certain financial parameters as reported to the Securities and Exchange Commission by the public companies that participated in the U.S. industry for 1984 and 1985. 2/ Data in this table highlight some of the changes in these parameters and indicate the large variation within these companies. Also, there was a marked improvement from 1984 to 1985 in net sales, although net income declined. The cost of goods declined slightly, and the total R&D expenditures

1/ Datext Inc., Woburn, MA.
2/ Data were available only for those companies that report data to the SEC, i.e., there were no data included in this compilation from privately owned companies. As such, 25 companies were represented of the total of 45 companies that comprise the domestic industry.

(as opposed to R&D for primary petrochemicals) increased, both being positive indicators of the rejuvenating competitiveness of the companies involved. 1/ In many cases, the companies are not oriented toward chemicals but toward energy materials, and therefore react even more dramatically to changes in the world petroleum situation.

1/ Ibid.

Table 6-2
U.S. Producers: Financial statistics, 1984-85

	Cost of goods	Net sales	Net income	Debt-to-equity ratio	R&D expense	R&D as percent of sales	Return on equity (ROE)	Return on assets (ROA)
	1,000 dollars			Percent	1,000 dollars	Percent		
1984:								
Minimum.............	944	1,711	-172,478	0.01	51,689	1	-24.1	-10.3
Maximum.............	58,865,000	95,873,000	5,528,000	3.51	1,621,000	8	19.2	8.7
Total...............	281,266,362	385,608,223	19,334,557	-	8,957,198	-	-	-
Average 1/..........	1,125,065	1,542,409	773,382	-	639,800	-	-	-
1985:								
Minimum.............	779	1,456	-581,000	.16	53,334	1	-119	-15.7
Maximum.............	54,238,000	91,620,000	4,870,000	1.07	1,705,000	8	25.4	8.5
Total...............	281,865,928	422,824,266	16,002,215	-	9,225,427	-	-	-
Average 1/..........	1,127,464	1,691,297	640,089	-	709,648	-	-	-

1/ The number of companies reporting data for each particular statistic may have varied.

Source: Data compiled by Datext, Inc., Woburn, MA, from various public sources.

Chapter 7. Competitive Implications for U.S. Domestic Consuming Industries

This chapter analyzes how changes in the level of competitiveness of the U.S. building-block petrochemical industry would affect U.S. end-user industries that depend on domestic suppliers of materials with significant petrochemical content. It particularly emphasizes the automobile, construction, and packaging industries. Because of the diversity of these industries, they are useful as indicators of possible impact on different types of end-user industries.

The current reliance of such industries on domestic suppliers does not necessarily support an assumption of adverse consequences associated with a scenario of declining competitiveness of the U.S. primary petrochemical industry. Such adverse effects are less likely to occur, for example, the more the end-product industries:

1. Use a standardized commodity-type material.
2. Have multiple supply sources worldwide.
3. Face low unit transportation costs.
4. Can substitute with materials of lower or no petrochemical content.

Conversely, certain product or supplier characteristics can create an end-user industry dependency, such as:

1. An absence of alternative sources of supply.
2. High unit transportation costs.
3. Tight delivery schedules.
4. Special quality requirements.
5. Special technical specifications.
6. Technological leadership.
7. Special services and technical support.
8. Customer service requirements.
9. Supplier reliability.

The automobile industry and the construction industry produce the most visible products using materials that have significant petrochemical content. The actual building-block petrochemical content in these end-use materials is not traceable on a quantitative basis because there is virtually no accounting made throughout the various value-added intermediate processes. Table 7-1 shows, by 4-digit Standard Industrial Classification (SIC) codes, a rough accounting of those industry sectors that report the highest share of their total material cost expenditures attributable to materials derived from basic petrochemicals, along with the respective share of those materials and the total reported costs of the petrochemical-based raw materials. 1/ Sectors

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1/ Compiled from data published by the U.S. Department of Commerce in the 1982 Census of Manufacturers.

Table 7-1
End-user industry sectors: Consumption of materials derived from basic petrochemicals, 1982

SIC industry classification (by 4-digit SIC code)	Materials consumed in production process: Total	Materials consumed in production process: Derived from basic petrochemicals	Ratio of petrochemical material cost to total material cost
	-----Million dollars----		Percent
Tires and inner tubes (3011).........	4,037.9	2,252.3	55.8
Miscellaneous plastics products (3079)..................	17,099.3	9,359.0	54.1
Rubber and plastic hose and belting (3041)....................	764.5	400.7	52.4
Fabricated rubber products, n.e.c. (3069).....................	2,744.0	1,127.0	41.1
Bags, except textile bags (2643).....	2,797.3	1,000.7	35.8
Rubber and plastics footwear (3021)..	277.5	85.4	30.8
Paper coating and glazing (2641).....	2,857.2	743.5	26.0
Truck trailers (3715)................	1,092.0	112.7	10.3
Folding paperboard boxes (2651)......	2,089.1	113.5	5.4
Setup paperboard boxes (2652)........	166.1	7.8	4.7
Electronic connectors (3678).........	856.1	39.5	4.6
Motor-vehicle parts and accessories..........................	17,772.2	792.2	4.5
Construction machinery (3531)............................	5,507.9	237.1	4.3
Motor vehicles and car bodies........	54,582.8	2,052.3	3.8
Fiber cans, drums, and similar products (2655)....................	850.0	27.4	3.2
Truck and bus bodies (3713)..........	1,227.0	37.5	3.1
Corrugated and solid fiber boxes................................	6,511.8	174.4	2.7
Sanitary food containers (2654)............................	1,423.9	37.4	2.6
Fabricated metal products, n.e.c.....	1,763.8	36.5	2.1
Valves and pipe fittings (3494)......	3,211.5	64.5	2.0
Conveyors and conveying equipment............................	1,113.2	21.1	1.9
Electronic components, n.e.c. (3679)............................	5,455.6	100.3	1.8
Industrial trucks and tractors (3537)....................	1,040.7	16.5	1.6
Semiconductors and related devices (3674)....................	2,966.6	41.1	1.4

Source: Compiled from official statistics of the U.S. Department of Commerce.

that have the greatest potential for being affected by changes in the status of the U.S. petrochemical industry tend to be part of the packaging industry, the construction industry, and one of the transportation industries.

7.1 Automotive industry

Petrochemicals and their downstream derivatives are an integral part of the automotive industry. End products of petrochemicals consumed by this industry include lubricants, adhesives and sealants, fabrics and carpeting, gaskets, belts and hoses, paints and pigments, dyes, synthetic elastomers, tires and tubes, electrical components, and other fabricated rubber and plastic products. As shown in table 7-2, raw materials used in the production of U.S. automobiles declined from an estimated 3,762 pounds in 1976 to 3,175 pounds in 1986, or by 16 percent, according to data published in Wards Automotive Yearbook, 1986. Downsizing was a direct result of the petroleum-price shock of 1973 when Federal Government imposed fleet fuel consumption standards and the demand for lighter, smaller, more fuel-efficient automobiles increased significantly. Overall, however, the absolute quantity of petrochemical-based materials in the average automobile increased from 506 pounds in 1976 to 532 pounds in 1986. This increase combined with the overall reduction in materials means petrochemical-based materials went from 13 percent of total materials in 1976 to 18 percent in 1986. 1/

In keeping with the total weight reduction, the use of plastics and plastics composites increased from about 163 pounds per automobile in 1976 to 216 pounds per automobile in 1986, or by 33 percent. 2/ The need for U.S. automobile manufacturers to compete with an ever-increasing import penetration means that even if automobile production declines, the consumption of certain petrochemical end products, notably engineering plastics resins, should grow at rates exceeding the Gross National Product (GNP) growth.

The steel industry, which supplies roughly 50 percent of the raw materials used for passenger cars, is also responding to the need for lighter and stonger automotive components. 3/ A recent study by the American Iron & Steel Institute (AISI) concluded that as much as 17 percent could be saved on the "body-in-white" 4/ costs of a passenger automobile by improving the uniformity of the coil steel provided by the steel industry and increasing the stamping efficiencies within the automotive industry. 5/ A further illustration of the efforts toward closer coordination between the two industries can be seen in Northwestern University's Steel Resource Center, which provides an academic forum to bring together steel suppliers and steel users.

1/ Wards Automotive Yearbook, 1986, p. 27.
2/ Ibid.
3/ R.P. Harvey and D.N. Smith, "Steel vs. Plastics," Automotive News, Sept. 1, 1986, pp. D18 and D20.
4/ An assembled, but unpainted, automobile body.
5/ K.K. Kappmeyer, "Marriage of Convenience," Automotive News, Sept. 1, 1986, pp. D22-D24.

Table 7-2
Estimated raw materials usage for passenger cars, 1976 and 1986

Material	Quantity 1976	Quantity 1986	Share of total material used 1976	Share of total material used 1986
	-------Pounds---------		-------Percent-------	
Non-petrochemical-based:				
Plain carbon steel............	2,075	1,470	55.2	46.3
High strength steel...........	120	224	3.2	7.1
Stainless steel...............	28	31	.7	1.0
Other steel...................	56	56	1.5	1.8
Iron..........................	562	466	14.9	14.7
Aluminum......................	86	140	2.3	4.4
Glass.........................	88	86	2.3	2.7
Cooper........................	32	26	.9	.8
Lead..........................	25	24	.7	.8
Zinc die castings.............	44	18	1.2	.6
Other.........................	140	102	3.7	3.2
Total.....................	3,256	2,643	86.5 1/	83.2 1/
Petrochemical-based:				
Plastics/composites...........	163	216	4.3	6.8
Fluids/lubricants.............	190	181	5.1	5.7
Rubber........................	153	135	4.1	4.3
Total.....................	506	532	13.5	16.8
Total.....................	3,762	3,175	100.0	100.0

1/ Because of rounding, figures may not add to the totals shown.

Source: Compiled from data published in Wards Automotive Yearbook, 48th ed., 1986, p. 27.

Relationship to building-block petrochemicals.--According to the Society of the Plastics Industry, Inc. (SPI), approximately 4.4 percent of total plastics production in 1985 (except polyurethanes) was used in the transportation industry. The passenger car and small truck sector consumed about 91 percent of all plastics resins sold directly to the transportation industry in 1985.

Data compiled from the four automotive industry respondents to the Commission's questionnaire 1/ on purchases in 1985 of certain materials with significant petrochemical content are shown in table 7-3. The total value of these purchases was $4.3 billion. Plastics and resins accounted for 3.5 percent or $149 million and represented about 19 percent of the value of total sales to the automotive industry.

Table 7-4 shows the principal resins sold to the passenger car and small truck sector during 1981-85. Total direct resin sales increased during 1981-85 by 25 percent to a quantity of 1.6 billion pounds with an estimated value of $786 million. 2/ The trend of individual resin sales varied considerably during this period. The SPI data base does not, however, provide information on plastics parts manufactured for the transportation industry by contract suppliers, or on imports.

A recent survey published in a plastics trade journal showed that 614 domestic processors of plastics now serve the domestic automotive market. 3/ Based on the response to their survey, the processors reported that sales to the automotive sector represented around 44 percent of their custom business. Other sources have estimated that in 1984, the automotive industry represented $1.5 billion of the total plastics market. 4/ This latter estimate is approximately 3 percent of the value of shipments in 1984 of miscellaneous plastics products classified under SIC 3079 by the U.S. Department of Commerce (DOC). 5/

According to the four auto manufacturers responding to the Commission's current questionnaire, the total value of purchases of products containing significant petrochemical polymers content during 1985 was $1.4 billion. As the respondents do not constitute the entire automotive industry and as the questionnaire data represents 93 percent of the estimate provided by the Journal of Commerce, the latter estimate of $1.5 billion is probably still a conservative evaluation of the actual market size.

1/ See app. C for the survey methodology.
2/ Value estimated by using the unit value of the grand total of plastics resins sales as reported in Synthetic Organic Chemicals, United States Production and Sales, 1985, USITC Publication 1982.
3/ Carl Kirkland, "Custom Molders vs. Detroit: Deep Dissatisfaction Remains," Plastics Technology, August 1986, pp. 52-55.
4/ The Journal of Commerce, Jan. 21, 1986, pp. 1A, 21B.
5/ 1986 U.S. Industrial Outlook, U.S. Department of Commerce/International Trade Administration, Washington, DC.

Table 7-3
Materials with significant petrochemical content purchased in 1985 by domestic automobile manufacturers responding to the Commission's questionnaire

Product type	Value	Percent of total
	Million dollars	
Tires and tubes 1/	1,360	31.8
Coated and manmade fabrics	1,275	29.8
Paints and allied products	553	12.9
Miscellaneous plastics products	502	11.8
Plastics and resins	149	3.5
Adhesives and sealants	127	3.0
Rubber and plastic hose and belting	125	2.9
Fabricated rubber products	106	2.5
Gaskets and sealing devices	76	1.8
Total	4,273	100.0

1/ Questionnaire respondents indicate that tubes comprise a very small portion of the value of these purchases as the majority of passenger vehicles and light trucks are equipped with tubeless tires.

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

Table 7-4
Plastics resins sold directly to the passenger car and small truck sector of the transportation industry, 1981-85

Material	1981	1982	1983	1984	1985	Average annual percent change 1981-85
	Quantity (million pounds)					
ABS 1/	115	66	75	125	130	3.1
Acrylic	29	18	27	23	23	-4.8
Nylon	53	62	88	104	114	21.0
Phenolic	20	13	16	18	19	-1.2
Polyacetal	13	13	18	19	18	8.5
Polycarbonate	18	11	16	22	25	8.6
Polyethylene	11	42	51	70	74	62.0
Polypropylene	221	210	254	270	285	6.5
Polyurethane	353	254	289	435	449	6.2
Polyvinyl chloride	143	119	132	160	157	2.4
Thermoplastic polyester	13	13	16	28	30	23.3
Unsaturated polyester	254	121	154	180	199	-5.0
Other	33	115	132	73	76	23.4
Total	1,275	1,056	1,266	1,527	1,599	5.8
	Percent of total quantity					
ABS	9	6	6	8	8	-
Acrylic	2	2	2	2	1	-
Nylon	4	6	7	7	7	-
Phenolic	2	1	1	1	1	-
Polyacetal	1	1	1	1	1	-
Polycarbonate	1	1	1	1	2	-
Polyethylene	1	4	4	5	5	-
Polypropylene	17	20	20	18	18	-
Polyurethane	28	24	23	28	28	-
Polyvinyl chloride	11	11	11	10	10	-
Thermoplastic polyester	1	1	1	2	2	-
Unsaturated polyester	20	12	12	12	12	-
Other	3	11	11	5	5	-
Total	100	100	100	100	100	-

1/ Acrylonitrile-butadiene-styrene resin.

Source: Facts and Figures of the U.S. Plastics Industry, 1986 Edition, the Society of the Plastics Industry, Inc., Washington, DC 20036.

That section of the chemical processing industry producing synthetic polymers views the automotive industry (including passenger cars and small trucks) as potentially a high-growth market. Starting from a current base level of between 146 and 186 pounds of plastics products per vehicle in 1985, they expect the quantity to increase to around 300 pounds per vehicle by 1990. 1/ Presently, all domestically produced automobiles use plastics in interior, trim, electrical, and certain mechanical parts. The three main motives driving the growing market for automotive plastics use are weight reduction, model differentiation, and production cost savings. One plastics industry trade journal segmented the automotive market into large sedans, sport cars, economy cars, and light trucks. 2/ Plastics use in each segment will be determined by different factors, but thermoplastics will remain the principal type of resins used as shown in table 7-5.

Large sedans.--For large sedans, the emphasis will be principally the weight-reduction advantage of plastics versus steel and the potential for more model differentiation within a fixed production volume for this class of vehicle. This latter consideration favors plastics body components since tooling costs for similar steel parts would be considerably higher. Replacement of steel bumpers with plastic reduces the weight of this part by about 40 percent but still meets the 5-mile-per-hour impact requirement. 3/ According to one U.S. producer of resins for the automobile market, the tooling costs for a set of fenders made from plastics are only 15 percent of the tooling costs for the equivalent steel product, or about $600,000. 4/

All-plastics automobile.--In 1953, the first all-plastic body automobile was introduced into the U.S. market--the Corvette. The fiberglass-reinforced plastics body was designed to contribute structural integrity to the vehicle, as did the traditional material, sheetmetal. With the introduction of the Pontiac Fiero in 1983, the same U.S. automobile manufacturer entered the U.S. market with another innovation. The Fiero is an all-plastic-body vehicle, but the body panels are hung on a steel birdcage frame. This birdcage construction enables the plastic panels to be processed separately from the frame components and hence expands the types of plastics that may be used. However, the body panels do not contribute to the structural integrity of the vehicle. Within this sport class of vehicles, the advantage offered by the lower tooling costs of plastics will permit manufacturers to offer more model diversification. This type of vehicle is not exceptionally price sensitive; hence, manufacturers will probably use these product lines to introduce innovative plastics applications prior to incorporating these into their larger unit volume models.

1/ Business Communications Co. News Release, December 23, 1985.
2/ "A Business Look-Ahead: Seven Key Plastics Markets," Plastics World, January 1986, pp. 52-54.
3/ R. Serpa, "Thermoplastic opportunities in exterior auto components-we've just begun," Advanced Materials--New Opportunities for Chemicals, the Chemical Marketing Research Association, February 1986, pp. 49-53.
4/ "GE says auto body panels key to resins growth in 1986," Chemical Marketing Reporter, Mar. 24, 1986, p. 5.

Table 7-5
Plastics polymers applications in the automotive industry

Application	Consumption 1985	1990	1995	Average annual rate of growth
	------Million pounds-----			Percent
Vertical panels	-	9	21	18.4
Hortizontal panels	6	30	84	30.3
Front end	165	207	213	2.6
Structural parts	1	6	20	34.8
Functional/mechanical parts 1/	228	255	267	1.6
Total	400	527	605	4.2

1/ Petrochemical derivatives are used in brake linings, radiator cooling fans, brake cylinder reservoirs, battery casings, ignition wiring systems and other electrical components, and in numerous other functional and mechanical applications.

Source: Plastics World, January 1986, p. 53.

In responding to Commission questionnaires, only one of the four respondents considered increased diversity of product mix and models in order to strengthen market position as an important factor in competitive trends and future competitiveness.

Economy models.--In the economy models, domestic manufacturers face heavy price competition from imports. Under these conditions, design considerations will not tolerate any innovation that does not confer a simultaneous cost-reduction advantage. 1/ With the exception of the so-called clean-sheet projects underway by the three major domestic producers to develop a totally new production process, the economy class of vehicles will be material hybrids for the near future. The first use of thermoplastic body panels was made in this class of vehicle by the Japanese automobile manufacturer Honda in the Civic CRX model. 2/ Also, the CRX front and rear bumpers are molded from a type of polypropylene.

Light trucks.--The light truck market is, for the most part, not under as much competitive pressure from foreign manufacturers. Nevertheless, cost savings from the ability to mold one complex part in one step, such as in tailgates and weight-reduction and design changes using composite materials for drive-train components, is forthcoming. 3/ The lower liability risks faced by the automobile producers for this utility class of vehicles will probably permit introduction of applications such as plastic fuel tanks in these limited-production areas. 4/

Body panels.--Body panels can be divided into vertical components (fenders and doors) and horizontal components (hoods, decks, and roofs). Presently, sheet molding compound (SMC) 5/ and reinforced reaction-injection-molding (RIM) polyureas 6/ are lead materials in vertical body component applications. Body panels must be produced with what the automotive industry refers to as a Class A surface, which is one that is free of blemishes and can take a high gloss finish. Both SMC and RIM polyureas must be painted offline, which is one limitation of these plastics materials components that must be considered at the vehicle design stage. Online painting ovens range from 290° to 400° F, but RIM parts can tolerate only 240° F maximum. However, recent changes in solvent emission standards are causing automobile manufacturers to move away from the low-solids paint formulations which

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1/ "A Business Look-Ahead: Seven Key Plastics Markets," Plastics World, January 1986, pp. 52-54.
2/ R. Serpa, op. cit.
3/ "A Business Look-Ahead: Seven Key Plastics Markets," Plastics World, January 1986, pp. 52-54.
4/ Ibid., and B. Miller, "Composite Structures: Next Wave in Detroit," Plastics World, November 1986, pp. 30-34.
5/ Sheet molding compound is a polyester resin reinforced with glass fibers longer than 1/2 inch.
6/ Glass-flake-polyurethane resins designed to be processed by RIM methods. See Glossary of terms.

required these high oven temperatures to high-solids formulations that allow thinner coats and reduce solvents levels as well as lower paint consumption. 1/ With these new paint systems oven temperatures as low as 175°F will be possible permitting online painting of plastics components.

Honda has used a resin composed of polycarbonate and acrylonitrile-butadiene-styrene (ABS) for the fenders on one Japanese-produced sports car. Other limited-production domestic models have used RIM-urethane fenders as early as 1981, which were reportedly 50 percent lighter than the equivalent steel fenders, but the costs of production were slightly greater for the plastic product.

At the present time, vertical body components are formed from SMC by a process using heat and pressure. This process has been constantly refined since the mid-1960's and is now capable of producing a part within the 1-minute cycle time required to match the one-per-minute automobile assembly rate of domestic automobile manufacturers. Matching part production and assembly rates permits auto producers to apply just-in-time (JIT) parts delivery manufacturing principles that confer considerable savings by permitting inventory reduction. But SMC methods are limited to only one certain type of compounded plastic resin and other special resins have been developed which yield a finished part with properties superior to SMC. These newer resins are processed by a method called RIM. The RIM process is more energy efficient than SMC, but, until recently, could not match the 60-second cycle time of SMC. Now, however, improvements in the RIM process have improved cycle times to 60-70 seconds per part, enabling processors to begin using a wider range of plastics resins. According to one plastics industry source, RIM-molded fenders can be produced more economically than their steel counterparts in volumes of 100,000 to 150,000 units per year. 2/

Horizontal body panels such as hoods and rear-deck lids have an additional requirement that must be met beyond those specifications already mentioned for vertical components, namely the ability to withstand high temperatures without sagging. To impart greater stiffness to these components, one domestic plastics molder developed an assembly process and built the molds to make a two-piece bonded hood assembly using SMC consisting of an outer skin and a reinforcing inner frame spider for support. 3/ Volvo, the Swedish automobile manufacturer, financed the development work and incorporated the part into its luxury sport sedan to be introduced in the fall of 1987. Volvo's design engineers required that the plastic part have no detectable difference from a steel hood. It had to match the surface quality of steel as well as the audible closing sound of a steel part. Collision performance also had to be identical, and here Volvo introduced the concept of designing deformation lines into the structure, which make the hood fold in a controlled fashion during collision.

1/ O. Kean, "Solvent Rules Spur New Auto Finishes," Chemical Marketing Reporter, Nov. 3, 1986, pp. 29-30 and 40.
2/ R. Serpa, op. cit.
3/ "Volvo Bets on SMC Panels," Plastics World, November 1986, p. 15.

Body panels and structural components offer high-growth opportunities for the plastics industry, and hence basic petrochemicals. Presently, two-thirds of all plastics consumed by the automobile industry go into automotive interior components such as instrument panels, floor consoles, seats and uphostery, and carpeting. 1/ Many new polymer blends have been developed to satisfy the special requirements for interior components. Since interior surfaces are generally textured, instead of the smooth class A surfaces needed for exterior applications, the types of resins and forming processes that can be used are far greater in number than those used for body panels. Federal legislation to mandate passive-restraint devices by 1989 is being considered that would require manufacturers to provide "soft" interiors to protect vehicle occupants in a 30-mile-per-hour impact. Such requirements will mean that interiors will need additional padded surfaces that will use more foamed plastics.

Other uses.--Vehicle manufacturers have already introduced drive-train components made from glass-fiber-wound epoxy resins. 2/ One U.S. automobile manufacturer successful with a filament-wound driveshaft in vans plans to expand usage to a heavier class of utility vehicle. Another domestic producer using reinforced plastic springs of fiberglass epoxy in its sports model has now begun to use this substitute part on its heavier luxury sedans. 3/ Other components such as engine valve covers, water pumps, and air cleaner housings will provide areas for substitution of heat-resistant plastics parts. 4/ One U.S. company, collaborating with a major U.S. petrochemical producer, has successfully developed a plastic engine for racing applications, and has expanded its program to include a second larger engine. 5/

In addition to the more visible substitution of petrochemical-based plastics for major structural and functional automotive components, the use of these types of materials requires new assembly techniques such as the use of adhesives rather than spot welding. 6/ One such system developed by a U.S. subsidiary of a foreign-based multinational chemical firm includes a robotic system for dispensing and applying the adhesive in a tape form. The permanent weld-type bond is then formed when the vehicle assembly passes through the heated paint oven. Based on data compiled from Commission questionnaires, the total value of adhesives and sealants purchased by all four respondents during 1985 was $127 million. All of the respondents purchased these items from U.S. suppliers.

1/ S. Wood, "Detroit's Real Proving Ground is Automotive Interiors," Modern Plastics, October 1986, pp. 46-50.
2/ J. Best, op. cit.
3/ "A Business Look-Ahead: Seven Key Plastics Automotive Markets," Plastics World, January 1986, pp. 52-54
4/ M. Schlack, "Under-Hood Plastics: Detroit Shifts Into Gear," Plastics 6orld, November 1986, pp. 41-44.
5/ "Polimotor Introduces Plastic V-6 Engine," Plastics World, November 1986, pp. 72-74.
6/ "An Adhesive System for Car Makers," Chemical Week, June 4, 1986, p. 43.

With the new Federal regulations regarding solvent emission levels in the workplace, automobile manufacturers have already begun shifting to petrochemical-based paint systems such as polyurethanes and others, which can not only maintain the deep-glass look of the older high-solvent systems, but are more compatible with plastics panels and use lower-temperature paint ovens for curing. 1/ This latter factor could simplify vehicle assembly line operations since plastic panels could be painted online. Data compiled from Commission questionnaires show that the total value of paints and allied products purchased during 1985 by all respondents was $552.8 million, or 12.9 percent of all petrochemical products purchased (excluding lubricants and additives) during this period.

Other petrochemical products used by the automotive industry include oils and greases. Specific information concerning OEM uses by automotive manufacturers is not available.

Forecasts of plastics use.--Forecasts for the increase in plastics use in the automotive market vary depending on the type of plastics and the process technology in question. The use of engineering thermoplastics is anticipated to increase by more than 50 percent during 1985-90, or 8.5 percent per year, according to a U.S. subsidiary of a major foreign multinational chemical producer. 2/ One spokeman for this firm stated that the most impressive growth will be in the use of compounded engineering thermoplastics, where a 74-percent increase in demand can be expected during the next decade. The company also states that "Twenty years ago, plastics accounted for 2-4% of car weight . . .; currently plastics constitute 8-10% of car weight; by the year 2000 it will be 15-20%." Another major U.S. resin producer predicted that engineering plastics consumption by domestic automotive producers will show "at least" a 20-percent annual growth rate well into the next century. 3/ A U.S. multinational chemical firm, which is one of the world's largest chemical producers, stated that their automotive business accounts for about $1.0 billion of their total annual sales and is expected to increase fourfold by the year 2000. 4/ To further emphasize the degree of importance this firm places on its automotive business segment, the head of its new automotive division stated that, "... if the new unit was an independent company it would

1/ O. Kean, "Solvent Rules Spur New Auto Finishes," Chemical Marketing Reporter, Nov. 3, 1986, pp. 29-30, p. 40.
2/ "Mobay Forecasts Increased Automotive Plastics Use Opens Detroit Sales Office," Plastics Technology, August 1986. p. 75.
3/ "GE Says Auto Body Panels Key to Resins Growth in 1986," Chemical Marketing Reporter, Mar. 24, 1986, p. 5.
4/ "DuPont Sets Automotive Unit With $2 Billion in Annual Sales," Chemical Marketing Reporter, June 9, 1986, pp. 3 and 26.

rank among Fortune's list of the nation's top 200 firms." 1/ The company has invested $25 million in a corporate automotive center located in Troy, MI to service the surrounding automobile plants more effectively. 2/ Other domestic chemical producers have publicly announced their intentions to direct significant portions of their research, marketing, and sales efforts toward establishing a strong presence in the automotive industry. 3/

Sourcing of materials. Concern is growing, however, over the extent to which foreign-based automobile producers with U.S. assembly plant facilities will continue to source their parts purchases from home-country suppliers. 4/ Japanese and Korean companies with U.S. locations are estimated to represent a combined purchasing power of around 540 million pounds of plastics and elastomers by the year 1990. 5/ Should these raw materials purchases come from foreign sources, the potential domestic market outlook will be less positive.

To counter the possible foreign purchasing of such products, U.S. firms are concentrating on improving or developing new technology and specialty resins. According to some industry representatives, aggressive marketing will play a crucial role if these potential high-growth opportunities are to be realized. 6/ Foreign suppliers are also aware of the need to remain technologically competitive with other world chemical producers and are actively developing new polymers for specific applications. 7/ To gain the fullest advantages offered by the automotive market, U.S. chemical producers, suppliers, and molders will have to establish international relationships and joint ventures similar to some arrangements already existing. 8/ An additional problem facing U.S. chemical producers and parts suppliers will be

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1/ Ibid.
2/ Ibid.
3/ "Mobay Forecasts Increased Automotive Plastics Use-Opens Detroit Sales Office," Plastics Technology, August 1986, p. 75.
"GE, PPG in Joint Venture to Produce Thermoplastic SMC," Plastics Technology, August 1986, p. 75; "Celanese Acquires GAF's Engineering Resins," Plastics Technology, p. 75; "General Electric Plastics," Chemical Week, Nov. 12, 1986, pp. 30-33; "Monsanto Targets Detroit for New ABS," CPI Purchasing, August 1986, p. 51; "BASF Plastics Unit Gears for Specialties," Chemical Marketing Reporter, Sept. 22, 1986, p. 7; and "Dow Auto Activity," Chemical Marketing Reporter, Oct. 20, 1986, p. 9.
4/ "Auto Parts Makers Gird for War," Chemical Week, Apr. 2, 1986, pp. 8-10, and "Auto Plastics Uses by Japanese in the U.S. Seen Having Major Impact on the Industry," Chemical Marketing Reporter, June 9, 1986, p. 4.
5/ Ibid.
6/ "Change Comes to the Resins Market," Chemical Week, Nov. 26, 1986, pp. 102-104.
7/ J. Dunphy, "Japan's Advances in Polymers Pose a Challenge," Chemical Week, Apr. 13, 1986, pp. 8-10.
8/ "Auto Plastics Uses by Japanese in the U.S. Seen Having Major Impact on the Industry," Chemical Marketing Reporter, June 9, 1986, p. 4, and "Carbides' Kennedy Sees Wave of Transnational Partnerships," Chemical Marketing Reporter, Nov. 3, 1986, p. 4.

the degree to which U.S. automobile producers will move production offshore to take advantages of lower wage rates and special duty provisions--moves which some automotive producers have already begun. 1/

Based on the available questionnaire data and data from other sources, the value of imported motor- vehicle parts as a share of the value of U.S. automobile production in 1985 was between 10 and 13 percent for wholly owned domestic firms and, for foreign subsidiaries, 50 percent or more. At least one respondent emphasized the need for producers and suppliers to form stronger international marketing relationships, and cited certain of their own actions toward this end.

Repairs to damaged vehicles.--At the present time, the use of plastics in motor vehicles is concentrated in interiors and bumpers. Although exterior uses for plastics, namely body panels, represent the largest potential growth market through substitution for traditional sheet metal, there are a very limited number of production automobiles actually using exterior panels of plastics materials. The majority of vehicles sold still use sheet steel stampings for body panels. Industry sources, such as the Inter-Industry Conference on Auto Collision Repair (I-CAR) feel that the actual cost of any single repair job is determined primarily by the conditions of the local market in which the work is done. 2/ If the current average costs of materials is considered, the replacement part price of a plastic versus a steel panel component is nearly identical. However, the repair cost for the plastic part would be greater than the repair using a similar metal part for the following reasons. Mounting a hybrid part, such as a plastic fender or door, to a metal frame requires several operations using a variety of additional materials (welding, adhesives, and fasteners) as compared with a single welding or bolting procedure for the equivalent metal part. I-CAR also pointed out that although the actual technology for repairing or replacing a plastic part on a hybrid vehicle is not difficult to learn, there is a lack of dissemination of this information throughout the domestic automobile repair industry. The association is in the process of developing training courses for its member organizations to remedy the problem.

The resistance of plastics to corrosion and the ability to spring back into shape after a low-energy impact are the two most favorable aspects as viewed by the automobile insurance industry. However plastic bumpers, once deformed, cannot be repaired but must be replaced, according to the Automobile Dismantlers and Recyclers Association (ADRA). 3/

Recycling and waste disposal.--The solid waste disposal problem has become a major concern to every industry. Metal reclamation and reprocessing plants have already proven to be a useful and efficient means of reducing the disposal problem associated with scrap automobiles. Some plastics can be recycled, but the cost competitiveness of resins produced from recycled

1/ S. Finley, "Special Custom Codes Send Molders South of the Border," Plastics World, November 1986, p. 19.
2/ Staff telephone conversation with an executive of the Inter-Industry Conference on Auto Collision Repair, Des Plaines, Illinois.
3/ Ibid.

plastics will depend on the costs of the virgin resins, which is mostly attributable to their feedstock costs. 1/ These latter costs, in turn, fluctuate in relation to the world price of crude petroleum or natural gas. Presently, the cost of virgin resin is low compared with the cost of recycling. Resin producers are also researching the ways that reprocessed materials must be handled to be suitable for reuse in a given end-market. 2/

Many plastics industry participants see recycling as only part of the answer to plastic scrap disposal, as some plastics undergo an irreversible chemical change when molded unlike a stamped steel part, and they cannot be recycled. They feel that an alternative to landfill disposal of plastics parts might be waste-to-energy incineration. 3/ However, the potential for such a process has not yet been investigated, leaving unanswered questions concerning such problems as potential toxicity. Also, the ADRA feels that the recyclable portions of scrapped vehicles has been declining significantly over the past several years and the rate of this decline is increasing. According to one ADRA spokesman, the percentage of nonusable material that automobile salvage dealers have to transport to landfills represents between 15 and 20 percent of a vehicle's weight. ADRA also added that the demand for undamaged replacement parts has declined, as the more corrosion-resistant plastics materials replace traditional materials on vehicles. 4/

Competitive status of the consuming industry.--According to one source, the vehicle cost differential between equivalent Japanese and American products is in the range of $1,300 to $1,700. 5/ The article points out that every subsystem of a vehicle produced by the "Big Three" is more expensive than that of an equivalent vehicle produced in Japanese plants. To narrow this price differential, some domestic automobile producers have already begun to redesign their manufacturing processes and substitute plastics materials for the more traditional materials. Historically, the automotive producers controlled the design and materials of each subsystem to be used in a new model vehicle. But under the newly initiated cost-reduction moves, the design of a new part and the selection of materials from which it will be made are being performed increasingly by the parts suppliers.

Chemical firms producing plastic resins, as well as other industries supplying the automotive manufacturers, have also recognized the need for this share-the-risk concept in order to take full advantage of this potential high-growth market. At least five major resin producers have already established facilities in and around the Detroit area to more closely serve the product development needs of the automotive market. This distribution of R&D responsibility carries with it the assumption that cost effectiveness,

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1/ "GE Examines the Recyclability of Thermoplastic Automotive Parts," Chemical Engineering, Mar. 16, 1987, p. 11.
2/ R.D. Leaversuch, Industry Begins to Face up to the Crisis of Recycling," Modern Plastics, March 1987, pp.44-47.
3/ Ibid.
4/ Staff telephone conversation with an executive of the Automotive Dismantlers and Recyclers Association.
5/ R.P. Hervey and D.N. Smith, "Steel vs. Plastics," Automotive News, Sept. 1, 1986, pp. D18 and D20.

along with product expertise, will be an integral part of all subsystem designs from the resin producers to the final end-product vehicle manufacturer.

A comprehensive analysis of the U.S. automobile industry was published by the Commission in June 1985. 1/ In 1986 there were eight domestic producers of automobiles. Only three of these were wholly United States owned, namely General Motors Corp. (GM), Ford Motor Co., and Chrysler Corp. Of the other five producers, two are joint-venture operations. New United Motors Manufacturing, Inc. (NUMMI), is a joint venture between Toyota Motor Corp. of Japan and General Motors, and American Motors Corp. (AMC) is a joint venture between American Motors and the French Motor company, Renault. 2/ The remaining producers, American Honda (Japanese owned), Nissan (Japanese owned), and Volkswagen of American (West German owned) are wholly owned subsidiaries of foreign firms.

According to the responses to the Commission's questionnaire, the four firms represented a combined capacity of 11.5 million motor vehicles per year in 1985, or about 82 percent of the total domestic capacity during this period. The four respondents reported that their total number of employees increased from 298,820 during 1982, to 365,252 during 1985. The number of production workers also increased during 1982-85 from 249,820, to 306,973.

According to DOC, estimated domestic new car sales in 1986 were 7.9 million units, or 4 percent less than sales in 1985. 3/ In 1986, the value of product shipments decreased by 8.5 percent compared with that in 1985, to $106 billion.

Data provided to the Commission's questionnaire on the value of product shipments were about $119.3 billion during 1985, or about 3 percent greater than the estimated value published for this industry by the DOC in the U.S. Industrial Outlook 1987. The firms responding to the questionnaire accounted for around 82 percent of the total domestic production capacity for motor vehicles during 1985 as estimated from data available from the questionnaire and from other sources. As the respondents do not represent the entire domestic industry, no estimate of capacity utilization during 1985 could be calculated; however, according to the MVMA, the rate during this period was 84 percent.

Sales of imports in 1986 were estimated to have been 3.1 million units, giving imports a 29 percent share of total new car sales during this year. DOC forecasts that by 1990 imports will represent about 37 percent of all new car sales.

From responses to the Commission's questionnaire, the total value of production of passenger automobiles, light trucks, and motor-vehicle parts for the four firms during 1985 was $121.5 billion. Since one respondent could not

1/ The Internationalization of the Automobile Industry and Its Effects on the U.S. Automobile Industry, USITC publication 1712, June 1985.
2/ American Motors Corp. was purchased in Februry 1987 by the Chrysler.
3/ U.S. Industrial Outlook 1987, U.S. Department of Commerce.

separate costs for each of the categories mentioned, no estimate of the value of production for passenger automobiles alone could be made.

Current questionnaire data provided by two of the four respondents indicate that, for domestic operations, the cost of raw materials with significant petrochemical content represented 48 percent of total raw materials costs for passenger automobiles, while foreign operations of these two firms showed a ratio of only 20 percent. Differences could be in either the relative costs of petrochemical products, or in the different product mix of the reporting automobile manufacturers in domestic and foreign plant locations. No comparable data exist from public information sources.

All four U.S.-based automobile producers have established joint ventures with foreign manufacturers. Completely assembled vehicles have been imported by these U.S.-based firms from their foreign-venture operations. Only two joint-venture relationships have resulted in U.S.-based production of vehicles; namely, NUMMI (GM-Toyota) and AMC (American Motors-Renault). The AMC-Renault joint venture allowed Renault to distribute French-produced vehicles through AMC dealerships in the United States, but also enabled AMC to distribute U.S.- and Canadian-built vehicles in other countries through Renault dealerships. The following tabulation lists the principal foreign companies that are joint-venture partners with the four U.S.-based companies: 1/

U.S. company	Foreign company	Country
General Motors.............	Isuzu	Japan
	Suzuki	Japan
	Toyota	Japan
	Daewoo	Republic of Korea
	Hindustan	India
	Hua Tung	Taiwan
Ford.......................	BMW	West Germany
	Hyundai	Republic of Korea
	Otosan	Turkey
	Fiat	Italy
	Renault	France
	Mazda	Japan
	Lio Ho	Taiwan
Chrysler....................	Mitsubishi	Japan
	Peugeot	France
	Maserati	Italy
American Motors............	VAM	Mexico
	Renault	France
	Mahindra	India
	Beijing Jeep	Peoples Republic of China

1/ The Internationalization of the Automobile Industry . . ., USITC publication 1712, June 1985.

General Motors owns approximately 34 percent of Isuzu Motors, 5 percent of Suzuki Motors, and 50 percent of the Korean firm Daewoo Motors. Ford Motor Co. owns 25 percent of Mazda Motors, and Chrysler Corp. owns about 24 percent of Mitsubishi and 15 percent of the French automobile producer Peugeot.

Foreign-owned automobile producers have already made considerable investments in plants in the United States, and plan to increase their presence in the future. Honda and Nissan have been producing vehicles in their U.S. plants since the early 1980's, and Toyota produces nameplate vehicles using the NUMMI joint venture operations with GM. In 1986, Toyota broke ground for a new manufacturing plant in Kentucky. The plant will cost \$800 million and employ about 3,000 people. Fuji Heavy Industries, Ltd., and Isuzu Motor Co. announced on December 2, 1986, plans to build a \$500 million auto- and truck-producing plant in Lafayette, IN. 1/ The plant is expected to employ about 3,000 workers. Mazda has invested \$450 million in an assembly plant in Michigan that will employ around 3,500 workers. Other foreign producers have developed vehicles that are targeted for the U.S. market. A listing of some of these planned new entries is shown in table 7-6. However, 1986 sales by Hyundai of 168,882 units have already exceeded forecasts (made only 18 months ago) for 1990 of 100,000 units sold.

Total sales of the so-called "Big 3" automakers (General Motors, Ford, and Chrysler) for 1981-85 are shown in table 7-7. Sales increased from \$110.9 billion in 1981 to \$170.4 billion in 1985.

1/ "Japanese Pick Lafayette, Indiana for Plant," Washington Post, December 3, 1986, p. C1.

Table 7-6
Major new foreign carmakers by 1990

Company	Country	Car line(s)	Date of entry	Anticipated volume	Building cars for
Austin Rover..	United Kingdom	XX, 2nd model	1987	20,000	Self
Daewoo........	Republic of Korea	Opel Kadett-derived	1987	80,000	Pontiac
Daihatsu......	Republic of Korea	Charade, other	1987	1/ 50,000	Self
Lio Ho........	Taiwan	Small Car	1988	40,000	Ford
Usines Chausson....	France	Sports Car	by 1990	1/ 5,000	Ford
Hyundai.......	Republic of Korea	Pony Excel, Stellar	1986	100,000	Self
		Excel model	1987	30,000	Mitsubis
Kia...........	Republic of Korea	Minicar	1987	70,000	Ford
		Minicar	1988	40,000	Mazda
AIM...........	Greece	Desta APV	1986	20,000	Self
SEAT..........	Spain	Malaga	1988	50,000	Self
Skoda.........	Czechoslavakia	Small car	by 1990	1/ 40,000	Self
Yue Loong 2/..	Taiwan	March	1988	50,000	Nissan
Zastava 3/....	Yugoslavia	Yugo	1986	150,000	Self
Total....				745,000	

1/ Estimated.
2/ Cars to be sold in North America through Nissan dealers.
3/ Zastava reportedly projects 40,000 Yugo sales for 1986 model year, 70,000 for 1987, 110,000 for 1988 and 150,000 by 1989.

Source: Automotive Industries, December 1985, p. 13.

Table 7-7
Total sales, total net income and average earnings per share of the 3 major domestic automobile producers, 1981-85

Year	Total sales	Total net income	Average earnings per share
	-------Billion dollars------		
1981.................	110.9	1.0	$0.83
1982.................	107.2	1.0	1.85
1983.................	132.3	5.4	7.73
1984.................	155.8	7.7	12.00
1985.................	170.4	5.9	9.45

Source: Data compiled by Datext, Inc., Woburn, MA, from various public sources.

Domestic factory sales increased to 8.0 million units in 1985 from 6.3 million units in 1981. Compared with 1985, domestic factory sales decreased by 6 percent in 1986 to 7.5 million units (table 7-8).

Table 7-8
New passenger automobiles: U.S. factory sales, imports for consumption, exports of domestic merchandise, and apparent consumption, 1981-86

Year	U.S. factory sales	U.S. imports 1/	U.S. exports	Apparent U.S. consumption	Ratio (percent) of imports to apparent consumption
	---------------Units---------------------------				
1981......	6,255,340	2,856,286	545,164	8,566,462	33.3
1982......	5,049,184	2,926,407	376,524	7,599,067	38.5
1983......	6,739,223	3,133,836	550,972	9,322,087	33.6
1984......	7,621,176	3,559,427	613,051	10,567,552	33.7
1985......	8,002,259	4,394,908	700,810	11,696,357	37.6
1986......	7,516,189	4,755,412	670,900	11,600,701	41.0

1/ Excludes foreign-trade zone imports; includes imports from Canada.

Source: Compiled from official statistics of the U.S. Department of Commerce.

During 1981-86, U.S. apparent consumption increased from 8.6 million units to 11.6 million units, or by 35 percent. The ratio of imports to consumption also increased during this period from 33 percent in 1981 to 41 percent in 1986.

U.S. imports of new passenger automobiles increased by about 67 percent during 1981-86. Imports in 1981 were 2.9 million units, while imports in 1986 were 4.8 million units. Japan remained the principal source of imports during this period.

Summed data from the four respondents to the Commission's questionnaire indicated that the total value of imports of passenger automobiles by these firms in 1985 was $7.32 billion. According to the respondents, imports from foreign subsidiaries accounted for about 99 percent of the value of total imports. Respondents stated that the principal sources for these imports during 1985 were Canada and Mexico.

Three of the four respondents had imported motor-vehicle parts totaling $2.9 billion during 1985, an increase of $926 million compared with 1982. In 1985, imported motor-vehicle parts accounted for 3 percent of the value of domestic production for these companies. Respondents were asked if domestic parts suppliers were given first consideration when purchases were considered. Except for one company, all answered that quality, reliability, and price were always the principal considerations for such purchases with no special consideration given to domestic firms. However, price, then quality, were the principal reasons given for the actual import purchases made during 1985. The principal sources for these imports were Canada, Mexico, Japan, and West Germany.

Exports of new passenger automobiles varied during 1981-86. Exports decreased from around 545,000 units in 1981 to 377,000 units in 1982. Exports increased to a high of 701,000 units in 1985, or by 86 percent, compared with 1982. In 1986, exports were 671,000 units, down by 4 percent compared with 1985.

Three of the four questionnaire respondents provided data on the value of exports during 1982-85. The total value of exports of passenger automobiles increased from $1.3 billion in 1982, to $3.7 billion in 1985. The total exports of motor vehicles and motor-vehicle parts increased from $1.7 billion in 1982, to $4.6 billion in 1985. In 1982, the value of these exports represented 2 percent of the domestic production of motor vehicles and parts, increasing to 4 percent of production in 1985. The remaining respondent stated that the value of their exports of these products was approximately 5 percent of domestic production during 1982-85. The principal markets for U.S. exports in 1985 were Canada and Saudi Arabia.

According to a report on the auto industry dated March 26, 1986, prepared by the firm of Drexel Burnham Lambert, Inc. (DBL), although many factors such as product mix, pricing, productivity, and the degree of manufacturing integration can affect automobile producers' net earnings, the key to profits is volume. 1/ Using their own model for earnings, DBL suggests that operating profits for automakers ranged between $2,500 and $3,600 for each average car or truck produced in 1985. The firm forecasts that earnings will remain relatively constant through 1990.

1/ D. Healy, Auto Industry Report, Drexel, Burnham, Lambert Inc., Mar. 26, 1986.

Current plans and future competitiveness.--Respondents to the current questionnaire cited several different strategies designed to improve their future competitive position. Three of the four respondents cited the need to improve product quality and concentrate on product service and support. When asked to rank factors that enhance the competitive position of foreign automobile producers in the U.S. market, three of the four respondents indicated price and quality as the predominant elements. One respondent referred to the tax structure of foreign countries as giving these suppliers an additional price advantage.

7.2 Construction Industry

Value of construction.--In the following tabulation, the value of U.S. new construction in 1985 was $356 billion, distributed (in percent): 1/

	Value
Residential	45
Office buildings	9
Other commercial buildings and facilities	10
Private industrial constuction	14
Other private buildings and structures	5
Highways	5
Other public works, buildings, and facilities	12
Total	100

In constant dollars, the growth rate of new construction since 1977 has averaged about 1.2 percent per year in spite of the fact that there was zero growth in the real value of new housing during 1977-86. In 1984, Federal expenditures, totaling an estimated $43.5 billion, accounted for 15 percent of all new construction and 65 percent of highways and other public works construction in the United States. 3/

The value of privately owned construction in place in the United States in 1985 has been estimated to be approximately $6.5 trillion, as shown in the following tabulation: 4/

1/ U.S. Dept. of Commerce, "1987 U.S. Industrial Outlook," January 1987, p. 1-1.

	Estimated market value of private realty 1985 ($ trillion)
Owner-occupied single-family homes	3.3
Rented and second single-family homes	.5
Multifamily dwellings	.4
Land	1.5
Commercial buildings	.7
Industrial buildings	.1
Total	6.5

For comparison, the market value for all publicly traded common stocks in the United States on September 30, 1986, was $2.1 trillion.

Construction materials.--U.S. consumption of construction materials in 1985 was about $77 billion. Building materials consumed in U.S. construction in 1985, measured in billions of dollars, were as follows (in billions of dollars): 3/

Item	Value of building materials consumed
Cement, concrete, and gypsum products	22.0
Glass, brick, tile, and cut stone	4.3
Structural metal including prefab buildings	10.8
Lumber	15.0
Other wood products	16.1
Asphalt	2.2
Plastics materials and synthetic resins	6.5
Total	76.9

Foreign trade is a significant factor in building materials despite their bulky, low-unit-value nature. Exports are small, but U.S. net imports in 1985 were about 5 percent of consumption.

Shipments of the conventional building materials in the preceding tabulation (i.e., all except plastics), measured in constant dollars, have not grown significantly since 1972. 4/ Consumption of plastics materials and

1/ National Research Council News Report, March 1987, p. 15.
2/ Chemical Marketing and Management, Winter 1987, p. 10.
3/ National Research Council News Report, March 1987, p. 15.
4/ U.S. Dept. of Commerce, "1987 U.S. Industrial Outlook," January 1987, p. 2-1; and Society of the Plastics Industry (SPI), "Facts and Figures of the U.S. Plastics Industry, 1986 Edition," September 1986, pp. 4-118, and other sources.

synthetic resins (plastics) in construction applications has more than doubled since 1972. 1/ For example, although built-up (multiple-ply) felt and hot asphalt are the primary materials used for flat and low-style roofs for commercial buildings made from plastics or synthetic rubber, several single-ply membrane products are gaining steadily in market favor.

Relationship of construction materials to building-block petrochemicals.--Plastics in buildings and other forms of construction sometimes contribute beauty and decorative effects and other times improve the quality and economics of the structures. In some cases, such as plastic pipe, the great saving comes from being able to use relatively unskilled labor to connect and install the plastic components. In exterior paint, improved synthetic resins adhere more permanently to the substrate; 8 to 10 years between repaintings of a house is not uncommon. Plastic glazing and lighting panels are resistant to breakage. Plastic flooring needs little effort and time to wax and otherwise maintain its surface. In contrast to wood and metal, continual improvements have been and are being made in the strength, toughness, and visual qualities of fabricated plastics products.

Plastics accounted for about 8 percent of the value of all building materials in 1985 and 1.8 percent of the value of construction. In fabricated form, such as pipe or flooring, their value is more than three times as great as other petrochemicals, such as organic solvents in protective coatings and synthetic rubber in flooring. Plastics resins (including plastics components of other products) represent close to 99 percent of all consumption of materials with significant petrochemical content by the construction industry.

In terms of quantity, the consumption of plastics in construction was about 13 billion pounds in 1985, as shown in table 7-9. In order of importance, the leading plastics in construction are polyvinyl chloride (PVC), phenolic resins, polyethylene, alkyd resins, polyester, and polyurethanes. The building-block petrochemicals used as raw materials for these plastics amounted to about 11 billion pounds in 1985, as shown in table 7-10. Ethylene and benzene accounted for more than one-half of the building-block petrochemicals consumed.

Table 7-11 is a breakdown by end-use of the consumption of plastics in construction in 1985. Pipe, plywood and fibrous/granulated wood, and paint account for more than one-half of the 13 billion pounds of plastics consumed.

Smaller uses not specified in table 7-11, but covered by the "other" category, include highway membranes, flame retardants and other petrochemical plastics additives, polymer-impregnated and -modified concrete, sewer pipe repair "sleeves," rebar coating, and soil anchors for erosion control.

1/ U.S. Dept. of Commerce, "1987 U.S. Industrial Outlook," January 1987, pp. 9-10.

Table 7-9
Plastics: Consumption in construction, 1985 1/

(Millions of pounds)

Material	Consumption	Principal raw materials 2/	Principal applications
Polyvinyl chloride (PVC)...	4,540	E	Pipe, wire and cable, flooring
Phenolic resins............	1,400	P, B, M	Plywood, insulation binders
Urea and melamine resins...	1,010	M, N	Fibrous/granulated wood
Alkyd resins...............	800	X	Paint
Polyethylene, high density..................	660	E	Pipe and conduit
Polyethylene, low density..	660	E	Wire and cable, pipe and conduit
Polyester (unsaturated)....	500	P, B	Bathroom components, tanks
Polyurethane...............	480	E, T	Foam laminates and roofing
Acrylic plastics and resins..................	410	P	Paint, glazing
Vinyl acetate polymers.....	350	E	Paint, adhesives
Acrylonitrile-butadiene-styrene (ABS)............	130	P, Bu, B	Pipe, conduit, and fittings
"Engineering plastics" group..................	100	Many	Glazing, electrical, plenum cables
Polypropylene..............	60	P	Pipe and conduit, wire and cable
Epoxy resins	40	B, P	Flooring, paving
Unspecified and other......	1,997	All	Many, including those above
Total................	13,137		

1/ Excludes use in carpets and carpet underlay and backing, but includes protective coatings (paint), wire, cable, and electrical fixtures.
2/ Ethylene (E), propylene (P), butadiene (Bu), benzene (B), toluene (T), xylene (X), methanol (M), and/or ammonia (N).

Source: Society of the Plastics Industry, op. cit.; SRI International, "Chemical Economics Handbook;" "Coatings 1986," Chemical Week, Oct. 22, 1986, pp. 30-56; Chemical & Engineering News, Oct. 20, 1986, pp. 17-56; and other sources, including estimates of the ITC staff.

Table 7-10
Construction plastics' consumption of building-block petrochemicals, 1985 1/

(In millions of pounds)

Construction plastics	Building-block petrochemicals Ethylene	Propylene	Butadiene	Benzene	Xylene	Methanol	Ammonia	Total 2/
Polyvinyl chloride (PVC)......	2,340							2,340
Phenolics..................		660		800		520		1,980
Urea and melamine resins.....						495	425	920
Alkyd resins...............					320			320
Polyethylene...............	1,380							1,380
Polyester (unsaturated)....		108		123	120			351
Polyurethane...............		250		170				420
Acrylic plastics and resins...................		160				180		340
Polystyrene................	160			435				595
Vinyl acetate polymers.....	140							140
Engineering plastics.......								3/
ABS........................	22		32	71				125
Polypropylene..............		66						66
Epoxy......................		16		27				43
Unspecified and other......	3/	3/	3/	3/	3/	3/	3/	1,980
Total (partial except for last column) 2/..	4,042	1,260	32	1,626	440	1,195	425	11,000

1/ Excludes use in carpets and carpet underlay and backing, but includes protective coatings (paint), wire, cable, and electrical fixtures.
2/ The last column totals for individually named plastics and the row of totals for building-block petrochemicals do not include inspecified amounts that are aggregated in the total for "Unspecified and other."
3/ Not available.

Sources: Society of the Plastics Industry, op. cit.; SRI International, "Chemical Economics Handbook;" "Coatings 1986," Chemical Week, Oct. 22, 1986, pp. 30-56; Chemical and Engineering News, Oct. 20, 1986, pp. 17-56; and other sources, including estimates of the staff of the U.S. International Trade Commission.

Table 7-11
Plastics: End uses of plastics consumed in construction, 1985 1/

(Millions of pounds)

End use	Consumption	Principal plastics
Pipe, conduit, and fittings 2/	3,781	PVC, polyethylene, ABS
Plywood, and fibrous/granulated wood	1,900	Phenolic and urea-formaldehyde resins
Paint (architectural coatings)	1,370	Alkyd, acrylic, vinyl, urethane
Flooring	1,313	PVC
Insulation materials 3/		
House siding and accessories 4/	1,180	PVC, several thermosets
Wire and cable 5/	750	Polyethylene, PVC, fluoropolymers
Adhesives, caulks, and sealers 6/	600	Polyvinyl acetate, latexes, epoxy, others
Bathroom and industrial components 7/	240	Polyester, acrylic
Decorative and industrial laminates 8/	230	Phenolic, urea, and melamine resins, urethane
Glazing and lighting fixtures 9/	150	Acrylic, polycarbonate
Electrical fixtures, components 10/	100	Acrylic, polyester, urea/melamine
Roofing 11/	80	Urea resins, chlorosulfonated polyethylene, PVC, others
Wall coverings	60	PVC
Doors, windows, and partitions	60	Polystyrene
Plastic "marble"	50	Polyester
Pool and pond liners	50	PVC
Paving, aggregates 12/	17	Epoxy
Unspecified and other	1,206	Polyethylene, polyester, polypropylene, others
Total	13,137	

1/ Excludes carpets and carpet underlay and backing.
2/ Water supply, sewer, DWV, irrigation, electrical and telephone conduit.
3/ Foam, binders for glass fibers, foam board for roofing.
4/ Includes structural panels for siding.
5/ Power transmission, communication, buildings.
6/ Other than binders for plywood, fiberglass insulation, and fibrous/granulated wood.
7/ Shower stalls, tubs, vanities, tanks.
8/ Countertops, paneling.
9/ Ceiling panels, globes, lenses louvers.
10/ Receptacles, wall switchboxes and covers, caps.
11/ Single-ply plastics and binders in fiberglass mats.
12/ Bridge decks, decorative walkways, concrete repair, mixtures with tar and asphalt.

Source: Society of the Plastics Industry, op. cit.; SRI International, "Chemical Economics Handbook;" "Coatings 1986," Chemical Week, Oct. 22, 1986, pp. 30-56; Chemical & Engineering News, Oct. 20, 1986, pp. 17-56; and other sources, including estimates of the ITC staff.

Measured in cubic feet per capita (excluding concrete and asphalt and insulation, which is mostly air), U.S. consumption of all materials in construction is less today than it was in 1905. 1/ On a cubic foot basis, plastics penetration into the construction market in place of lumber, brick, metals, and glass probably exceeded 8 percent by 1985, and this has been projected to exceed 12 percent by 1990. 2/ Total construction expenditures, measured in constant dollars, grew at an average rate of 1.7 percent per year during 1978 through 1986. 3/ Growth in U.S. population has been close to 1.0 percent per year.

Increasing the competitiveness of U.S.-produced plastics in construction.--Responses to the Commission's questionnaire on construction reveal the difficulties of builders/contractors in maximizing the advantages of plastics in innovative components of their buildings and structures. Whether large or small, most of the respondent builders of residential housing (which accounted for 45 percent of all construction expenditures in 1985) say they act as general contractors and typically subcontract 100 percent of their development and construction work, and, therefore, usually do not know which of the subcontractors' installed products are plastics related, or the prices of those components or materials.

Plastics products purchased by builder respondents to the Commission's questionnaire were valued at about 1.0 percent of their sales of housing and commercial buildings. 4/ This is far below the percentage for all new construction. In order of importance, the petrochemical-related purchases of the respondents to the questionnaire were for adhesives and sealers, carpeting, miscellaneous plastics products (e.g., pipe and siding), paint, tires (for mobile homes), and plastics tubs and showers.

Respondents noted that their company objectives include improving their profit center net income, increasing their market share, and improving their

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1/ M.G. Marbach et al., Shell Chemical Co., "The Market for Polymers," presentation to the Society of Plastics Engineers, May 1982.
2/ Ibid.
3/ U.S. Dept. of Commerce, "1987 U.S. Industrial Outlook," January 1987, pp. 1-9.
4/ From industry listings of the companies classified by the U.S. Department of Commerce in the residential construction industry, the top 26 companies, in terms of value of sales, were sent questionnaires, along with followup contact with these firms. Useful responses were obtained from five. Even if all recipients of questionnaires could be counted on to respond, obtaining quantitative data for the entire construction industry would have necessitated sending questionnaires to a significant number of the many thousands of (mostly small) local contractors. (In the District of Columbia Yellow Pages, for example, there are 141 painting contractors and 150 roofing contractors listed.) Because of this problem, the U.S. producers of plastics, in a continuing joint-marketing-research effort sponsored by their trade association (SPI), combine and publish their quantitative end-use information related to construction and other consuming industries, and it is these end-use data that are the principal basis for tables 7-17 through 7-19.

company image. As far as competition from foreign competitors is concerned, the responses stated that there is no significant current foreign competition and there will most likely be very little even in the long term. In response to hypothesized future shortages of materials because of lost domestic petrochemical industry competitiveness and/or other situations, construction company respondents believe they can use other substitutable materials and not suffer significant adverse consequences.

The improvement and promotion of plastics products in construction is, of necessity, in the hands of the plastics resins manufacturers (numbering about 250 in the United States) and their immediate customers, i.e., the producers of pipe, siding, shower stalls, insulation, and the hundreds of other construction-related products.

Rapid though the growth rate of plastics in construction has been in recent years, their potential on a technical basis is far greater. In construction, growth has been slowed by customers' hesitation to buy plastics (or other nonconventional materials) for new applications unless they can be convinced that the products will still be in trouble-free service 10 to 20 years from now.

Other factors impeding further adoption of plastics and other innovative construction technologies include the following: 1/

- --In housing, preference of most customers for traditional design and appearance.
- --Lack of standards
- --Local building codes, many of which are restrictive rather than performance related.
- --Plastics bear the burden of the public's fear of toxic fumes from plastics in burning buildings. (Considerable effort has been expended in recent years to develop flame retardants--many are petrochemicals--which can be added to plastics without unduly increasing their cost or lowering their strength.) 1/
- --Restrictive trade union rules.
- --Lack of inservice performance data, or reliable predictors of long-term durability for new products.
- --The need to develop or adapt a new design or a new construction method to take best advantage of a new plastic (or other new material).
- --Lack of a systematic, comprehensive structural methodology to innovatively design and analyze new buildings--one that properly accounts for properties of new materials, components, or structures.
- --Fear of liability and lawsuits.
- --Confusion in specifications: In public construction, thousands of Federal, State, and local agencies are involved, and each of these agencies independently may set specifications and purchasing practices.

1/ Battelle Memorial Institute study, 1986.

--Emphasis on low initial cost and contract awards to the lowest bidder in public construction: For many innovations, initial costs are likely to be higher; the advantage lies in substantial reduction of life-cycle costs.

--Requirement for demonstrated long life: It may take many years to prove that innovation is acceptable, although accelerated testing techniques can ease this problem.

--The nature of the construction industry--diverse, with many specialties and crafts. Subcontractors are highly specialized in single areas of building practice. The industry is broadly dispersed with no geographical concentrations. As the construction process moves from site to site, new subcontracting arrangements are usually made for each project. This, of course was the major factor cited by respondents to the Commission's questionnaire.

Therefore, for plastics and other new materials and technological innovations to overcome the barriers and be accepted, they must offer the following:

--Clear and significant cost or performance advantages.
--Proven reliability, safety, and long-term durability.
--Evidence of acceptability by the ultimate consumer.
--Compatibility with building codes and acceptability to building officials.
--Compatibility with other aspects of construction.
--Potential for use at a variety of locations and in various types of construction.
--New systems that workers can easily learn and that unions will accept.

Share of petrochemical sales accounted for by the construction industry.--The 11 billion pounds of building-block petrochemicals consumed in plastics for U.S. construction applications in 1985 were valued at about \$1.8 billion of which about \$650 million was for ethylene and about \$350 million was for benzene. These sums included captive consumption by producers as well as sales to other companies. Thus, the share of building-block petrochemicals destined for construction applications was about 14 percent of their value for all applications in 1985. However, in value, they accounted for only about 0.5 percent of U.S. construction expenditures. Therefore, the ups and downs of building-block petrochemical supplies and prices are understandably of scant interest to builders and large general contractors.

Competitive status of consuming industries.--Construction may be a low-growth industry but, approaching \$400 billion per year in the United States in the late 1980's and employing more than 5 million workers, it is a major factor in the national economy. International competition is in services such as contracting, finance, and insurance. Contract awards won by the 250 top international contractors were \$82 billion in 1985, down from

$108 billion in 1980. During this period, the share of all international contracts won by U.S. firms declined from 41 percent to 35 percent. Most of the present-day problems in international contracting stem from low commodity prices (for their exports) and debt-repayment requirements in most of the major Third World markets. International competition is increasingly focused upon each contractor's ability to provide attractive financing. 1/

A large number of foreign-owned construction companies have entered the U.S. market during the past several years. Foreign construction firms won approximately $7.3 billion in construction contracts in 1985, up from $3.6 billion in 1982. This accounted for 3.2 percent of all construction contracts awarded in the United States during 1985. This foreign penetration of the U.S. market can be compared with the $28 billion in contracts won by U.S. firms in overseas markets during 1985. 2/ Investors in Japan and other countries with excess capital, attracted by the drop in the value of the dollar and other attractions, have turned to U.S. real estate. Japanese investors are building U.S. factories for their products, and have bought about $6 billion worth of U.S. real estate in 1986, more than 4 times the 1985 level, including office buildings, hotels, condominiums, and industrial parks.

Japanese construction firms have become active in the United States, and in 1986 were building homes, hotels, factories, and other structures, including the start of a $700 million parcel of projects in Hawaii. 3/

Conceivably, a U.S. construction firm operating in a foreign country could specify or favor the use of U.S.-manufactured building components, but a previous U.S. International Trade Commission study reported such tie-ins are insignificant. 4/

International competition in merchandise does exist in the fabricated and formulated plastic products that go into buildings and structures, but only toa small degree. Imports of plastic film and sheet were 11 percent of U.S. consumption in 1985 but those of plastic pipe and of paint were less than 1 percent of consumption. Exports of paint were about 2 percent of U.S. production but those of plastic pipe and film and sheet were negligible in 1985. Many products such as insulation and house siding are impractical to ship long distances, or unsuitable for the types of construction favored in other countries.

Competitive success in the U.S. construction industry in future years will depend on development of new construction methods, attractive financial packaging, and increasing its productivity, which has been stagnant for 20 years. The Research Council Committee of the Federal Construction Council

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1/ U.S. Dept. of Commerce, "1987 U.S. Industrial Outlook," January 1987, pp. 9-10.
2/ Ibid.
3/ Time, Mar. 9, 1987, p. 62.
4/ U.S. International Trade Commission, The Relationship of Exports in Selected U.S. Service Industries to U.S. Merchandise Exports, USITC Publication 1290, September 1982.

said the construction industry "probably invests proportionately less in R&D than any other U.S. industry and also less than the construction industries of some foreign countries, notably Japan." The committee estimated that expenditures for all types of construction-related R&D in the United States totaled $1.2 billion in 1984, or less than 0.4 percent of the $312 billion spent for new construction. 1/ Partly because federal expenditures account for 15 percent of all new construction, the committee recommended that Congress "formally acknowledge the need for Federal leadership in conducting, funding, and coordinating construction related research" to spur technological progress and productivity growth--similar to federal R&D programs in agriculture, transportation, and medicine. 2/

7.3 Packaging industry

Packaging is a way to protect the product and prepare goods for shipment, storage, merchandising, and end use; it also facilitates the marketing and distribution of commodities to manufacturers, distributors, and consumers.

Packaging market.--This highly diversified market constitutes the single most important domestic end use for thermoplastic resins 3/ as well as the largest end-use market for the primary building-block petrochemicals. 4/ At the present time, packaging uses comprise about 32 percent of the volume of thermoplastic resins consumed domestically and about 28 percent of all resins consumed domestically. Packaging materials includes both rigid and flexible plastics such as shrink wrap, blister containers, bottles, disposable cups, boxes, closures, and trays, all of which are familiar consumer items. The value of U.S. shipments for the total packaging industry was $55.8 billion in 1985, 3.7 percent more than the $53.8 billion in 1984, and 23.7 percent more than the $43.5 billion in 1979. 5/ The quantity of plastics materials used by the packaging industry increased to 12.8 billion pounds in 1985, up 3.2 percent from 12.4 billion pounds in 1984, and up 24.3 percent from 10.3 billion pounds in 1979.

1/ National Research Council, "How to Increase Productivity in the Construction Industry," NRC News Report, March 1987, pp. 15-16.
2/ Ibid.
3/ A plastic material that will repeatedly soften when heated and harden when cooled. Thermoplastic resins represent more than 99 percent of all synthetic resins used in packaging.
4/ More than 99 percent of the petrochemical content consumed by the packaging industry are plastics.
5/ Rauch Associates, Inc. The Rauch Guide to the U.S. Packaging Industry, Date for 1984, 1985 and Projections to 1990, Bridgewater, NJ, 1985, pp. 1-4. "Packaging" as defined by this source includes rigid and flexible products and shipping containers; also included are certain secondary packaging such as wrappers, components, and other related materials, including adhesives, coatings, and inks. This source does not include related disposable products, such as household and institutional bags and wraps, grocery and merchandise bags, single-service trays, cups, etc. in the shipment value of the packaging industry.

In 1985, plastics materials accounted for $10.3 billion, or 18.5 percent of the value of shipments of the U.S. packaging industry, an increase of 6.2 percent from $9.7 billion in 1984, which represented 18.0 percent of the value of total packaging shipments that year. 1/ The growth of plastics in packaging has been at the expense of both traditional materials (glass, paper products and nonferrous metals) and older plastics (e.g., cellulosic plastics). There are two major end-use categories for plastics in packaging: containers, such as bottles, and flexible packaging, such as specialty bags. 2/ Together, these two categories represented about 86 percent of the value of shipments of all plastic packaging products in 1985, and 16 percent of the total value of shipments of the U.S. packaging industry in 1985. 3/

Vertical integration.--Currently, there are few petrochemical companies that are vertically integrated forward from either building-block petrochemicals, such as ethylene, or its derivative, polyethylene (PE) resins to become merchant suppliers of plastics packaging materials. Their number has declined in recent years because major petrochemical companies reportedly have shifted towards specialty products, such as engineering plastics, and away from commodity materials. 4/ Another reason plastics producers have moved away from vertical integration into packaging containers is that this type of integration normally puts the resin producers in competition with their customers, the plastics fabricators or converters. These latter are the firms which are dedicated to merchant packaging development. Another reason for plastics producers divesting themselves of their packaging operations is that some of the packaging areas in which these firms have been involved have reached a mature stage and are less profitable. In addition, some plastics manufacturers believe that their corporate goals are better served if they concentrate resources on plastics, rather than on operations that serve as outlets for their resins. 5/ Still another reason for divestiture is that the

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1/ Rauch Associates, Inc. The Rauch Guide to the U.S. Packaging Industry, Date for 1984, 1985 and Projections to 1990, Bridgewater, NJ, 1985, pp. 1-3.
2/ The National Import Specialist for the U.S. Customs Service (New York City) stated during a telephone conversation on Apr. 27, 1987, with a staff member of the USITC that only goods in the stream of commerce are classified in TSUS item 772.20. Therefore, plastic grocery bags (known in the trade as "T" shirt bags) received at the supermarket checkout counter and used to transport your purchases home are not classified in item 772.20 but rather in the basket category, item 774.50. This basket classification also holds true for plastic merchandise bags obtained at the point of purchase in department stores, and which frequently are embossed with the stores name and/or logo.
3/ Rauch Associates, Inc. The Rauch Guide to the U.S. Packaging Industry, Date for 1984, 1985 and Projections to 1990, Bridgewater, NJ, 1985, pp. 1-3.
4/ "Potential Outruns Profits in Plastic Packaging," Chemical Week, Oct. 15, 1986, pp. 38-40; Monsanto Finds a Buyer for Its Container Business," Chemical Week, Nov. 5, 1986, p. 5. U.S. International Trade Commission, The Shift From U.S. Production of Commodity Petrochemicals to Value-Added Specialty Chemical Products and the Possible Impact on U.S. Trade, USITC Publication 1677, April 1985, pp. XI-XV; Restructuring: The Next Phase, Chem Systems, Inc., Tarrytown, NY; and, "Ball Likely to Buy Monsanto's Plastic Container Business," Plastic Technology, December 1986, p. 77.
5/ "Ibid.

packaging business is not a market where a few firms dominate, as is typical in many basic U.S. industries; in fact, the top 48 companies controlled only 50 percent of the packaging market in 1984. 1/ Therefore, changes in the number of vertically integrated plastics packaging producers apparently relate more to shifts in current corporate goals of the individual plastics producer than to any decline in competitiveness of the U.S. building-block petrochemical or derivative industries. 2/

The supplier and end-user respondents to the Commission's packaging questionnaires were in accord in their belief that U.S. producers of primary building-block petrochemicals and plastics derived from them are going to remain competitive on a worldwide basis. 3/ This conviction is based on the capital-intensive nature of these products, the U.S. petrochemical industry's domestically available feedstock supply, and its general overall technological advantage. Most of the packaging end users that responded stated that U.S.

1/ The Rauch Guide to the U.S. Packaging Industry, Data for 1984, 1985 and Projections to 1990, Bridgewater, NJ, 1985, p. 8.
2/ Short of a major global catastrophe that interrupts the normal flow of crude petroleum from the Mideast, industry sources do not believe that U.S. building-block petrochemicals, or the resins derived from them for packaging applications, are going to become noncompetitive pricewise, either with building-block petrochemicals from the rest of the world, or with traditional materials in the United States. This statement is based on information obtained from industry sources during fieldwork for this study, and it represents a uniform consensus.
3/ Tabulations shown later in this section are based on information aggregated from the questionnaires returned to the Commission, each with varying amounts of usable statistical data. For several reasons, tabulations based on the questionnaires data do not warrant broad interpretations or generalizations. First, the size of the sample compared with the products' total universe is small (i.e., nine bottle questionnaires with useful data out of more than 200 total domestic producers of plastic bottles, six cap and closure questionnaires with useful data out of more than 500 total domestic producers of plastic caps and closures; three dual-ovenable, plastic cookware producers out of about 40 total domestic producers of dual-ovenable plastic cookware, and, 20 plastic packaging end users out of a universe that encompasses all domestic manufacturing). Secondly, the packaging suppliers and end users generally could not limit their questionnaire responses to only the requested items (i.e., bottles, caps and closures, and so forth) because of the accounting procedures of the individual firms. The data reported frequently included statistics for total plastics packaging operations. Finally, the responding firms were not always able to present data for similar products on the same quantity basis (i.e., pounds versus units), or in the same timeframe (calendar year versus fiscal year). Where these packaging questionnaires proved to be most useful in enhancing the analysis provided in this investigation was in the qualitative responses. The verbalizations by respondents who are truly knowledgeable regarding plastics packaging, both from a supplier's standpoint and from an end user's standpoint, permitted an insight into various aspects of this industry that are not available from secondary sources, such as trade magazines. See app. C for the survey methodology.

suppliers of packaging products have been very resourceful in the development of new product and process technology, and, as a result, enjoy product and processing technological advantages in most packaging areas, compared with their foreign competition.

Companies that responded to the Commission's questionnaires have reported that the increase in leveraged buy outs, acquisitions, and restructuring of major business firms in the past several years have affected the character of certain markets, including that of the packaging suppliers. 1/ Acquisitions often change the direction/purpose/products of the acquired operation. New owners do redefine their company missions and this could have a long-range effect on some marketplace conditions. Several respondents reported that acquistions and restructuring have had a more adverse effect on packaging suppliers than has the competitiveness of the U.S. building-block petrochemical industry.

Horizontal integration.--Many of the larger firms involved in plastics packaging are horizontally diversified companies. 2/ These include producers of glass, metal, or paperboard packages which have diversified into plastics to upgrade their traditional packaging material by combining it with plastics and to maintain or increase their market share by offering a broader line of packaging products. Many of the largest domestic food companies are also leaders in packaging innovation since package design, color scheme, symbols, or characterizations (i.e., in the aggregate these are known as "trade dress") are means by which customers identify a product and develop loyalty to the identifiable product.

Packaging material trends.--The packaging producers that responded to the Commission's questionnaire were asked to estimate their domestic shipments of materials with significant petrochemical content to its four most significant market sectors (e.g., automotive, aerospace, packaging, other, and so forth). 3/ These respondents included large, diversified firms (e.g., Owens-Illinois, Inc.; Continental Can Company, Inc.; and so forth); and yet, of the firms responding with usable data, only three firms reported shipments of products with significant petrochemical content to end users for purposes

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1/ Based on information obtained from end-user questionnaires returned to the Commission. An example given by one respondent is that of a major domestic supplier of plastic tubes that was acquired recently by another firm and, as a result of this acquisition, has now removed itself completely from the plastic tube market.

2/ A partial, nonexhaustive listing of such references includes Rauch Associates, The Rauch Guide to the U.S. Packaging Industry, Date for 1984, 1985 and Projections to 1990, Bridgewater, NJ, 1985, pp. 8-10; "Potential Outruns Profits in Plastic Packaging," Chemical Week, Oct. 15, 1986, pp. 38-40; Ronald H. Foster, op.cit.; Roger C. Griffin, Jr., op.cit., pp. 18, 73, 168, 169, 176, 185, 186, 312, 364, and 365; and, "Packaging: The Flavor Revolution," Modern Plastics, August 1986, pp. 53-65.

3/ There were 15 questionnaires returned to the Commission from packaging suppliers with usable information out of a total of 30 questionnaires sent to suppliers of plastics packaging products.

other than packaging. In other words, virtually all of the plastics consumed by the responding, supplying firms was geared to products used in the packaging sector.

In general, respondents reported that they selected plastics over other packaging materials for reasons of economics, consumer functionality (e.g., such as a handle for large 64-ounce bottles, easy to pour and will not break/leak), shelf impact (e.g., for detergents, plastics will accommodate fluorescent colorant, label, and so forth), manufacturing (filling line speed), and distribution efficiencies (that is, plastics ability to withstand the demands of the total distribution system). A major producer of detergents reported, for example, that with plastics they were able to design the bottle to accommodate a self-draining closure; this was not possible with glass.

Respondents reported that, as recently as the early 1980's, typically a packaging end user focused primarily on price. Large volumes were supported by multiple sources for supply assurance. By 1986-87, this concept had changed, and end users of plastics packaging are now placing greater emphasis on "total quality" and this trend reportedly is leading the end users of plastic packaging to establish quality objectives which require a smaller supply base. 1/ These end-user firms report that packaging suppliers that implement a total quality concept in their packaging products will have a competitive advantage. 2/

1/ Based on information compiled from end-user questionnaires returned to the Commission.

2/ It was reported that the concept of "Total Quality" is an industrial management technique developed by the Japanese in the early 1950's. In this case, it requires the development of a close knit relationship between the packaging supplier and the packaging end user in order to ensure that the product (i.e., the packaged good) is saleable, is free from deficiencies, and that it meets the needs of the ultimate consumer. This concept involves company-wide quality management and requires that quality be dealt with with on a project by project basis and throughout the product's development. "Total Quality" is a managerial breakthrough that introduces a new parameter of concern in the overall business objectives, and it raises quality management to a level equal with current critical parameters, such as marketing or finance. Sources reported that companies which identify quality planning and analysis as a strategic element in the conduct of their business will develop product improvements faster than their competitors, and they will be the survivors during economic downturns.

The above information was furnished by a respondent to the packaging questionnaire and a member of a marketing institute founded by one of the U.S. pioneers of the "Total Quality" concept.

The following tabulation shows the consumption of U.S.-produced thermoplastic resins in packaging, by end-use, for 1981-85 (in millions of pounds, dry-weight basis): 1/

End use	1981	1982	1983	1984	1985	Share of packaging market 1981	Share of packaging market 1985
						--Percent--	
Bottles, jars, and vials	1.698	1,802	2,310	2,128	2,137	16.3	16.8
Food containers, including disposable cups	2,079	1,852	1,591	2,114	1/ 2,228	19.9	17.5
Blister and bubble containers	329	174	186	2/	2/	3.2	-
Flexible packaging (bags, liners, etc.):							
Household and institutional refuse bag and film	1,972	2,034	2,267	2,397	2,698	18.9	21.2
All other flexible packaging	2,702	2,721	3,188	3,268	3,081	25.9	24.2
Total	4,674	4,755	5,455	5,665	5,779	44.8	45.4
All other packaging	1,640	1,857	2,209	2,440	2,583	24.8	20.3
Grand total, packaging	10,420	10,440	11,751	12,347	12,727	100.0	100.0

1/ Excludes disposable cups in 1985. Starting in 1985, disposable cups were grouped in the disposable food serviceware category under another major market, consumer and institutional products.
2/ Not separately available; combined with "all other" packaging.

From this tabulation, it can be seen that domestic consumption of thermoplastic resins in packaging increased by 21.8 percent during 1981-85, or at an average annual growth rate of about 5.1 percent.

1/ The Society of the Plastics Industry, Inc., Facts & Figures of the U.S. Plastics Industry, New York, New York, major markets section and appendix A of various annual editions. Although the above data show only the thermoplastic resins, they annually represent 99.5 percent or more of the total domestic resin consumption in packaging. The thermosetting resins are not shown for each appropriate packaging end use due to the possibility of disclosure.

The following tabulation shows the total amount of resins consumed both in the packaging industry and overall during 1981-85: 1/

Year	Quantity (dry weight basis) Packaging	Total	Ratio (percent) of U.S. resins consumed in packaging to total resin sales and use
	----Million pounds----		
1981	10,465	36,956	28.3
1982	10,497	35,109	29.9
1983	11,813	40,502	29.2
1984	12,398	43,327	28.6
1985	12,744	45,340	28.2
Average annual rate of increase (percent)	5.0	5.2	-

Packaging's share of total U.S. resin consumption, including exports, has remained nearly constant, between 28 percent and 30 percent during 1981-85. From the above tabulation, it can be shown that total U.S. resin sales and use increased by 22.7 percent during 1981-85, an average annual rate of about 5.2 percent, at about the same rate as for packaging alone.

The apparent consumption of plastics in packaging on a value basis is presented for 1981-85 in the following tabulation (in millions of dollars): 2/

1/ Facts and Figures of the U.S. Plastics Industry, op.cit., various years. Thermosetting resins have annually represented less than 0.5 percent of the total resins consumed in packaging.
2/ Trade data are compiled from official statistics of the U.S. Department of Commerce. U.S. shipments for 1984 and 1985 are from the Rauch Guide, The Rauch Guide to the U.S. Packaging Industry, Date for 1984, 1985 and Projections to 1990, Bridgewater, NJ, 1985, p. 2; estimates of U.S. shipments for 1981-83 were obtained during a telephone conversation on Nov. 19, 1986, between James A. Rauch of Rauch Associates and a staff member of the U.S. International Trade Commission.

Year	Shipments	Exports	Imports	Apparent consumption	Ratio (percent) of imports to consumption
1981............	$8,100.0	$108.3	$77.8	$8,069.5	1.0
1982............	8,730.0	100.3	95.5	8,725.2	1.1
1983............	9,400.0	100.1	160.9	9,460.8	1.7
1984............	9,672.0	114.8	190.4	9,747.6	2.0
1985............	10,255.0	107.2	251.6	10,399.4	2.4
Average annual rate of increase (percent).....	6.1	-0.2	34.0	6.5	-

U.S. shipments of plastics packaging products increased by more than 26 percent during 1981-85, or at an average annual rate of growth of about 6.1 percent; apparent consumption increased by about 29 percent during this period, or at a somewhat faster average annual rate of growth of 6.5 percent.

The following tabulation shows the shipments of plastic bottle materials (in millions of pounds) by resin and the percent of the total each resin accounted for in 1982, 1984, and 1985: 1/

Resin 2/	1981	1982	1983	1984	1985 3/	Percent of total for-- 1/ 1982	1984	1985
	----------------	Million pounds	----------------					
HDPE............	1,426.6	1,027.0	1,248.5	1,335.5	1,400.0	58.6	65.1	63.6
PET............	357.2	450.0	420.5	452.0	500.0	25.7	22.0	22.7
PVC............	92.6	94.0	118.2	131.3	150.0	5.4	6.4	6.8
LDPE...........	61.7	126.0	58.1	60.4	63.0	7.2	2.9	2.9
PP.............	66.2	50.0	57.0	63.5	78.0	2.9	3.1	3.5
PS and other..	2/ 4.5	5.0	6.3	8.1	9.0	.3	.4	.4
Total......	2,008.8	1,752.0	1,908.6	2,050.8	2,200.0	100	100	100

1/ Because of rounding, columns may not add to the totals shown.
2/ Resins shown are HDPE--high-density polyethylene, PET--polyethylene terephthalate, PVC--polyvinyl chloride, LDPE--low density polyethylene, PP--polypropylene, and PS--polystyrene.
3/ Estimated.

1/ The years 1982-1985 from the U.S. Department of Commerce, U.S. Industrial Outlook, various years; and 1981 from Packaging Reference Issue 1985, and from Modern Plastics, January 1983, pp. 67-71. The two sources for 1981 data are not directly comparable with the official source for 1982-85; therefore, it cannot be assumed that 1982 and 1983 shipments were actually lower than 1981.

The respondents to the Commission's questionnaire for the packaging suppliers' sectors reported both the following total production and the total shipments for the plastic bottles during 1982-86 (in millions of dollars): 1/

Year	Production	Shipment
1982	1,073	1,124
1983	1,112	1,169
1984	1,300	1,358
1985	1,275	1,389
1986 1/	1,618	1,782
Average annual rate of increase (percent)	10.9	12.2

1/ Estimated from partial-year data.

These same respondents also supplied the Commission with employment data on the average number of persons as well as on the production workers employed in their U.S. plants in which materials with significant petrochemical content were produced during 1982-86, and the wages (total compensation to both full-time and part-time employees) those workers received during this period. These data are shown in the following tabulation: 2/

1/ Production and shipment data were compiled from 9 questionnaires returned to the Commission with usable information out of a total of 15 questionnaires mailed to producers of plastic bottles. The data reported frequently included statistics for other plastic products as the firms reporting were unable to statistically separate bottles from their other plastic products in order to fit the needs of the Commission's study. It should also be cautioned that this return represents but a small sample. For example, the Rauch Guide, The Rauch Guide to the U.S. Packaging Industry, Date for 1984, 1985 and Projections to 1990, Bridgewater, NJ, 1985, p. 99, notes that there are over 150 companies making blow-molded plastic bottles for sale or captive use.
2/ The number of production workers engaged in the production of plastic bottles and the wages for these workers were compiled from eight questionnaires. The number of total persons employed in the reporting plants and the wages for all respondents were reported by nine respondents and six respondents, respectively.

Year	Average number employed		Wages	
	All persons	Production and related workers	All persons	Production and related workers
			---------1,000 dollars---------	
1982.........	14,157	12,697	175,007	187,862
1983.........	14,254	12,666	188,089	201,124
1984.........	17,400	15,371	236,823	242,954
1985.........	15,718	13,613	267,568	225,187
1986 1/......	17,408	15,409	202,163	219,682

1/ January-August 1986.

Many of the respondents, both end user and suppliers, commented that suppliers of plastic bottles (e.g., detergent bottles) are traditionally located within a close proximity to the filling plant of the end user (usually about 30 miles) because of shipping considerations. 1/ These considerations include the light-weight, bulky nature of plastic bottles; the resultant high freight costs; and the need to service customers quickly. This proximity to maintain quick delivery service is reported by the respondents to be an important sales/marketing tool and critical to supplier selection as it offers the end users an advantage in terms of response time. 2/ On the other hand, plastics packaging containers that can be economically transported unfilled, such as plastic tubs for cottage cheese and plastic tubes for toothpaste, shampoo, and so forth, can ideally be located up to 100-150 miles from the users' plant. Many respondents reported that another advantage of having

1/ This information was obtained as a consensus from questionnaires of many of the responding end user and suppliers'. Most of the respondents to the end-users' questionnaire stated that the products are shipped either delivered or F.O.B. supplier's producing plant, and, primarily for bottles, freight is absorbed (prepaid) by the suppliers, in which case the selling methods are essentially the same. Rebates are granted as a volume incentive. If materials are not produced, or delivered per the agreed-upon schedule, the suppliers normally will pay air freight or special handling costs.

The most common terms of payment reported in both the suppliers' and users' questionnaires is the open account with either a 1 percent discount if the invoice is paid within 10 days of the invoice date or the net (full) amount is due within 30 days.

2/ An example of economic advantage based on distance was furnished by one of the respondents. This firm, a major packaging end user located in Ohio now buys 64-ounce PE bottles from suppliers within 30 miles of its Ohio plant and pays as little as \$50 to \$60 per truckload. This end user reported that a similar shipment from Washington, DC to its Ohio filling plant would cost them about \$800 per truckload. However, in other cases this proximity advantage could be offset to the extent that the chosen packaging supplier's raw material (i.e., plastics) supply points increased freight costs to them versus their competition.

suppliers located nearby is that it permits them to carry less overall inventory.

Many respondents reported that another advantage of having suppliers located nearby is that it permits them to carry less overall inventory. As packaging users move to "just-in-time" (or, "right-on-time") inventory management, suppliers within several hundred miles of the end-user's plant have a distinct advantage. The packaging end-users report that their ability to manage inventory at a lower level while improving overall quality will result in lower overall cost.

The respondents that supply plastic bottles among other packaging needs to end users reported that they rely heavily on the strategy of having a superior technical capability for package developments for major customers. 1/ Virtually all of the respondents to the suppliers' questionnaire on plastic bottles were in accord on the marketing techniques and strategies they have relied heavily on in the last 5 years. All respondents reported a medium-to-heavy reliance on pricing policy, product quality, and technical service. The manufacturers of plastic bottles that responded generally ranked feedstock/fuel prices, feedstock/fuel availability, and R&D as the three factors which have the greatest impact on the ability of these producers to compete at present in domestic markets. Further, the respondents cannot conceive of the U.S. Government permitting a worst-case scenario to develop where U.S. building-block petrochemicals and the downstream packaging resins are not available domestically. If the scenario developed, one firm, perhaps the largest in the industry, said it would "close the doors" on its plastics bottles operation and that the metal can and/or glass bottle packaging would replace the plastic bottle.

Four examples of plastics packaging are the gallon milk container, the 2-liter soft drink bottle, the closure, and the dual-ovenable food trays. The first three are well-known examples of plastic packaging or packaging components. The latter is a recent development in plastics packaging, and results from America's growing fondness for microwave ovens and the danger of arcing and the risk of damage to microwave ovens from aluminum trays. 2/

Gallon milk container.--High density polyethylene (HDPE) resin, an ethylene derivative, is the plastic of choice for gallon-size milk bottles, and plastics now account for about 80 to 85 percent of the gallon milk container market, in which about 55 percent of all packaged milk is sold.

1/ Based on information obtained from suppliers' questionnaire returned to the Commission.
2/ Packaging: Reference Issue 1986, p. 20; "Microwave Oven Sales Jump 119% in 3 Years," Packaging, October 1986, p. 37, states that U.S. shipments of microwave ovens increased from 4.07 million units in 1982 to 10.88 million units in 1985, or by 167 percent. This source estimates microwave oven shipments at 11.75 million units in 1986, and forecast them at 13.30 million units in 1988.

Plastics growth in the gallon-size milk container market will be slow, owing to the large current market share controlled by plastics. 1/ Shipments of plastic milk bottles, nearly all 1-gallon size and virtually all HDPE, increased from 2,563 million units in 1982 to 2,750 million units in 1985, or by only 7.3 percent. 2/ In 1985, 650 million pounds of HDPE were consumed domestically in 1-gallon milk bottles, a 4-percent increase compared with 625 million pounds of HDPE consumed in 1984. 3/

Coated paperboard now dominates the one-half-gallon milk container market. Industry sources estimate that by the mid-1990's, HDPE will gain on coated paperboard and will virtually replace glass in the one-half-gallon milk container market. 4/ Industry sources estimate that the one-half-gallon milk container represents a potential market for HDPE of 125 million pounds to 175 million pounds per year.

Soft drink containers.--Polyethylene terephthalate (PET) resin, also an ethylene derivative, is the plastic of choice for soft drink containers, especially the 2-liter and 3-liter size. Industry sources report that PET for soft drink bottles increased from 535 million pounds in 1984 to 595 million pounds in 1985, or by 11 percent. 5/ PET has been one of plastics' great success stories in the large-drink container, having virtually replaced glass since first being introduced in the 2-liter bottle in 1977. Industry sources estimate that by 1979 PET already represented about 75 percent of the 2-liter soft drink container market. 6/ By 1985, PET had virtually taken over the 2-liter soft drink market from glass, primarily on the basis of PET's shatter resistance, a safety feature, and the light weight of the PET 2-liter bottles compared with glass which eases handling and reduces shipping charges.

In smaller soft drink bottles, PET has usually been more expensive than glass, and carbonation retention for adequate shelf life has also been a problem in the smaller sized PET soft drink bottles. However, a recent study predicts a tenfold rise in the usage of 16-ounce PET soft drink bottles

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1/ Rauch Associates, Rauch Guide, The Rauch Guide to the U.S. Packaging Industry, Date for 1984, 1985 and Projections to 1990, Bridgewater, NJ, 1985, pp. 93-95. Another source, Pulp & Paper, April 1986, p. 137, reported that plastics accounted for 96.7 percent of the 2,028.5 million pounds sold in 1983 in 1-gallon containers, and that this represented about 60 percent of all fluid milk sold by package; paper accounted for the rest of the milk sold in gallon containers. However, in the half pint, pint, and quart size, paper accounted for 99.5 percent, 99.5 percent, and 97.1 percent, respectively; while plastics accounted for only 1.2 percent, 0.4 percent, and 0.4 percent, respectively.
2/ U.S. Department of Commerce, U.S. Industrial Outlook 1985, pp. 6-7 to 6-9; and, U.S. Industrial Outlook 1986, pp. 6-5 and 6-6.
3/ "Materials '86," Modern Plastics, January 1986, p. 60.
4/ Based on information obtained from industry sources during fieldwork.
5/ "Materials '86," Modern Plastics, January 1986, p. 62.
6/ Kline Guide to the Packaging Industry, Fourth Edition, Fairfield, NJ, March 1980, p. 118.

between 1986 and 1995. 1/ If the projection is realized, plastics (virtually all PET) would hold over one-third of all packaged soft drinks by 1995, including 5.5 billion 1- and 2-liter bottles. 2/ This represents an increase from 25.2 percent of the package soft drink market in 1985. This same source projects that all PET soft drink bottles will total 13.4 billion units in 1995, an average annual increase of more than 22 percent from 4.9 billion units in 1985, a rate much greater than projected GNP growth. 3/ This source estimates that 16-ounce PET bottles for soft drinks will reach 8 billion units in 1988, up from about 870 million units in 1985. 4/ As stated above, the 1- and 2-liter PET soft drink bottles will reach 5.5 billion units in 1995, up from 4.1 billion units in 1985.

Closures.--"Closures" is a general term and includes caps, lids, stoppers, and so forth. Unlike the plastics containers covered in this study, closures are not restricted to packaging applications, although packaging accounts for nearly all of the end uses. Examples of nonpackaging applications are covers on batteries and window-wash reservoirs in automobiles. The principal types of closures are the screw-on (threaded or lug type), the press-on, the roll-on, and the crimp-on or crown, which, although believed to be a mature segment of the market, is still the least expensive and single most important type. The crown-type closure is, being the cheapest, normally made of steel (with a plastic liner or gasket); it is used primarily for single-serving bottles of beer and, to a lesser extent, soft drinks, and plastics closures do not compete with it. 5/ However, as the soft drink industry shifted its package mix toward large, family-sized containers, bottlers' requirements shifted to aluminum closures (with a plastic liner or gasket). Plastics compete chiefly with aluminum in the closure market. At present, aluminum dominates the carbonated soft drink market through the roll-on closure with its tamperproof ring. 6/ Plastics closures tend to "dome" under the three to four volumes of carbonation used in the United States for soft drinks; in contrast, they have been successful in

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1/ Plastics Focus, Apr. 28, 1986, pp. 3-4. The article is based on data from a study by Chase Econometrics and Sabre Associates.
2/ Modern Plastics, May 1986, p. 130. Also, the Society of the Plastics Industry, Profiles in Plastics: Bottles, March 1986, reports that PET bottles supplied 21.4 percent of the packaged soft drink market in 1984.
3/ Modern Plastics, May 1986, p. 130.
4/ Ibid.
5/ Roger C. Griffin, Jr., Stanley Sacharov, and Andy L. Brody, Principles of Packaging Development, 2nd ed., Westport, CT, 1985, pp. 81-84.
6/ Beverage Industry, July 1986, pp. 4, 6, and 11, states that aluminum has had continued success in the soft drink market because of its current pricing structure and now holds an 80-percent share in the soft drink market; aluminum is the closure of choice in the beer and and wine industries.

Europe because European soft drinks receive only one or two volumes of carbonation owing to shorter shelf-life requirements. 1/

Industry sources report that convenience and safety will lead to an increase in the use of plastics for dispensing and tamper-indicative closures for food and personal-care items. 2/ Sources in the plastics industry predict that, by 1990, plastics closures will have a 60 to 70 percent market share; however, manufacturers of aluminum closures report the market will be evenly split between aluminum and plastics. In 1985, U.S. shipments of plastics container closures amounted to an estimated 26.0 billion units, or about 32 percent of a total of 81.5 billion container closures. 3/

Dual-ovenable, plastic trays.--The dual-ovenable plastic trays are the most recent development of the four examples and are still in the product "takeoff" stage. The dual-ovenable plastic trays can safely be heated in either microwave ovens, or in the more conventional convection and infrared oven equipment. 4/ There are several plastics competing for dominance: thermoset polyester resins, polycarbonate resins, polyetherimide resins, and crystallizable polyethylene terephthalate (CPET) resins. 5/ On a cost/performance basis, CPET appears to be the current resin of choice for this application by several plastics fabricators and food processors. These dual-ovenable trays are cost effective and heat stable to 450°F. 6/ In addition, they have impact strength at temperatures as low as minus 40°F, so they can withstand drops and impacts. However, there is intense material competition for the dual-ovenable tray market. For example, one major food company has turned to polycarbonate resin instead of CPET resin. Polycarbonate resin is generally more expensive than CPET resin, but polycarbonate resin offers extra conveniences, such as a high-gloss, antistick surface, to the consumer without adversely affecting the foods' taste or appearance. At the other end of the scale, composite food trays of paper pulp and plastic are also competing with

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1/ Polypropylene closures are now appearing on PET soda bottles in the United States. Industry observers foresee a mechanical and linerless plastic closure coming on the market within a few years, and predict that within 5 years, the aluminum cap for PET soft drink will be history. This was drawn from "Packagers to Feel Impact of Resin Technology," Packaging, June 1986, pp. 58-64.
2/ Packaging Reference Issue 1986, pp. 140-150. "Child-Resistance Closures Address Specific Needs," Packaging, May 1986, pp. 32-34; "Innovative Packages at Chesebrough-Ponds, "Packaging, May 1986, pp.22-28; Packaging, November 1986, p. 15; and, The Rauch Guide, The Rauch Guide to the U.S. Packaging Industry, Date for 1984, 1985 and Projections to 1990, Bridgewater, NJ, 1985, pp. 135-140.
3/ Rauch Guide, op.cit., p. 136; Beverage Industry, July 1986, pp. 4, 6, and 11; and, Food & Drug Packaging, February 1986, p. 25.
4/ "Years Technical Developments Promise Corning Change," Packaging Reference Issue 1986, pp. 18-22; and, "Trays, Ovenable, Plastic," Packaging Reference Issue 1986, pp. 158 and 159.
5/ See Glossary of terms.
6/ Packaging Reference Issue 1986, pp. 20 and 37; and, "What's the Outline for Dual Ovenables?," Modern Plastics, August 1986, pp. 63-65.

CPET trays. Although not as upscale as CPET trays, the composites are more economical at one-third the cost of CPET trays. 1/ At present, there are some four billion containers per year consumed in the microwaveable/convenience food market, or about 25 percent of the total can-replacement market. 2/

Industry sources estimate that these dual-ovenable plastic containers will grow from a relatively small market in 1986 to a $125 million market in 1990. 3/ Another source estimates that sales of CPET for dual-ovenable trays could reach 130 million pounds annually by 1989 versus 7 million to 10 million pounds in 1985. 4/

Controlled-atmosphere packaging.--A new and potentially large market for plastics in packaging is controlled-atmosphere packaging (CAP). The basic principle of CAP is to use a film, or combination of films, to control the gas levels in a mixture containing oxygen, nitrogen, and carbon dioxide. The levels of these three gases varies greatly from one kind of vegetable or meat to another. CAP keeps foods naturally fresh instead of protecting them with barrier materials. The product is put under a "gas hat" that can more than double the shelf life of certain fruits and vegetables. Coffee and grated cheese represent additional potential candidates for CAP.

Recent developments of materials, known as "smart" films, specifically designed for CAP applications, combined with the onset of centralized retail food distribution, has led industry experts to predict that, by the turn of the century, CAP could consume more film and sheet than all other forms of plastics-based barrier packaging structures combined. 5/ At present, about 114,000 tons of foodstuffs are being marketed in CAP and the potential for CAP for food packaging alone is estimated at $2 billion.

Relationship to building-block petrochemicals.--The cost for basic resin components of packaging has generally represented about 50 percent of the value of plastics packaging products, although the cost varies from one plastics type to another. Industry sources report that the building-block petrochemicals or monomers, such as ethylene, have typically represented about

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1/ "Plastic Pulp Vies for Ovenable Trays,' Plastic World, December 1986, p. 17, and, "Premium-Polymer Oven Trays Enter Mass Market, Modern Plastics, December 1986, p. 13.
2/ "1986: Breakthrough Year for Barrier Food Packaging," Modern Plastics, March 1986, pp. 60 and 66.
3/ Ibid.
4/ Chemical week, Oct. 16, 1985, pp. 100-104.
5/ "Smart Films Give a Big Lift to Controlled Atmosphere Packaging," Modern Plastics International, September 1986, pp. 58 and 59; "Years Technical Developments Promise Coming Change," Packaging, Reference Issue 1986, pp. 18-22; "Statistics of Packaging," Packaging Reference Issue 1986, pp. 35-38; and, "Plastics Industry Fattens Up on Deluxe Package Diet," Chemical Business, February 1986, pp. 35-37.

75 percent of the cost of the basic resin, such as polyethylene. 1/ Therefore, the value of the building-block petrochemicals, such as benzene or ethylene, typically represents about 35 to 45 percent of the value of the plastics packaging product. For larger packaging products of plastics, such as 55-gallon drums, the value of both the resin and the building-block petrochemicals declines below 50 percent and 35-45 percent, respectively. The value of the plastic may exceed the 50-percent level for multilayer barrier structures of high- performance plastics used for critical packaging applications, such as pharmaceuticals or medicinals, or upscale gourmet-style frozen dinners.

As reported by the end-user firms, the share of the cost of production of packaged products related to petrochemical materials ranged from 19 to 48 percent. 2/ This variation is primarily due to the difference in cost of the different types, sizes, and materials involved in the package itself, and the point at which the end user becomes involved in producing the package (i.e., whether the user firm purchases resins or a finished bottle).

The respondents that are suppliers of plastic bottles for packaging reported that the plastic feedstock costs ranged from 40 to 55 percent of the total product costs. 3/ The respondents reported that feedstock costs for plastic caps and closures ranged between 25 and 35 percent of the total production costs. For dual-ovenable plastic trays, this percentage was reported to range between 40 and 60 percent. Based on these responses, it appears that as the product becomes more sophisticated, requiring a high-performance material, the plastics' share of the overall production costs increases.

The trend of the building-block petrochemicals' share of the cost of the packaging products is highly dependent on feedstock prices, which are directly affected by the prices of crude petroleum and natural gas. Although prices of four of the five large-volume resins were down in August 1986 compared with August 1985, they were down by an average of only 6 percent from levels that

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1/ Based on information obtained by a staff member of the U.S. International Trade Commission from an official at Chem Systems, Tarrytown, NY, during fieldwork for this study, and information obtained from an official at Dow Chemical Co., Midland, MI, during a telephone conversation on Oct. 27, 1986, with a staff member of the U.S. International Trade Commission.
2/ Data for end-users firms (e.g., food-processing firms) are compiled from 20 questionnaires returned to the Commission with usable information out of a total of 45 questionnaires mailed to users of plastic packaging products.
3/ Based on information obtained from questionnaires returned to the Commission from suppliers of plastics packaging.

existed prior to the decline of crude petroleum prices. 1/ Therefore plastics fabricators, such as those firms which convert plastics into packaging products, have not had a decrease in resins prices proportional to the decrease in prices of feedstocks. 2/ The decline in prices of crude petroleum and natural gas during the first half of 1986, however, did permit producers of building-block petrochemicals and of plastics to increase their profit margins.

The variable cost of producing ethylene (from the natural gas feedstock ethane) for the third quarter 1986 was 11.8 cents per pound; the market price (i.e., bulk rate price) for ethylene during that period was 14.0 cents per pound. 3/ The margin was 2.2 cents per pound. For one major grade of low density polyethylene (LDPE) resins, the total product manufacturing cost was 25.8 cents per pound in 1986, of which ethylene represented 55.8 percent of the product manufacturing cost. 4/ For HDPE (blow molding grade), ethylene represented 57.0 percent of the product manufacturing cost during 1986. For polystyrene homopolymer resin, styrene monomer represented 68.4 percent of the product manufacturing cost. For polypropylene (homopolymer molding grade), propylene represented 52.6 percent of this cost.

Until 1986, a steady correlation had existed between starting materials (i.e, crude petroleum and natural gas) and building-block petrochemicals (e.g., ethylene) and also between the building-block petrochemicals and the

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1/ Industry sources report that crude petroleum-monomer-resin cost relationships are complex. For example, major plastics are operating at optimum capacity, which precludes large price reduction. In addition, firms with "swing" capacity shifted to crude petroleum sources for ethylene instead of ethane, and this resulted in a higher proportion of propylene byproducts than from those units using ethane as a source of ethylene. This resulted in a more abundant supply and lower prices for propylene. Also, for the first time in years, ethylene prices could rise because of tightening supplies, regardless of feedstock costs. The foregoing was drawn from "Oil and Gas Cost Down, Why Not Resin Prices?," Modern Plastics, October 1986, pp. 56-59, and from "Ethylene and PE Tabs: A Tenuous Link?," Chemical Week, Nov. 19, 1986, pp. 36 and 38.
2/ "Oil and Gas Cost Down; Why Not Resin Prices?," Modern Plastics, October 1986, pp. 56-59.
3/ "Oil and Gas Cost Down; Why Not Resin Prices?," Modern Plastics, October 1986, p. 59. The product manufacturing cost in this source includes raw materials, labor, plant overhead, maintenance, property taxes, insurance, freight, distribution, and administrative costs. Plant depreciation is excluded. The price for ethylene reported in the trade journal generally agrees with the questionnaire responses on U.S. data (see pages 34 and 35) which reported the net feedstock cost for ethylene at a current range of 6 to 13 cents per pound.
4/ Ibid.

plastics used in packaging (e.g., polyethylene). 1/ Industry sources believe that because of tightening ethylene supplies, ethylene prices will rise regardless of crude petroleum and natural gas costs; in fact, profit margins had already risen for ethylene producers during 1986. 2/ Industry sources believe that ethylene prices will continue to rise even if prices for polyethylene (PE) resin do not follow suit. The reason is that, unlike PE, very little ethylene is traded on the world market. In contrast, U.S. exports represent 10 percent of PE's markets. By raising the price of PE too high, U.S. producers could lose their export market and also risk inviting a surge of PE imports from lower priced foreign sources. 3/

Competitive status of consuming industries.--The potential for plastics in packaging is, of course, affected by price. Plastics have to be price competitive with one another, as well as with traditional materials, to either gain or maintain a market share in any segment of packaging. 4/ Another cost-driven factor is energy requirements. Typically, the amount of total energy (i.e., both process and feedstocks) required to produce a particular plastics package, starting with conversion of the feedstock (e.g., natural gas) to plastics, right on through the final fabrication of the plastics package, is about one-half the energy required to produce an equivalent-sized

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1/ "Ethylene and PE Tab's: A Tenuous Link," Chemical Week, Nov. 12, 1986, pp. 36 and 38.
2/ "Oil and Gas Cost Down; Why Not Resin Prices?," Modern Plastics, October 1986, p. 59. The effect of the decline in crude petroleum and natural gas prices has also resulted in improved margins for plastics producers in Europe. This was drawn from "Plastics Price Developments Reflect Oil Price Collapse," European Chemical News, July 26, 1986, pp. 11 and 12.
3/ "Oil and Gas Cost Down; Why Not Resin Prices?," Modern Plastics, October 1986, p. 59. The product manufacturing cost in this source includes raw materials, labor, plant overhead, maintenance, property taxes, insurance, freight, distribution, and administrative costs. Plant depreciation is excluded.
4/ A paper by Ronald H. Foster, Northern Petrochemical, entitled "Plastics Barrier Packaging: The Future is Bright," at the Society of the Plastics Engineers regional technical conference in Cleveland, OH on Apr. 4-5, 1986. In his paper, Mr. Foster has several tables detailing the comparative costs between plastics and traditional materials and also intraplastics competition; and also from a speech by Rich Freundlich, Campbell's Soup Plastics Center, entitled "Innovations in Barrier Packaging," which was given before the Society of the Plastics Industry, International Outlook Conference, the theme of which was The Plastics Industry - Positioning for Growth, Mar. 20 and 21, 1986, New York; and, from "Look-Alike Packages Cause Legal Problems," Packaging, November 1986, pp. 60-64.

can or glass bottle. 1/ Therefore, even under high-priced-energy scenarios, the plastics materials have a competitive advantage vis-a-vis metal or glass containers. Plastics packaging can also be market driven; for example, dual-ovenable plastics containers are market driven in that they respond to specific consumer wants--convenience, table readiness, easy-open features, and recloseability for many servings.

At the other end of the spectrum are those products bought on the basis of their price alone. Plastics will not be able to compete in this market, unless they are lower in total costs (including both the cost of the individual container and the product filling rate) than metal cans, which industry sources believe will be a difficult goal to reach. 2/

Although plastics are not a panacea for the packaging industry, trade sources are predicting phenomenal growth for plastic packaging during the next 5 to 10 years. One study predicts that, whereas the total container market, both food and nonfood, will climb from 18.0 billion units in 1985 to 20.4 billion units in 1990, the plastics share of this market will increase from 1.2 billion units in 1985 to 6.0 billion units in 1990. 3/ The following tabulation shows that, of this total for plastics containers, plastic barrier bottles for food products are projected to climb from 300 million units in 1985 to 3.2 billion units in 1990 (in millions): 4/

1/ A paper by Ronald H. Foster, Northern Petrochemical, entitled "Plastics Barrier Packaging: The Future is Bright," at the Society of the Plastics Engineers regional technical conference in Cleveland, OH on Apr. 4-5, 1986. In his paper, Mr. Foster has several tables detailing the comparative costs between plastics and traditional materials and also intraplastics competition; and also from a speech by Rich Freundlich, Campbell's Soup Plastics Center, entitled "Innovations in Barrier Packaging," which was given before the Society of the Plastics Industry, International Outlook Conference, the theme of which was The Plastics Industry - Positioning for Growth, Mar. 20 and 21, 1986, New York; and, from "Look-Alike Packages Cause Legal Problems," Packaging, November 1986, pp. 60-64.
2/ "Potential Outruns Profits in Plastic Packaging," Chemical Week, Oct. 15, 1986, pp. 38-40. In addition, several industry sources reported that metal cans are generally preferred at present for packaging certain types of large-volumne, low-priced vegetables (e.g., low-acid products such as string beans) because of the metal cans adaptability to high-speed filling lines. Under current production conditions, metal cans can be filled with food at a rate of 300 to 400 cans per minute. On the other hand, a plastic container presently available for these low-acid types of food has a filling/sealing rate of about 120 units per minute.
3/ "Barrier Resins Hold Key to Plastics Food Packaging," Plastic Engineering, March 1968, pp. 57-61; "American Can Sells Packaging Business," Plastics World, September 1986, pp. 14 and 15; and, "Packaging: Barrier Bottles," Plastics World, January 1986, pp. 61 and 63. The latter source, p. 61, estimates that glass and metal containers will decline in the aggregate from 16.8 billion units in 1985 to 14.4 billion units in 1990. In 1985, about 12 billion glass bottles were used for packaging high-acid foods, while 3 billion glass bottles were used for low-acid foods.
4/ Plastics World, January 1986, p. 61.

Product	1985	1990
Catsup	225	400
Tomato sauce/paste	0	300
Spaghetti sauce	0	200
Juice	0	350
Fruits	0	50
Baby food	0	400
Barbecue sauce	50	200
Salad dressing	0	1,000
Jams/jellies	25	200
Total	300	3,200

Another study reports that annual usage of food packaging containers made from coextruded, high-barrier multilayer plastics will grow from 300 million containers in 1985 to 29 billion containers by 1995, an average annual growth rate of 58 percent. 1/ The projected growth in plastics packaging, especially barrier containers, is predicated mainly on the following three factors:

1. Changing consumer demography and life styles that want convenient, disposable packaging that is microwaveable.

2. Packagers' need for merchandisable packages that allow design flexibility and offer advantages such as lighter weight, shatter resistance, easier and cleaner dispensing, and cost competitiveness.

3. The mutual development of technologies, equipment, and plastics that will permit plastics to be cost competitive in areas such as aseptic packaging. 2/

1/ "High-Barrier Plastics Growing at Fast Pace," Chemical Marketing Reporter, Apr. 21, 1986, p. 13. This article is based on a study by Business Communications Co., Stamford, CT.
2/ "R&D Sustains Coex Container Growth," Plastics World, January 1986, pp. 9-11.

As reported by the end-user firms, the aggregated U.S. production and the domestic shipments of their finished packaged goods (e.g., dairy products, cosmetics, household detergents and cleaners, miscellaneous food products, and so forth) produced in their U.S. plants during 1982-86 were as follows (in millions of dollars): 1/

Finished packaged goods	1982	1983	1984	1985	1986 1/
U.S. production..........	1,109	1,202	1,399	1,505	1,599
Domestic shipments.......	1,725	1,893	2,083	2,307	2,671

1/ Estimated from partial-year data.

The aggregated U.S. production of the finished package goods reported by the 10 responding end users grew from $1,109 million in 1982 to an estimated $1,599 million in 1986, or by 44 percent, an average annual growth rate of 9.6 percent. The domestic shipments of the finished packaged goods reported by seven respondents grew from $1,725 million in 1982 to an estimated $2,671 million in 1986, or by 55 percent, an average annual growth rate of 11.5 percent. The one conclusion that can be reasonably drawn from the above tabulation is the relative unimportance of foreign trade compared with domestic shipments for the food processors, soap and detergent producers, and the personal care products manufacturers that responded to the Commission's end-user questionnaire.

R&D.--Many of the responding suppliers stated that they strive to remain a full service supplier of plastics packaging products by stressing, among other things, continued technological improvement and development, through R&D which highlights upgrading quality and emphasis on product design. The packaging end users reported that they are pursuing, through R&D, ways to improve the container in which their product is marketed so that, from the point of view of price, quality, and package design, they remain competitive in the market place. 2/ The end users also reported that a package design (i.e., esthetics) that differentiates and distinguishes their product from that of their competitors' products is very important. This is especially critical when the products themselves are either identical or virtually indistinguishable by the consumer. R&D costs affect the competitiveness of the packaging industry more than does the competitiveness of the U.S. building-block petrochemical industry. The high R&D costs are especially pronounced for food packaging, which must receive approval from a host of

1/ There were 45 end-user questionnaires mailed out, and 20 of them were returned to the Commission with varying amounts of usable data. Of those 20 returned with usable data, 10 had production data and 7 had shipment data. Only two respondents reported packaging exports and only one end user reported packaging imports.
2/ This statement is based on information derived from seven supplier questionnaires and five end-user questionnaires.

Federal agencies and is subject to State and local laws. 1/ Industry sources report that R&D costs for the development of a typical plastic food container generally reaches eight figures. The profit margins of most packaging companies are often too low for individual packaging companies to be able to fund such R&D. Therefore, in the future, more of the R&D for plastics packaging will apparently have to be done by major plastics producers. 2/

Technology limitations and consumer preference are just as important as the price of the building-block petrochemical. For example, domestically, aluminum is the material of choice in the rapidly growing beer market, as cans now represent about 70 percent of the total packaged beer. 3/ Industry sources report that, domestically, plastics are not likely to displace aluminum in this market anytime soon. 4/ Also, purchasers of expensive perfumes prefer glass to plastics, although acceptable plastics containers are available; also consumer preference dictates glass containers when purchasing high-priced liquors and wines. Milk is now available in aseptic packaging and, worldwide, milk and milk products account for 80 percent of the aseptic packaging; however, in the United States, consumers continue to resist the concept, owing to the belief that milk needs to be refrigerated to prevent spoilage. 5/

If the building-blocks, ethylene, propylene, and styrene, were measurably less expensive than at present, plastics would still not move more rapidly into the packaging markets now held by the traditional materials. The easy markets for plastics in packaging have already been penetrated. Many of these markets, such as household chemicals (e.g., laundry detergent) and the 2-liter-size beverage bottles, are mature and have approached market saturation, and the rate of growth of these products is slowing down to reflect the growth of the GNP which, in turn, reflects the general economy. The major packaging markets that are left for plastics to enter are areas of food packaging where flavor integrity is at stake. 6/ In addition, producers of packages from traditional materials have not been dormant; they are also

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1/ The Rauch Guide, The Rauch Guide to the U.S. Packaging Industry, Date for 1984, 1985 and Projections to 1990, Bridgewater, NJ, 1985, pp. 28 and 29; "Potential Outruns Profits in Plastic Packaging," Chemical Week, Oct. 15, 1986, pp. 38-40, and, "FDA Okays PVC Packaging for Food Use," Chemical Marketing Reporter, Dec. 8, 1986, pp. 5 and 25.
2/ Ibid.
3/ "Beverage Packaging: New Sizes, New Containers," Packaging, December 1985, pp. 38-41.
4/ "Potential Outruns Profits in Plastic Packaging," Chemical Week, Oct. 15, 1986, pp. 38-40.
5/ "Statistics of Packaging," Packaging Reference Issue 1986, pp. 35-38, and, Paper, Film, and Foil Converter, December 1985, pp. 50 and 51.
6/ "Barrier Resins Hold Key to Plastics Food Packaging," Plastics Engineering, March 1986, pp. 57-61; and, a paper entitled "Plastics Barrier Packaging the Future is Bright," by Ronald H. Foster, manager, Application Department, Northern Petrochemical Co. at the Society of Plastics Engineers Conference, Packaging Challenges for the 80's, Apr. 4-5, 1984, in Cleveland, OH.

attempting to improve their products through innovative technology. 1/ In addition to the cost of the building-block petrochemicals, the ability of plastics to move into barrier packaging of food will depend on the following factors.

1. The ability to meet packaging requirements;
2. Public acceptance;
3. Fabrication technology;
4. Packaging technology; and,
5. Economics, of which the cost of the building-block petrochemicals costs are only a part. 2/

Foreign trade.--Foreign trade is not an important element in the packaging industry as consumption for the most part is local and roughly equal to production and the transportation of most packaging products is extremely costly as these products generally are lightweight and bulky. U.S. shipments of plastics packaging products, including containers, flexible packaging, closures, and other components (e.g., beverage carriers and closure liners) were reported at $10,255 million in 1985; 3/ U.S. exports of containers of rubber or plastics in 1985 amounted to only $107.2 million. 4/ That year, imports of rubber or plastics containers, caps, and other closures, amounted to $251.6 million. 5/ In 1985, exports represented about 1.0 percent of U.S. shipments, and imports were about 2.4 percent of U.S. consumption. The following tabulation, compiled from official sources, shows the value of U.S. exports and imports of containers and closures for 1981-85 (in millions of dollar): 6/

Year	Exports	Imports
1981.............	108.3	77.8
1982.............	100.3	95.5
1983.............	100.1	160.9
1984.............	114.8	190.4
1985.............	107.2	251.6

1/ "Rating Package Suppliers," CPI Purchasing, December 1986, p. 21. This source says that purchasing managers also look for package suppliers that help solve problems, supply representative new test packaging samples from time to time, and have salesmen who are both easy to work with and who build a relationship based on mutual trust and confidence.
2/ For example, can the plastic container be filled at the same rate as the container it is replacing, and is the plastics container compatible with in-place packaging equipment?
3/ The Rauch Guide, The Rauch Guide to the U.S. Packaging Industry, Date for 1984, 1985 and Projections to 1990, Bridgewater, NJ, 1985, p. 2.
4/ Schedule B No. 772.2120 and 772.2140. Virtually all of a these items are of plastics material.
5/ Containers of rubber or plastics enter under TSUS item 772.20 and caps, lids, etc. of rubber or plastics enter under TSUS item 772.85. Virtually all of these items are of plastics material.
6/ Compiled from official statistics of the U.S. Department of Commerce.

Respondents' answers to the questionnaires provided some insight into their thinking. The following are comments by four packaging end users on foreign trade and "worst case" scenarios. The first packaging end-user respondent stated that purchased resin materials averaged less than $1 per pound. And, since freight and duties for plastics from Europe, for example, average about $0.20 per pound, a foreign source would need a significant competitive advantage, such as proprietary technology, or unique plastic material, to be able to compete effectively on a price/cost basis in the U.S. market. 1/ This includes not only increased freight costs but also increased inventory costs necessitated from buying offshore. One end user stated that, if this unlikely scenario occurred, it would consider alternative non-petrochemical-based packaging materials. Another end user stated that it purchased domestic materials because of service and logistical considerations which cannot be duplicated by an offshore source. 2/ For the worst case scenario, this second firm concurred and stated that, in the event that plastics were not domestically available, it would consider utilizing alternate packaging such as glass, cans, and various paper products.

A third end user stated that its packaging needs are film, and although film, unlike plastic bottles, can be shipped long distances economically, this firm does not usually consider importing plastic film for the following reasons. 3/ First, most packaging film for the U.S. market has to meet strict Food and Drug Administration (FDA) requirements which may not be the case for foreign-purchased materials; second, certain packaging film is made by complex coextrusion or lamination for which U.S. producers have a high level of expertise; and third, most U.S. producers require short supply leadtimes to meet just-in-time delivery, precluding most foreign sources. However, for the worst case scenario, the end user stated that it would be flexible and would move to alternate domestically produced materials, or would switch to foreign sourcing as dictated by competitive conditions, including the action of other firms.

A fourth end user buys flexible and rigid plastic packaging for its cheese, margarine, and ice cream products line, and makes its own milk jugs

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1/ This respondent is a large manufacture of wax products for home use (i.e., furniture and floor). This unit value is only for the resin it purchases. The plastic bottles it buys are purchased on a unit basis, not a pound basis. Further, it would never consider importing the bottles, only the resin.
2/ This is the personal care division of a major firm. They make about 10 percent of the plastic bottles used captively for after-shave lotion and liquid deodorant and buy the rest. This 10/90 make-buy ratio also holds true for the firms other plastic packaging containers (e.g., blister packaging). This firm stated that it does make/buy studies on how it will supply its production needs--petrochemical feedstock costs reportedly do not enter into its equation. They reportedly only buy domestically because of logistics and the small amounts it requires.
3/ This respondent is a large food processing company with plants located across the United States. This firm buys significant quantities of plastics film and smaller quantities of plastic which it converts to packaging film .

from purchased resin. 1/ This respondent stated that, if foreign sources were used under the "worst case" scenario, leadtimes would be greatly extended, causing potential supply problems, and foreign sources might be less in tune to the quality needs of the domestic end-user markets. It was also stressed that access to technical service would be difficult from overseas sources, and, without domestic competition, efforts to hold down pricing would be difficult.

Respondent suppliers of plastics packaging were generally in agreement with the comments of the respondent packaging end users. For the packaging suppliers, the consensus was that they rely on U.S. plastics producers for consistent quality, ontime availability, and reliable, timely technical service. They emphasized their belief that "quick response" technical service would be difficult to achieve by foreign sources.

For the "worst case" scenario, the plastic packaging suppliers stated that their alternatives are very limited, and the smaller respondent firms believed that they would be especially disadvantaged. If they had to depend on foreign sources for plastics materials, many supplying firms cited a return on their part to making packaging from traditional materials--metal closures and glass bottles; larger packaging supply firms might decide to abandon this segment of its multifaceted business. However, some suppliers said they would be forced to import their plastics requirements since the packaging products they produce (i.e., dual-ovenable trays) reportedly cannot be produced from alternative materials. Overall, some of the suppliers believe that the "worst case" would ultimately lead to higher plastics prices, inferior plastics quality, and inferior plastics technology.

Both packaging suppliers and end users view the effects of foreign packaging sources on them as minimal. 2/ The domestic packaging suppliers and packaging end users report that they would be more heavily affected by finished products containing petrochemical components since this is what they either sell (i.e., supplier) or buy (i.e., end user). The effects of imports of first-stage materials, such as chemicals and/or derivatives (e.g., plastics materials), is less immediate and does not seriously affect suppliers and users as it is easier for suppliers and end users with value-added products to defend against.

For both the suppliers and the end users, Canada is the one exception as a foreign source for plastics and plastic packaging products. Canada has excellent resin technology, much of which is based on U.S. patents (many of the major Canadian resin producers are U.S. subsidiaries). Its fabricating industry, although small, is capable of delivering acceptable standard packaging products, and, most important of all, it is economically accessible as a contiguous neighbor especially to both domestic plastic packaging suppliers and packaging end users in the Northern Tier States.

1/ This respondent is also a large food-processing company whose name is almost synonymous with butter.
2/ Based on information aggregated from seven packaging end-user questionnaires and from five packaging supplier questionnaires.

7.4 Other industries

The building-block petrochemicals covered by this study enter many markets in addition to those discussed earlier. Those markets that will be covered in this section are composites, electrical chemicals, finished textile products, paints and coatings, pharmaceuticals, plastics products (other than those used in automotive, construction, and packaging), and synthetic detergents.

Some of the product areas mentioned represent new specialty chemical areas such as the composites and electrical chemicals, where both the applications and the technology are still evolving. 1/ Although pharmaceuticals represent a well-established market for petrochemical-based compounds, pharmaceutical products involve some of the most advanced, sophisticated chemical technology known to the industrialized world and are part of the specialty chemical market. For pharmaceuticals, there are long development times, large safety risks, and the need for quick payback to write off R&D expenses before patents expire. 2/ Pharmaceuticals, certain plastic products, and synthetic fibers are global in scope, whereas paints and coatings and synthetic detergents are usually formulated on a local basis to serve local markets, thereby either eliminating, or at least minimizing competition from foreign-based sources. 3/

Advanced composites.--Advanced composites are high-performance structural materials made from engineering resins reinforced with carbon, aramid, and boron fibers. The advanced plastics composites (a sophisticated member of the reinforced plastic family) have four major market segments: aerospace, sports equipment, industrial applications, and the automotive industry. 4/ The most important feature of the plastics composite is its high strength-to-weight ratio, which permits a weight reduction of 30 to 50 percent compared with alternative materials and often is translated into increased performance or decreased energy need. The aerospace industry, which represents the "leading edge" for advanced composites, is a small market in terms of volume, but at present is the only high-volume, high-growth area, reaching 37 million pounds

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1/ The basic composite technology is five decades old, but new resins, new processes, changing engineering and design philosophies, plus new economic appeal in large market segments are combining to push a number of composities, such as those designed for uses in spacecraft and military aircraft, to the front. "Composites: The Low End Grows High-Tech," Chemicals Business, June 1986, pp. 10-12.
2/ "U.S. Chemical Industry in Midst of Major Restructuring," Chemical & Engineering News, Apr. 7, 1986, pp. 8-10.
3/ "Playing Catch-Up in Globallization," Chemical Week, June 25, 1986, pp. 85 and 86.
4/ A paper entitled "Advanced Structural Composites: Building the Future," by James N. Burns, Market Director, Graphite Materials & Composite Structures, Hercules Inc., before the World Chemical Congress of Marketing and Business Research at Newport Beach, CA, Sept. 7-10, 1986.

in 1986, up 12.1 percent from 1985. 1/ It is the aerospace market, which includes advanced aircraft and spacecraft, that uses state-of-the-art engineering resins and high-performance fibers such as carbon, aramid, and boron fibers. At present, advanced composites represent about 3 percent of the structural weight of commercial aircraft and, according to official sources, eventually could account for as much as 65 percent. 2/ These official sources report that the aerospace sector now consumes about 80 percent of the annual domestic consumption of advanced composites. 3/ However, it is the automotive sector that reportedly offers the greatest opportunity for advanced composites. At present, advanced composites are used in limited production in the manufacture of drive shafts and leaf springs. By 1995, advanced composites could be used in the production of unibody frames for automobiles. However, to be economically competitive with current materials, production methods 10 times faster than current methods will have to be developed for advanced composites in this end use.

Shipments of composites and reinforced plastics totaled 2.3 billion pounds in 1986, a 2.8-percent increase from 1985. For 1987, shipments are projected to grow another 3 percent to nearly 2.35 billion pounds. 4/ The following tabulation shows how the industry estimates composites' performance in terms of change in volume of shipments in 1986 versus 1985 and forecasts 1987 in light of 1986 data: 5/

Market segment	Shipments 1986 1/	1987 2/
	Percent	
Aircraft, aerospace, military	12.1	8.1
Appliances, business equipment	2.3	3.7
Construction	2.7	1.8
Consumer products	3.5	2.0
Corrosion-resistant equipment	-1.4	3.1
Electrical, electronic	5.8	3.5
Marine	3.0	3.2
Transportation	3.0	4.0
Specialties	5.0	2.4

1/ Compared with 1985.
2/ Based on a 3-percent growth estimate.

1/ U.S. Department of Commerce, U.S. Industrial Outlook 1987, pp. 14-2 and 14-3, "Composites, Reinforced Plastics Use Hits Record," Chemical & Engineering News, Feb. 9, 1987, p. 5; and, James N. Burns. op. cit.
2/ Office of Technical Assessment, New Structural Materials Technologies: Opportunities for the Use of Advanced Ceramics and Composities, September 1986, pp. 6, 7, and 50-65.
3/ Ibid.
4/ "A Big Win for Composites," Chemical Week, Feb. 11, 1987, pp. 13 and 14; "Composites, Reinforced Plastic Use Hits Record," Chemical & Engineering News, Feb. 9, 1987, p. 5; and , James N. Burns, op. cit.
5/ Tabulation taken from "A Big Win for Composites," Chemical Week, Feb. 11, 1987, pp. 13 and 14. The original source was the Society of the Plastics Industry Composite Institute, New York City.

Electronics chemicals.--Electronics chemicals are not end products themselves, but rather are components of products (e.g., semiconductors and printed circuit boards (PCB's)) which are themselves components of end products (e.g., personal computers, sophisticated electronic equipment for industrial and consumer applications). Therefore, a change in the price of the building-block petrochemicals, even as much as 50 percent, would have little effect on the competitiveness of the U.S. electronic chemicals industry. Also, many of the electronic chemicals are inorganic compounds and, therefore, totally unaffected by pricing changes in building-block petrochemicals. 1/

The global market for chemicals aimed at the electronics industry was estimated by one source to have been more than $6 billion in 1985, with the U.S. industry accounting for about one-half of this demand. 2/ Another industry source projects that the increased use of electronic components in automobiles, computers, and other commonplace consumer goods will result in U.S. shipments of electronics chemicals increasing by more than 14 percent per year to approach $15 billion in 1995. 3/ This source sees semiconductors pacing expansion in electronics chemicals at 12 percent a year; chemicals for PCB's are expected to grow 7.5 percent annually, and 7.3-percent growth per year is seen for chemicals for passive components (e.g., hybrid circuits, capacitors, and resistors). This source estimates that chemicals for semiconductors represents 43 percent of the electronics chemical market, those for PCB's 39 percent, and those for passive components 15 percent. A 1-percent share is estimated for chemicals used in photovoltaic cell production.

Industry sources now believe that the U.S. share of the worldwide electronics chemicals sales will erode as U.S. electronic equipment manufacturing continues its shift to the Far East. 4/ Also, large foreign chemical firms have entered the U.S. electronic chemical market for several reasons: first, the semiconductor industry was born in the United States; second, the U.S. market for electronic equipment is the largest single market in the world; third, the U.S. offers foreign investors political and monetary stability; and, fourth, there is customer acceptance for high-quality products.

Textile products.--Finished textile products represent a relatively weak competitive area for the U.S. chemicals industry as such finished products as apparel are normally considered labor intensive. U.S. imports of textiles and apparel reportedly reached an all-time high in 1986 of 12.7 billion square

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1/ "The Internationalization of the Electronics Chemicals Business," Chemical Marketing & Management, Winter 1986, pp. 35-42.
2/ "Fast Switching Clicks in Electronic Chemicals," Chemical Business, July 1986, pp. 10-14
3/ "Chemical Men See a Bonanza in the 'Ubiquitous' Computer," Chemical Marketing Reporter, May 5, 1986, pp. 39 and 42. These are projections of the Freedonia Group, Inc. of Cleveland, Ohio.
4/ "The Internationalization of the Electronics Chemicals Business," Chemical Marketing & Management, Winter 1986, pp. 35-42.

yards equivalent, 1/ which is a value of $24.7 billion, up 17 percent over 1985. Exports totaled $3.5 billion, and the textile and apparel deficit of $21.5 billion represented 12.5 percent of the nation's total merchandise trade deficit. 2/ The synthetic organic polymers that go into synthetic or manmade fiber (i.e., nylon, polyester, acrylic and modacrylic, and olefin and vinyon) usually represent a small portion of the cost and price of the finished dress, shirt, or other products. 3/ However, imports of apparel limit U.S. production of fibers and the intermediates used to make them thus adversely affecting the primary petrochemicals industry. 4/

1/ "Textile Imports a Record Again, Man-Made Fiber Imports Rise Too," Chemical Marketing Reporter, Feb. 9, 1987, pp. 4 and 26, and, "Textile Industry Had Better Year in 1986, But Still Sees Problems," Chemical Marketing Reporter, Dec. 29, 1986, p. 7.

2/ "Textile Imports a Record Again; Man-Made Fiber Imports Rise Too," Chemical Marketing Reporter, Feb. 9, 1987, pp. 4 and 26, and, "Synthetic Fiber and Textile Chemicals: The Shrinking U.S. Share," Chemical Week, July 24, 1985, pp. 18-24.

3/ "Oil and Gas Cost Down; Why Not Resin Prices?," Modern Plastics, October 1986, pp. 56-59; "Ethylene and PE Tabs: A Tenuous Link?," Chemical Week, Nov. 12, 1986, pp. 36 and 38; "Petrochemicals 1986: A Painful Costly Rethinking," Chemical Business, April 1986, pp. 13-16; "Restraints on Imported Apparel Lift Synthetic Fiber Output," Chemical & Engineering News, Nov. 17, 1986, pp. 9-12; "Fiber Intermediates Demand Dampened by Apparel Imports," Chemical & Engineering News, Oct. 6, 1986, pp. 11-14; and, H.L. List, op. cit, pp. 72-77, pp. 180-185, and pp. 245-259.

These sources show, for example, xylenes at 14 cents per pound; dimethyl terephtalate (DMT) at about 26 cents per pound; purified terephthalic acid (PTA) about 28 cents per pound; and polyester fiber of round 150-denier yarn at 80 cents per pound and staple at 70 cents per pound. Similar relationships are shown for the other building-block petrochemicals, fiber intermediates, and fibers. Another example is benzene at about 12 cents per pound to cyclohexane at about 14 cents per pound to nylon carpet staple for $1.40 to $1.70 per pound or low-denier textile fiber at $1.80 per pound. It's obvious that even a 25-percent change in the price of a major building-block petrochemical (e.g., ethylene at 14 cents per pound) would have little effect on the finished cost of a suit, dress, or shirt.

4/ "Fiber Intermediates Demand Dampened by Apparel Imports," Chemical & Engineering News, Oct. 6, 1986, pp. 11-14; "Textile Imports a Record Again Man-Made Fiber Imports Rise Too," Chemical Marketing Reporter, Feb. 9, 1987, pp. 4 and 26; "Textile Industry Has Better Year in 1986; But Still Sees Problems," Chemical Marketing Reporter, Dec. 29, 1986, p. 7; and, "Restraints on Imported Apparel Lift Synthetic Fiber Output," Chemical & Engineering News, Nov. 17, 1986, pp. 9-12. This source states that because labor costs are lower in Pacific Rim countries, vast increases in U.S. imports of apparel from them have resulted in declines in apparel manufacture and, thus, in synthetic fibers produced in the United States during the 1980's. The gap in labor costs may be closing because wage and benefit costs in the various Asian countries are increasing while those same costs in the U.S. garment industry are declining as a result of capital investment in new technology.

<u>Paints and coatings</u>.--Paint is produced by more than 1,000 producers in the United States as transportation costs are relatively high and sold through a wide range of outlets, including 18,000 independent paint retailers, 3,000 supplier-operated stores, home improvement centers, hardware stores, general merchandise stores, and mass retail chains. 1/

Official sources reported that paint industry shipments reached $11,101 million in 1986, a 5.3-percent increase over $10,539 million in 1985. 2/ Industry shipments increased regularly by 18.6 percent from $9,144 million in 1981 to $10,848 million in 1984 before declining by 2.9 percent in 1985. In 1981, the ratio (percent) of imports to exports was 8 percent. By 1986, the ratio had climbed to 75 percent, which may indicate that, for certain types of paints and coatings, international trade may become important in the future. 3/

The paint industry's fragmented nature, maturity, increasing technological sophistication to meet environmental considerations, relatively high transportation costs, and globalization taking place across the entire expanse of the petrochemical industry are reshaping it. 4/ Industry sources therefore, doubt that any foreseeable change in the price of building-block petrochemicals worldwide would alter the events now underway in the U.S. paint industry.

<u>Pharmaceuticals</u>.--The pharmaceutical industry produces very sophisticated and complex chemical products that are far removed from the building-block petrochemicals. For most pharmaceutical products, there usually are many processing or manufacturing steps required in a final product, and much value added to the starting materials. These specialty chemicals are being touted by industry sources both for globalization and as a viable alternative to commodity petrochemicals which are sensitive to price changes in building-

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1/ "Coatings '86: The Big Splash from Emission-Free Formulations," <u>Chemical Week</u>, Oct. 22, 1986, pp. 30-56; U.S. Department of Commerce, <u>U.S. Industrial Outlook 1987</u>, pp. 15-1 to 15-4; "How Paint Makers are Remodeling," <u>Chemical Business</u>, October 1986, pp. 10-13; and, "Paints for Special Applications Capture Growing Share of Market," <u>Chemical & Engineering News</u>, Oct. 20, 1986, pp. 17-56.
2/ "Coatings '86: The Big Splash from Emission-Free Formulations," <u>Chemical Week</u>, Oct. 22, 1986, pp. 30-56, and, U.S. Department of Commerce, <u>U.S. Industrial Outlook 1987</u>, pp. 15-1 to 15-4.
3/ "Coatings '86: The Big Splash from Emission-Free Formulations," <u>Chemical Week</u>, Oct. 22, 1986, pp. 30-56, and, U.S. Department of Commerce, <u>U.S. Industrial Outlook 1987</u>, pp. 15-1 to 15-4.
4/ "Paint for Special Applications Capture Growing Share of Market," <u>Chemical & Engineering News</u>, Oct. 20, 1986, pp. 17-56; "How Paint Makers are Remodeling," <u>Chemical Business</u>, October 1986, pp. 10-13; Standard & Poor's, <u>Industry Surveys: Chemicals-Basic Analysis</u>, Vol. 154, Oct. 9, 1986, pp. C32 and C33; "Coatings '86: The Big Splash From Emission-Free Formulations," <u>Chemical Week</u>, Oct. 22, 1986, pp. 30-56; and, U.S. Department of Commerce, <u>U.S. Industrial Outlook 1987</u>, pp. 15-1 to 15-4.

block petrochemicals. 1/ Pharmaceuticals can be considered in a global context because their development must be supported by a large financial base that can support a large R&D expenditure. 2/

An official source reports that overseas, especially in Japan and Europe, major U.S. pharmaceutical firms are evolving new fully owned subsidiary companies. 3/ On the other hand, direct foreign participation in the U.S. drug market has grown at a rate of 4 percent a year for the past decade, and there are now reportedly 26 foreign firms that have pharmaceutical operations in the United States.

The value of shipments by the pharmaceutical industry increased steadily from $22.3 billion in 1981 to $33.4 billion in 1986, or by about 50 percent. 4/ The following tabulation shows the level of imports and exports for the pharmaceutical industry and the ratio of imports to exports for 1981-86:

1/ The theme for globalization and/or the restructuring of the U.S. chemical industry toward specialty chemicals and away from commodity petrochemicals is found in recent books such as H.L. List, Petrochemical Technology: An Overview for Decision Makers in the International Petrochemical Industry, Englewood Cliffs, NJ, 1986, pp. XV-XXX; Joseph L. Bower, When Markets Quake, Harvard Business School, 1986, pp. 49-74; and, OECD, Petrochemical Industry: Every Aspects of Structural Change, Paris, France, 1985, pp. 47-49 and 85-103.

Recent articles promoting the restructuring/globalization theme of the U.S. chemical industry, including pharmaceuticals, may be found in "U.S. Chemical Industry In Midst of Major Restructuring," Chemical & Engineering News, Apr. 7, 1986, pp. 8-10; "Calling the Turns in the Chemical Industry," Chemical Marketing & Management, Winter 1986, pp. 31-33; "Playing Catch-Up on Globalization," Chemical Week, June 25, 1986, pp. 85 and 86; "The Chemical Industry: Where in the World Is It Going?," Manufacturing Chemist, November 1986, pp. 55-59; "HPI Spending Prospects for 1987," Hydrocarbon Processing, December 1986, pp. 49-57; "A Worldwide Future for R & D," Chemical Week, Feb. 26, 1986, pp. 15 and 17; "Strategies for Survival and Growth," Chemical Engineering Progress, June 1986, pp. 21-24; and, "Global Business Strategies for the 1990's," Chemical Engineering Progress, December 1986, pp. 14-17. This list is not intended to be exhaustive, only representative.

2/ U.S. Department of Commerce, U.S. Industrial Outlook 1987, pp. 17-1 to 17-7. This source reports that as R&D for pharmaceuticals becomes more complex, costly, and time consuming, firms are collaborating in order to cut R&D expenses. R&D costs for the industry were estimated at $4.7 billion in 1986, 15 percent above 1985. This included an estimated $800 million on R&D for U.S. pharmaceutical firms overseas.

3/ Ibid.

4/ The U.S. Industrial Outlook reports that the pharmaceutical industry consists of three components: biologicals, medicinals and botonicals, and pharmaceutical preparations. Pharmaceutical preparations are the most important segment, accounting for 77 percent to 79 percent of the aggregated shipments during 1981-84 and then increasing in 1985 and 1986 to 80 percent and 81 percent, respectively.

Year	Imports	Exports	Ratio of imports to exports
	---Million dollars---		Percent
1981	1,047	2,220	47.6
1982	1,051	2,298	45.7
1983	1,312	2,533	51.8
1984	1,665	2,637	63.1
1985	1,896	2,671	71.0
1986	2,359	2,839	83.1

An official source reports that in 1987 U.S. pharmaceutical exports are forecast to increase to $3,085 million, or by 9 percent from 1986. 1/ U.S. imports of pharmaceuticals are projected at $3,030 million for 1987, virtually even with exports, and 28 percent above the import level in 1986.

As stated at the beginning of this section, pharmaceuticals are generally considered to be specialty chemicals that are produced in relatively small quantities, and are many steps removed from the building-block petrochemicals. Therefore, it is unlikely that these high value-added products would be more than marginally effected by price changes and/or availability of the basic building-block petrochemicals.

Surface-active agents (surfactants).--Surfactants are organic chemicals that reduce the surface tension of water and are the active components of detergents and other cleaning agents. The synthetic building-block petrochemicals for surfactants, such as ethylene, benzene, butylene, and propylene, compete head to head with natural fats and oils for market share. 2/ Those surfactants that are based on natural products (e.g., coconut oil or palm oil) afford the United States no feedstock advantage. On the other hand, synthetic surfactants have value added through many processing steps from the building-block petrochemical. Further, the final product, the detergent, contains many other ingredients as the surfactant typically accounts for only 8 to 30 percent of the aggregated compound.

U.S. industry shipments of surfactants increased regularly from $2,062 million in 1981 to an estimated $2,678 million in 1986, or by about

1/ U.S. Department of Commerce, U.S. Industrial Outlook 1987, pp. 17-1 to 17-7.
2/ "Principal Players Switch Roles Following Mergers, Buyouts; Technical and Market Changes Mandate Reformulations," Chemical Week, May 7, 1986, pp. SAS3 to SAS28. This source states that fats and oils, the basis for virtually all of the fatty acid-based surfactants, are primarily market price driven by their use as foodstuffs. The prices of these products are largely dependent on food pricing, and on all the uncertainties that go with being largely an agricultural crop.

30 percent. 1/ U.S. imports of surfactants climbed irregularly from $58.7 million in 1981 to an estimated $181 million in 1986, or by more than 208 percent. During this period, U.S. exports of surfactants increased irregularly from $177 million in 1981 to an estimated $178 million in 1986, or by about 0.6 percent, from a low of $145 million in 1983 to a high of $156 million in 1982. U.S. exports exceeded U.S. imports of surfactants by between $60 million to $100 million annually during 1981-84. During these years, apparent domestic consumption was annually 5 percent or less below the value of industry shipments. However, by 1985, the value of U.S. surfactant imports and exports was virtually equal at $145 million and $149 million, respectively, so that U.S. shipments were virtually equal to domestic consumption. For 1986, it is estimated that U.S. imports of surfactants slightly exceeded U.S. exports of surfactants at $181 million and $178 million, respectively. The principal U.S. sources for surfactants in recent years have been France, West Germany, and the United Kingdom; the principal U.S. markets for surfactants in recent years have been Canada, the United Kingdom, and Panama.

Miscellaneous plastics products.--The products covered here excluded those plastics products covered earlier; that is, automotive, construction, and packaging, which, in 1985, represented 4.4 percent, 22.1 percent, and 28.2 percent, respectively, of the sales and captive use of plastics in the United States. 2/ The remaining 45 percent of plastics consumed in the United States enters such diverse markets as the following: electrical/electronic (e.g., home and industrial appliances, wire and cable, communications equipment, and so forth), furniture and furnishings (e.g., carpet and carpet components and so forth), and consumer and institutional products (disposable food serviceware, health care and medical products, and so forth). Not only are the markets unrelated, but the products within a given market that contain plastics are dissimilar (for example, in the electrical/electronic market, there are both storage batteries and electrical laminates).

Some plastics, such as polyethylene resin, polypropylene resin, polystyrene resin, and polyvinyl chloride resin, are only one to three processing steps removed from the building-block petrochemicals, ethylene, propylene, or benzene, and are, therefore, quite sensitive to any price changes in the building-block petrochemical. On the other hand, engineering resins such as nylon resins or high-priced resins such as fluorocarbon resins are many production steps removed from the starting material and/or sell at many dollars per pound, thereby minimizing the 10 to 15 cents per pound that the building-block petrochemicals sold for in early 1987. 3/ The U.S. miscellaneous plastic products industry (SIC 3079) is susceptible to import competition from those products which are highly labor intensive (e.g., artificial plastic flowers) and/or those plastic products which nestle or stack well (e.g., film rolls, trays, and pails or buckets).

1/ U.S. Department of Commerce, U.S. Industrial Outlook 1987, pp. 16-1 to 16-7.
2/ The Society of the Plastics Industry, Inc., Facts & Figures of the U.S. Plastics Industry, 1986 edition, New York, NY, September 1986, pp. 112 and 113.
3/ "Production of Basic Petrochemicals Will Continue Upward in 1987," Chemical & Engineering News, Feb. 9, 1987, pp. 9-13.