MA-RD-770-87025
DOT-TSC-RSPA-87-2

Forecasting Trade and the Merchant Fleet

Bruce Weiers
Jeanette Kelleher

Transportation Systems Center
Cambridge, MA 02142

April 1987
Final Report

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

U.S. Department of Transportation
Maritime Administration

Office of Advanced Ship Operations
Washington, DC 20590

Technical Report Documentation Page

...port No.	2. Government Accession No.	3. Recipient's Catalog No.
RD-770-87025		

...tle and Subtitle	5. Report Date
...ECASTING TRADE AND THE MERCHANT FLEET	April 1987
	6. Performing Organization Code: TSC/DTS-46
...thor(s) ...ce Weiers, Jeanette Kelleher	8. Performing Organization Report No.: DOT-TSC-RSPA-87-2
...rforming Organization Name and Address ... Department of Transportation ...earch and Special Programs Administration ...nsportation Systems Center ...bridge, MA 02142	10. Work Unit No. (TRAIS): MA707/W7002
	11. Contract or Grant No.
...onsoring Agency Name and Address ... Department of Transportation ...itime Administration ...ice of Advanced Ship Operations ...hington, DC 20590	13. Type of Report and Period Covered: Final Report Jan. 1985-Sept. 1986
	14. Sponsoring Agency Code: MAR-770

...pplementary Notes

...bstract

This report presents the results of an effort to develop a forecast ...the ships required for U.S. oceanborne foreign trade. The ability to ...urately identify trends that affect the fleet can provide important ...ormation to the U.S. maritime industry.

Within an economic framework, the prospects of U.S. maritime foreign ...de, future development of seaborne trade, and ships that carry trade ... discussed. Principles of trade, factors governing the development ...the merchant fleet, past trends, and recent forecasts are examined; ...lications are drawn regarding the developments to the end of the ...tury and beyond. Nominal fleet forecasts using notional ships are ...sented to quantify the relationship of trade growth to the need for ...et expansion.

...ey Words	18. Distribution Statement
...anborne Trade, Merchant Fleet, ...parative Advantage, Trade Pat-...ns, Commodity Forecasts	DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161

...ecurity Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
...nclassified	Unclassified	210	

DOT F 1700.7 (8-72) Reproduction of completed page authorized

PREFACE

This paper presents the results of an effort to develop a forecast of the ships required for the U.S. oceanborne foreign trade. The effort was sponsored by the Maritime Administration, Office of Advanced Ship Operations, and the paper was prepared by the Transportation Systems Center, Office of Research and Analysis.

The ability to identify accurately trends affecting the fleet that will be serving U.S. oceanborne foreign commerce can provide important input to the U.S. maritime industry. Ports, ship operators, and shipyards can use this information to project the future implications of their current investment decision-making. Government agencies can use this information to evaluate prospective policies.

Forecasting the U.S. foreign trade and the fleet required to serve it have been traditional Maritime Administration activities. Forecasts have been prepared from time to time by varying methods and with varying resources. An important stimulus for this particular fleet forecast was that two recent forecasts of the U.S. foreign trade would be available as starting points. One of these had been prepared by Data Resources, Inc. for the Maritime Administration (and is referred to in this report as the DRI/MARAD forecast); the other was prepared for the Congressional Office of Technology Assessment by Wharton Econometrics (and is referred to as the OTA/Wharton forecast). The present effort was undertaken with more limited resources than some past fleet forecasting efforts. The challenge of resource constraints was met through the use of previously and independently generated trade forecasts and the use of a simple, microcomputer-based method for producing nominal fleet forecasts based on those trade forecasts.

The extent and quality of published data available on trade and the merchant fleet were identified during the course of the study as important constraints on the quality and depth of analysis. Finally, a concluding chapter describes these problems and suggests improvements in the government's data that would increase the ability of the private analysts in the maritime community to generate high quality analysis for particular purposes.

Larry Smith and John Reeve of Temple, Barker & Sloane, Inc. shared their experience concerning forecasting methodologies. Henry Marcus of the Massachusetts Institute of Technology reviewed drafts of the paper and offered many useful criticisms. The patient advice and criticism of Paul Mentz of the Maritime Administration is gratefully acknowledged. Thomas Harvey and Michael Wolfe of the Transportation Systems Center reviewed several drafts of the document and provided detailed criticisms.

TABLE OF CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY

Within an economic framework, this report assesses the prospects of the U.S. maritime foreign trade, discussing the future development of seaborne trade and the ships that carry that trade. Principles of trade, factors governing the development of the merchant fleet, past trends and recent forecasts are examined, and implications are drawn regarding the developments to the end of the century and beyond. Nominal fleet forecasts using notional ships are presented to quantify the relationship of trade growth to the need for fleet expansion.

Trade Development

The growth in the U.S. oceanborne trade in the last twenty years has been phenomenal, more than tripling between 1960 and 1982. This growth has been supported primarily by growth in a few of the commodities which dominate trade. Vastly increased imports of petroleum and exports of grain and agricultural products were the major factors supporting the increase in tons shipped. Increased imports of steel, automobiles, textiles, and, most recently, consumer electronics, have supported the increase in the value of trade.

Total U.S. oceanborne foreign trade has grown from approximately 475 millon long tons in 1970 to 677 million long tons in 1984. Increasing demand for petroleum and petroleum products from abroad has been particularly important in the growth of U.S. imports. On the export side, dry bulk commodities such as grain account for a large portion of tonnage. The most valuable trade items are capital goods, accounting for more than one third of the total value of U.S. exports and about fifteen percent of the value of U.S. imports.

The rapid expansion in U.S. trade has been accompanied by a shift in the patterns of trade. Historically, the major trading

Fleet Development

Over the last twenty years, the world merchant fleet has sustained remarkable and nearly revolutionary changes. Increasing ship size and specialization have been nearly universal. Many very large tankers for the carriage of petroleum were built in the 1960s and early 1970s, setting a series of new records for largest ship in the world ending with ships over 500,000 deadweight tons (dwt). The average tanker in the world merchant fleet increased from about 20,000 dwt in 1962 to approximately 60,000 dwt in 1982. The dry bulk carrier fleet also witnessed major increases in ship size, increases which continued into the 1980s, with the average dry bulk carrier more than tripling in size from 12,500 dwt in 1962 to almost 40,000 dwt in 1982. At the same time the bulk carrier fleet greatly expanded in number, the variety of cargoes shipped in bulk increased, and new specialized ships were developed to carry goods not previously carried in bulk form.

The prospects for bulk shipping are greatly affected by the expectation that the major bulk trades are likely to grow more slowly than in the past while the minor and specialized bulk trades are likely to become more important. At the present time, there is insufficient movement of petroleum to employ all of the very large tankers available. It is likely to be several years before resumed growth in petroleum trade and lengthening trade routes again combine to create demand for these ships. In the U.S. export bulk trades of coal and grain, several factors are likely to work against the rapid or universal employment of very large or specialized vessels.

General cargo shipping experienced changes at least as great as bulk shipping, largely as a result of containerization and related efforts to unitize cargoes. The immediate effect of cargo unitization was to make economically practical much larger

TABLE E-1. NUMBER OF SHIPS BY SIZE CLASS REQUIRED TO CARRY THE PROJECTED TRADE

Service	DWT	1975	1980	1985	1990	2000
General Cargo	45,000	0	5	18	45	152
	35,000	0	20	53	100	180
	25,000	110	140	145	155	170
	15,000	172	205	215	220	245
	5,000	975	1045	1045	1050	1100
General Cargo Ship Subtotal		1,257	1,415	1,476	1,570	1,847
Dry Bulk	125,000	20	65	90	155	335
	70,000	130	230	325	400	685
	35,000	400	490	550	600	715
	15,000	430	485	505	535	585
Dry Bulk Ship Subtotal		980	1,270	1,470	1,690	2,320
Tanker	250,000	5	5	2	5	8
	150,000	12	32	34	43	65
	70,000	152	179	168	170	190
	35,000	506	515	385	400	405
Tanker Ship Subtotal		675	731	589	618	668
Average General Cargo Ship (DWT)		8,119	8,993	9,986	11,433	14,383
Average Dry Bulk Ship (DWT)		32,704	38,307	41,378	45,207	53,287
Average Tanker (DWT)		46,519	50,075	52,451	54,369	58,720

1. INTRODUCTION

1.1 OVERVIEW

Importance of Oceanborne International Trade -- Every year over 7,000 different merchant vessels out of the world fleet of over 25,000 ships make some 19,000 entries into the U.S. carrying the U.S. foreign trade. The oceanborne foreign trade and the ships which carry it are of great economic importance to the United States and to the world. The U.S. maintains an annual foreign trade in excess of one billion dollars with each of 58 nations.[1] In 1981, as the world's largest trading nation, the U.S. accounted for nearly a quarter of the total of world exchange. International trade is also an increasingly essential element of U.S. GNP. In 1961, total foreign trade as a proportion of GNP amounted to slightly less than 10 percent, but by 1981, total trade accounted for nearly 20 percent of total GNP.

The U.S. has increased its reliance on both foreign markets for American goods and services and on overseas suppliers of raw materials and manufactured goods. The agricultural sector especially depends upon foreign demand to consume its excess production and raise farm revenues. In 1983, agricultural exports of 34.8 billion dollars represented about one-quarter of farm sales revenue and the output of 35 percent of the harvested cropland.

Although the importance of air carriers in international trade has been growing in recent years, the vast majority of U.S. trade is still shipped by sea. In fact, in tonnage terms, U.S. trade

---

[1] An Assessment of Maritime Trade and Technology (Washington, DC: U.S. Congress, Office of Technology Assessment, OTA-O-220, October 1983), p.23.

Pacific trade accounts for the largest share of U.S. foreign trade.

The merchant fleet has also changed dramatically since 1960. In 1960, the world was marveling at the Universe Apollo, the first oil tanker to exceed 100,000 deadweight tons (dwt). Bulk carriers, as a type distinct from general tramp ships, were very few outside the iron ore trades, and most of them were ships of less than 18,000 dwt. Containerization of liner cargoes was just starting in the U.S. domestic trades.

1.2 PURPOSE AND PLAN OF THE REPORT

The purpose of this report is to assess the prospects for the next twenty-five years. In what direction is the merchant fleet headed? What will be the trends for the next five years, the next ten, or the next twenty? In twenty-five years, when few ships afloat today still serve actively, what will the fleet look like?

There are two ways to frame consideration of questions like these. One is purely technical and concerned with the design and equipping of ships; the other is organizational and concerned with the configuration of the fleet, with the size and specialization of ships. This report is framed entirely in the organizational manner, being concerned with trends in the configuration of the fleet -- the number, size and types of ships required. These aspects of fleet development are governed by certain economic principles and depend largely on the volume and pattern of international trade. The principle topics of this report therefore are, first, the principles and dynamics of ship development and, second, the trends and prospects for international seaborne trade. History and economic reasoning are used to support assertions about trends in ship size and specialization. To support speculation on the future development of the U.S. foreign trade, it is necessary to rely on various economic forecasts.

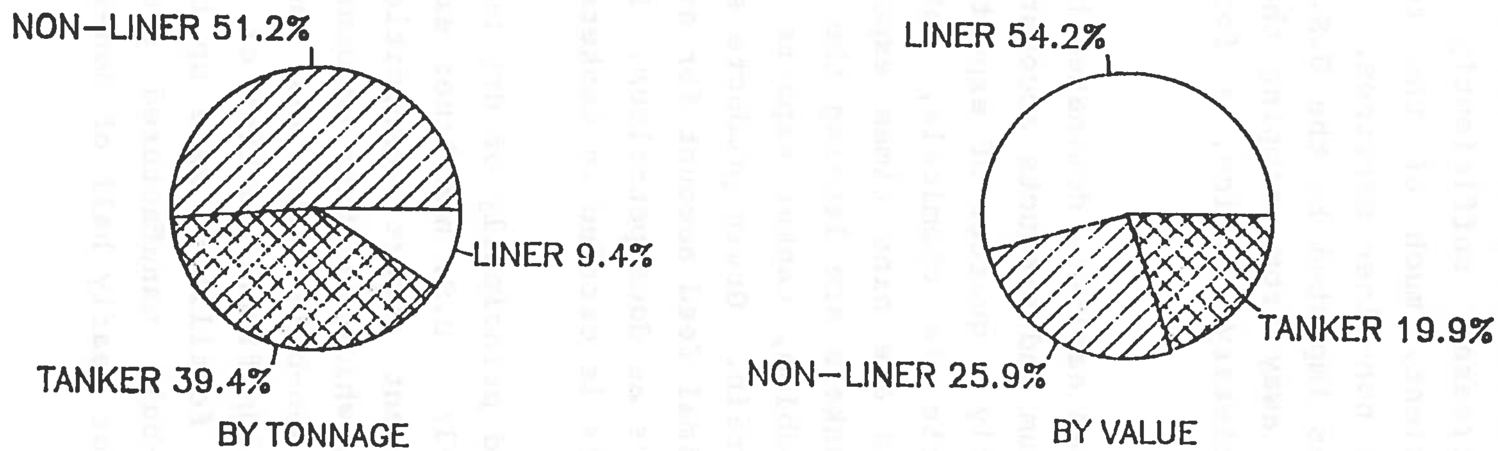
world's leading supplier of grain. The U.S. is also the world's largest exporter of coal. Coal is the second leading dry bulk commodity in terms of tons, comprising more than 22 percent of trade by tons, but only 9 percent by value. Because these commodities comprise such a significant proportion of U.S. trade by tonnage, they will be analyzed individually in greater detail in Chapter 2.[3]

By contrast with the bulk commodities, many of the high value manufactured goods which make up a large proportion of U.S. trade by value rank very low in terms of tons. The U.S. foreign trade in manufactured goods is considered in its own section of Chapter 2.

The Pattern of Trade Among Sectors of the Merchant Fleet -- The sectors of the fleet commonly associated with high value manufactured goods are very different from the sectors associated with low value, bulk cargoes. There are two common methods of describing this situation in oceanborne trade. One method divides trade into two major services: liner and non-liner. In liner services, ships operate on a fixed schedule along an established route. All other trade is considered non-liner service. Another method is to divide trade into general cargo and bulk, with sometimes a further distinction between liquid bulk (e.g., petroleum) and dry bulk (e.g. grain, iron ore, or coal). Tankers and various kinds of bulk carriers are employed to transport cargoes in bulk. General cargo, which may include any mix of small lot items and packages, is transported by various types of freighters. Neither of these methods of characterizing ocean trade is entirely satisfactory, since there are many services and cargoes which do not neatly fit into the available categories. For example, there is a good deal of shipping, often proprietary, which operates on a schedule

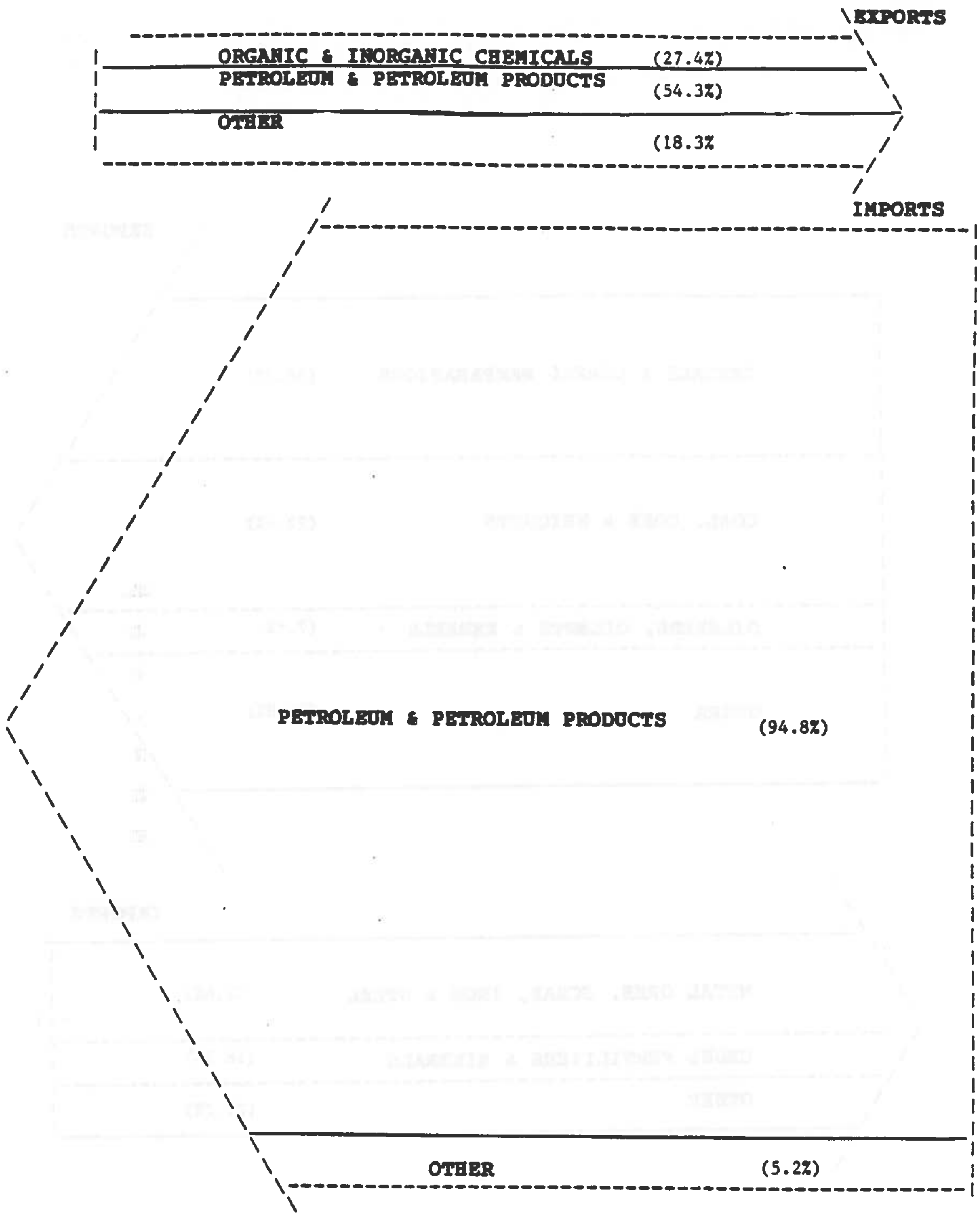
---

[3] United States Oceanborne Foreign Trade Routes (Washington, DC: U.S. Dept. of Transportation, Maritime Administration, August 1986), pp. 185-204.



SOURCE: U.S. Dept. of Transportation, Maritime Administration, <u>U.S. Oceanborne Foreign Trade Routes</u>, 1984.

FIGURE 1-1. DIVISION OF U.S. OCEANBORNE TRADE BY SERVICE, 1984



SOURCE: U.S. Dept. of Transportation, Maritime Administration, U.S. Oceanborne Foreign Trade Routes.

FIGURE 1-2. TANKER TRADE BY TONNAGE, 1984 categories, liner operators cater to shippers wishing to move relatively small shipments (always much less than shipload) various kinds. In pricing their services, liner operators must allocate the cost of ship movements over a great many small shipments. Traditionally, liner operators have charged a mix of "what the traffic will bear and what will bear the traffic." Rates tend to be ad valorem, or related to the value of the goods; high-value goods, for which the cost of transportation will not add much to the total price of the goods, tend to be highly rated. For many low value goods which would not be shipped at all if the rate was too high, liner operators will, when unfilled capacity is available, offer more attractive rates. The composition and pattern of liner trade reflects these practices: high-value goods predominate and there is no single dominate commodity, and liner trade is almost equally split in terms of tonnage between imports and exports (see Figure 1-4). This evident balance between imports and exports is due in part to the willingness of liner operators to offer very attractive rates to low-value cargoes where there is unfilled capacity. In U.S. trade with both Europe and the Far East in recent years, the U.S. has imported a much larger volume of high-value manufactured goods than it has exported. The value per ton for imports carried in liner service is significantly greater than for exports, and much of the volume of U.S. liner exports is of goods of very low value. Waste paper, for example, has been among the larger volume liner export commodities.

Many of the commodities carried by liners are shared with non-liners. On the export side, grain, lumber and lumber products, fertilizers and chemicals are among the top twenty commodities for both liners and non-liners. Iron and steel ores and products, foods and beverages, automobiles and parts, and non-metallic mineral manufactures are all among the twenty leading import commodities for both liners and non-liners. The transport of bulk commodities on liner ships, especially in the outbound trades, reflects a need to generate cargo, to fill ships and containers. It is the manufactured goods (motor vehicles, industrial machinery, telecommunications equipment, etc.) that provide most of the value of liner trade.

Characteristics of the Fleet -- The fleet that carries the U.S. foreign trade is made up of ships of many flags, of many types and of a great range of size. A tabulation of the ships entering the U.S. in 1980, prepared as part of a study of the impact of port user fees to be imposed by the Coast Guard, provides a useful profile of this fleet. (See Table 1-1.) Of a total number of 7,695 merchant vessels entering the U.S. in 1980, 3,348 were of types designed to carry general cargo and the remainder carried commodities in bulk, either liquid or dry. These ships range in size from very small freighters registering less than 5,000 gross tons to many tankers in excess of 50,000 gross tons. The three most numerous were dry bulk carriers, the freighters, and tankers. Many specialized types were also represented in 1980.

The fleet serving the U.S. has been undergoing many changes, reflecting changes in the world fleet of merchant vessels. On the bulk side, ship size and specialization has increased. On the general cargo side, cargo unitization has resulted in the development of new ship types (container ship, LASH ship, ro-ro, etc.) and a general increase in ship size. The underlying forces governing these developments are discussed in Chapter 3.

The factors that will govern the future development of trade and the fleet can be only imperfectly discerned among the facts and theories at hand. The variables must be categorized into scenarios to fit the purpose. A decade ago, it was customary in forecasts of foreign trade and the maritime fleet to concentrate on variables related to energy use. No such single economic variable can be used so universally today. Popular phenomena attracting attention today include the rapidly growing importance of the trans-Pacific trade to the U.S., the glut of large tanker

TABLE 1-1. SUMMARY OF VESSELS ENTERING THE U.S. IN THE FOREIGN TRADE, 1980 (Continued)

	Number of Vessels by Gross Registered Tonnage			
	<5,000	5-23,000	23-50,000	50,000+
Liquid Bulk Carriers				
Tanker	47	330	439	276
Asphalt carrier	2	4	0	0
Bitumen carrier	0	4	0	0
Chemical carrier	47	136	6	0
Molasses carrier	1	4	0	0
Phosphorus carrier	0	2	0	0
Sulfer carrier	1	4	0	0
Wine tanker	1	0	0	0
Liquid Gas Carriers				
LPG carriers	16	55	26	0
LNG carriers	0	0	3	11

2. FORECASTING THE U.S. FOREIGN TRADE

Perhaps the single most important factor determining the size and character of the oceangoing merchant fleet, the most important factor in the development of new types of ships, in the development of larger ships and in determining the deployment of ships, is the volume and pattern of international trade. In Chapter 3, the principles underlying the development of different sizes and types of ships are discussed, and certain trends described. In general, merchant ships have been becoming more specialized and the range of size has increased as larger and larger ships have been built and employed. These developments, partly explained as technological evolution in pursuit of greater efficiency, have been supported by a fairly steady growth in world trade since the Second World War. Increasing volumes of stable trade, particularly in commodities, with nations and industries becoming dependent in many cases on regular oceanborne supplies, have contributed to making increased ship size and specialization economical. As international trade has expanded outside of the North Atlantic, lengthening trade routes have reinforced this trend, because the scale economies of a large ship are more important when hauls are made over greater distances.

International trade will continue to be the most important factor in the development of the merchant fleet in the future, and understanding the prospects for the future development of trade is a key to understanding the prospects for the development of the merchant fleet. In this chapter, the future of world trade and the U.S. foreign trade in particular are discussed and described by means of a review of recent forecasts.

Approaches to Trade Forecasting -- Economic forecasts, obviously colored by very recent events and overly precise, often lack credibility even when they reflect sophisticated thinking about fundamental trends. Precise numbers can distract from the more commodities carried in bulk: petroleum, coal, grain and iron ore.

of comparative advantage, with individual nations developing their productive resources, specializing in the production of some goods and trading them to obtain others. To forecast the development of trade, it would appear enough to characterize the lines along which specialization will take place and to identify what will condition the rate at which it will occur.

Micro- and Macro- Level Forecasts -- Forecasts of trade divide broadly into micro-level forecasts and macro-level forecasts: the former focus on the prospects for a particular industry, product or commodity; the latter attempt to project trends in the aggregate. Since world trade in volume terms is dominated by a few major commodities such as oil and grain, micro-level forecasts are often of great importance. Macro-level forecasts, because of their broader coverage, also must be considered of significant interest.

Micro-level forecasters can focus on a particular technology and the prospects for consumption of specific products. The major bulk commodities -- oil, grain, coal and iron ore -- receive the most attention in this way, but minor bulk trades, such as bauxite, phosphate rock, cement, etc., are often treated in a similar framework. Trade in the major bulk commodities has developed as specific, related industries have developed, with the structure and growth of the industry largely determining the pattern of trade.

The economic growth of North America, Western Europe, Japan and the newly industrializing nations of the Far East in the period since the Second World War has been in large part built on international trade, as certain basic industries were able to restructure themselves on a global basis. First and foremost among these were the oil and steel industries. The oil industry, seeking new sources of crude petroleum across the globe to feed the growing energy needs of the industrial and industrializing nations, generated huge increases in the volume of trade. The regions produce a surplus, and only a small fraction of world production is traded internationally. Trade is used to make up shortfalls in local production. As a result, trade in grain is driven less by fundamental trends than by all the short-term, localized fluctuations in production and demand, and it fluctuates greatly from year to year. This aspect of international trade places an important limit on any forecasting effort based on use of fundamental concepts.

2.1.2 Four Key Ideas in Forecasting Trade

There are four key ideas which are commonly considered by forecasters:

1. Tariffs and other barriers to trade between nations, which can seriously affect the volume of trade;

2. Business cycles, which are clearly related to a nation's trade volume, with expanding national economies drawing increased imports;

3. The rapid economic development and industrialization of some nations, which creates new potential for their increased participation in international trade with possibly profound effects on the overall pattern of trade;

4. The increasing importance of information in governing the development of the world economy, which may be causing the substitution of communication for transportation and an economizing on the consumption of material resources.

Tariffs and Trade Barriers -- An important condition for the development of the U.S. foreign trade in the post-World War II period has been the U.S. commitment to leading the world in the reduction of tariffs and other barriers to trade. The very high level of tariffs common in the 1920s and 1930s were widely recognized as having contributed to the misery of the Great Depression, and the political momentum was in the direction of tariff reduction. The ratio of duties to the value of dutiable restriction which will inhibit the future growth in trade and, consequently, in the economy. The focus of international discussions, nevertheless, remains on the topic of how to reduce trade barriers, and the United States and other nations continue to discuss ways and means of accomplishing this objective.

The Business Cycle and Trade -- One of the most common explanations for the changing pattern and growth of U.S. foreign trade is that it is part of a general increase in international trade worldwide which is part of a general economic expansion involving many individual national economies. As the national economies of the world have become more dependent on one another, their business cycles have increasingly come to affect one another and the volume of international trade between them. As a nation's economy expands into a period of prosperity, it tends to draw the products and resources of other nations, through trade, to feed its economic growth, while a nation experiencing a period of recession will have a sluggish demand for imports, contributing little to the growth in economic trade. Where different nations are in their respective business cycles relative to one another has become an important explanator and predictor of the balance of trade between them. An expanding and prospering national economy is expected to increase its imports, while expansion of its exports is seen as dependent upon prosperity of its foreign markets.

s the U.S., and the nations of the world in general, have become ore economically interdependent over the last ten to fifteen ears, with international trade accounting for larger portions of he national economy and involving more industries in a ignificant way, the business cycle explanation has increased in mportance and value as a predictor of international trade flows.

orecasts of international trade built on econometric models rely specially on the business cycle argument in their conceptual ormulation. The result of two econometric forecasts will be

TABLE 2-1. AVERAGE ANNUAL GROWTH RATES BY REGION

	1980 EXPORTS ($ MILLIONS)	ANNUAL AVERAGE GROWTH RATES 1950-60	1960-70	1970-74	1974-81
WORLD	2,012,700	6.4	9.3	27.9	15.1
NORTH AMERICA					
U.S. & CANADA	283,330	5.1	8.7	22.6	13.7
EUROPE					
DMEC-EUROPE	812,570	8.2	10.1	25.8	14.6
CPE-EUROPE[1]	157,200	10.8	8.7	21.5	14.3
EAST & SOUTHEAST ASIA					
JAPAN	129,812	15.9	17.5	28.9	16.4
KOREA	17,505	1.4	39.6	56.1	25.9
HONG KONG	19,720	-0.4	14.5	25.8	22.3
ASEAN[2]	68,060	0.5	4.4	39.0	20.4
CPE-ASIA[3]	20,360	10.9	3.1	30.1	21.5
OUTH ASIA					
INDIA	8,378	0.0	3.7	18.4	11.8
CEANIA					
AUSTRALIA & NEW ZEALAND	26,390	1.5	6.7	24.7	12.0
ARIBBEAN					
CACM[4]	4,520	4.0	10.4	18.5	11.6
CARIBB. COMM.[5]	6,000	10.2	5.2	28.2	9.6
ORG. OF E. CARIBB.[6]	2,013	5.7	4.8	24.6	15.8
OUTH AMERICA					
BRAZIL	20,131	-2.0	7.2	33.5	16.7
ARGENTINA	8,016	-0.2	4.8	24.9	13.3
ANDEAN GROUP[7]	32,450	6.0	3.1	29.4	13.9
FRICA					
NORTH AFRICA	43,660	2.3	11.5	34.2	14.9
OTHER AFRICA	48,550	4.8	8.0	30.9	12.3
SIAN MIDDLE EAST					
ARAB/MOSLEM COUNTRIES	211,130	11.3	9.3	62.4	15.0
ISRAEL	5,294	19.3	13.6	23.8	20.1

OURCE: United Nations Conference on Trade and Development, Handbook of rade and Development Statistics.

U.S. News and World Reports has summarized the situation which has called so much attention to the Pacific Rim countries:

> Over the past decade, the average compounded growth rate in these five "miracle" countries has been 8.2 percent -- roughly three times that of the nations of the European Community. Similar gains have been registered by Indonesia and Malaysia.
>
> Since 1978, U.S. trade has expanded on a spectacular scale -- by more than 75 percent -- with 12 friendly countries that ring the far Pacific. In 1983, such trade reached a level of 1.36 billion dollars -- exceeding by 26 billion the two-way exchanges between the U.S. and its traditional European trading partners.
>
> East Asia has supplanted Western Europe as the No.1 foreign market for American agricultural exports. It now accounts for nearly one third of total sales abroad of U.S. farm products.[7]

This region of the world includes Korea, Taiwan, Hong Kong, and Singapore, four nations whose income and manufacturing activity put them in the class of newly industrializing nations. The newly industrializing nations, a class which can also include Mexico, Brazil and Argentina, have demonstrated repeatedly since the 1960s a capacity for extremely rapid economic growth and the fast development of manufacturing resources. These countries are at a stage in their economic development made familiar by the examples of other nations which have preceded them, a stage which many believe presents special opportunities for rapid growth.

Closely related conceptually to the reasoning about the prospects of the newly industrializing nations is a belief that many developing countries with substantial income from the export of bulk commodities will find it advantageous to invest some of that income in-plant for the processing of those commodities into higher valued products. Saudi Arabia, for example, is investing heavily in petrochemical processing plants in a course which will

---

[7] Ibid., pp.45-6.

The Wharton/OTA forecast illustrates the startling projections which can be result from reasoning about the potential of the economic development of the newly industrializing nations to dictate new trade patterns. It is, of course, only one scenario which can be drawn. History has shown that newly industrializing nations can sustain rapid growth during a long domestic peace, but that the rapid social change associated with economic growth and development makes them vulnerable to political unrest, which can interrupt growth. During the last five years, the newly industrializing nations of Latin America have stagnated, while those of East and Southeast Asia, inspired and stabilized by Japan, have managed to achieve remarkable rates of economic growth. In the long run, Latin America, with the restoration of stable politics, may enjoy again the rapid growth achieved before 1974, while the prosperity of Asia may prove vulnerable to unrest or to instability in China.

Rapid economic growth in Latin America has very different implications for the pattern and composition of U.S. trade. The uch shorter trade distances mean that any growth in trade with atin America would have much less impact in terms of a equirement for new shipping capacity. Brazil and Argentina have uch greater agricultural export potential than the nations of outheast Asia, and economic development is likely to only add to heir capability to compete with the U.S. in agricultural export arkets; it certainly would not create the demand for U.S. grain hat Asian development very possibly will.

rade in the Information Age - Just as economic developments in he newly-industrializing nations are expected to affect the attern of trade, the further economic development of the fully ndustrialized nations, including the U.S., is seen by many as aving major implications for trade. Some economists have escribed the evolution of the U.S. economy toward a post-ndustrial stage in which the production of services occupies an applied to the control of production processes tends to conserve resources. Information applied to the design of products tends toward miniaturization, exemplified in the shrinking size and expanding power of succeeding generations of computers. It is possible that an information-intensive economy will lead to a restructuring of society which itself would be resource conservative. Peter Drucker has observed in this context that,

> Sixty years ago, the ability of large numbers of people to commute by car to work was considered a fundamental improvement in their standard of living. Twenty years from now -- probably even sooner -- we are likely to consider it a fundamental improvement in standard of living that large numbers of people do not commute to work over long distances but work instead in office clusters near their homes and let information travel rather than travel themselves.[9]

The implications of a resource-conservative, information-intensive economy for trade are startling. Most forecasts of trade, especially of trade in bulk commodities, assume that further economic development and per capita income growth will lead to more than proportional resource consumption. The rationale is simply that richer people, almost by definition, demand and consume bigger cars, more housing, larger workspaces, more electricity, more meat, more clothing, and so on, all of which require increased consumption of the primary products, such as oil, grain, steel, and lumber. Over most of the period since the Second World War, industrial development and economic growth have been associated with rapidly increasing consumption of these primary products, and for the most part, international trade in primary products has tended to grow more rapidly than the U.S. economy generally.

If the U.S. economy is evolving toward an information-based one, then it is possible than this key assumption about the

---

[9] Peter F. Drucker, "Out of the Depression Cycle," Wall Street Journal, January 9, 1985.

2.2 MANUFACTURED GOODS

The United States was involved (as importer or exporter) in one-quarter of the world's international trade in manufactures in 1982. About one-half of all U.S. foreign trade, by value, is accounted for by manufactured goods. Trade in manufactured goods can be divided into five broad categories: capital goods, automotive vehicles and parts, aircraft and parts, iron and steel products, and consumer goods. Of these five categories, capital goods, which include both electrical and non-electrical machinery, account for about one-quarter of U.S. foreign trade (exports and imports added together) by value. Consumer goods are the next largest category, accounting for a little over 11 percent in 1982. Automobiles account for another 11 percent, although nearly half this trade is with Canada and conducted overland. Aircraft were about 3 percent of total trade in 1982, and iron and steel products, about 2 percent.

In the period from 1972 to 1982, the value of U.S. foreign trade in manufactured goods (in current dollars) increased more than four times, compared to an increase in the overall gross national production of a little over 2.5 times, highlighting the leading role of trade in economic growth. The fastest growing category was the capital goods. While exports of capital goods generally kept pace with overall growth in the value of trade, imports of capital goods, both electrical and non-electrical soared, multiplying over 6.5 times. Imports of aircraft and automobiles (excluding Canada) also increased substantially.

This section describes the development of trade in manufactured goods and the prospects for the future.

2.2.1 Comparative Advantage and the Pattern of Trade

International trade in manufactured goods since the Second World War can generally be understood to have developed in line with comparative advantage. The international trade in most bulk commodities is easily understood largely in terms of a comparative advantage related to natural endowments of resources, climate or geography.

International trade in manufactures is governed by the same principles of comparative advantage which determine trade in bulk commodities, but there are some important differences introduced by the special characteristics of manufactured goods. Three special characteristics of manufactured goods deserve to be highlighted. First, while production of most bulk commodities is dependent in some significant way on natural resource endowments, efficient manufacturing is usually more dependent on the quality of human resources, on knowledge of and experience with technology, and on the availability of capital. Second, while most bulk commodities are the crude products of a simple, limited set of processes in which the most important input is a natural resource, producing most manufactured goods involves many discrete stages of processing, fabrication, assembly and distribution, each of which has different resource requirements. Third, manufactured goods are very often highly differentiable, meaning that even for the same type of product, there may be several different classes possessing different qualities for the consumer and requiring different mixes and qualities of resources to manufacture. For example, a sophisticated valve for use in the chemical industry may require extensive engineering design and precision machining, a simple plumbing fixture may be amenable to mass-production assembly, and a fire hydrant requires the application of labor-intensive casting technology.

These three characteristics of manufacturing have an important influence on how the pattern of trade in manufacturing goods develops. Because of these three characteristics, the development of a comparative advantage in the production of manufactured goods of one type or another is less dependent on a country's natural endowments such as mineral deposits, geography large amounts of capital, considerable organizational skills and engineering knowledge; at the top of the hierarchy are industries which are knowledge-intensive, requiring flexible organizations adept at problem-solving and innovation, and depending on the availability of resources for research and development. If a nation improves and develops its manufacturing resources, it may shift its comparative advantage up the hierarchy. Such general gains will be reflected in rising labor productivity. Comparative statistics on labor productivity are often used as indicators of general shifts in comparative advantage in manufacturing, as well as explanators of changes in competitive advantage.

Some of the shifts in comparative advantage that will occur internationally over the next ten to twenty years appear easily anticipated, from historical experience and governmental intention. The widely-anticipated impact of the newly industrializing and resource-commodity-rich developing countries on trade in manufactured goods (discussed in Section 2.2) is based on beliefs about how economic development will affect comparative advantage. More problematic to anticipate are the potential effects of shifts in comparative advantage among the fully industrialized nations. The differences in wage rates, labor productivity, cost of capital and availability of technological knowledge among the U.S., Japan and Western Europe are so small that more subtle factors often appear to govern the long run pattern of trade, while transitory phenomena such as currency fluctuations or labor unrest obscure the short-term.

The more numerous the industrialized nations of the world, the more they will tend to compete with one another, through nationally-based business firms, to manufacture the same or similar products. This competition becomes a process of more narrowly identifying and defining the areas of comparative advantage. The competition between business firms in nations with similar resource costs and productivity (i.e., with a principles of comparative advantage. After the war, the United States was alone among the major nations of the world in having an intact industrial capability and it dominated world trade in most important manufactured goods. As Western Europe and Japan first recovered and then advanced, they gained comparative advantage in some manufacturing activities. Shipbuilding, textiles and apparel, and shoe manufacturing are examples of industries in which either the Japanese or Europeans quickly gained comparative advantage and began to compete effectively with the U.S. Steelmaking and automobile manufacturing, among others, followed, as the capabilities of the other industrial nations improved.

The improving manufacturing capability of other nations relative to the U.S. has been reflected in their more rapid accumulation of the factors required for advanced manufacturing. Table 2-2 demonstrates how much more rapidly other nations have been increasing their industrial capital, skilled labor and technical resources.

The general proliferation of manufacturing competence and the reduction in the number of industries dominated by the United States have been important features of the development of international trade over the last twenty years. A recent review by the New York Stock Exchange of U.S. competitiveness in world manufacturing trade found that, in constant dollar terms, the U.S. share of world manufacturing exports had shown no clear trend between 1962 and 1982. The U.S. share declined from 14.8 percent in 1962 to 12.1 percent in 1972, and then rose to 14.7 percent in 1980 and had declined again to 12.3 percent in 1982. The number of industries in which the U.S. enjoyed a 20 percent share of world exports had declined steadily from 12 in

1962 to 6 in 1972 to only 5 in 1982. (Forty industries were considered.) The decline in U.S. dominance, however, at least partially reflects what has happened as more nations have industrialized.

In general, the industrial countries have been becoming more dependent on one another for manufactured goods. This trend has been evidenced by the increasing share of imports in the domestic markets of most industrial countries. A recent survey by the OECD has shown that, for the eleven most industrialized countries, import penetration of the manufacturing sector rose by an annual average of 4.6 percent over the period from 1970 to 1980. For the United States, import penetration rose an above average 5.3 percent annually over the period, although absolute import penetration in the U.S. remained relatively low at 9.3 percent in 1980.[10]

One of the most remarkable developments during the last decade in the international trade in manufactured goods has been the increasing dominance of Japan in several important industries. Japan has come to dominate international trade in ships, consumer electronics, motor vehicles, communication and electronic equipment, and iron and steel products, accounting for more than

---

[10] The highest levels of import penetration among industrial countries are recorded in Europe among members of the European Community, reflecting the effects of their long-standing customs union. These range from France with 23.3 percent to Belgium, which imports 83 percent of its manufactured goods. Japan has the lowest import penetration - 5.8 percent.

2.2.3 Summary of Manufacturing Trade Prospects

The foregoing discussion of trade in manufacturers has several implications for the future course of the development of the U.S. foreign trade in manufactured goods. This summary will be used to highlight them.

The prospects for continued rapid growth in the value of U.S. imports and exports of manufactured goods appear to be excellent for the next decade and, very possibly, for the next quarter century. Barring the adoption of a truly restrictive trade policy, secular growth in manufactured goods trade will almost certainly outrun growth in the U.S. national economy as a whole, as it has during most of the post-World War II period.

The common feature in the way trade in manufactured goods is evolving between the U.S. and both industrialized and newly industrializing countries is the increasing importance of intermediate goods, that is, products which are still in the process of being finished. Rather than being products ready for final sale and in transit between manufacturer and merchant, which may have historically been more common, a large portion of manufactured goods in international trade today are being transferred by the manufacturer between one production process and another. For a variety of reasons, this is a portion of the trade which appears likely to grow in importance.

Reasoning about comparative advantage and trade in manufactured goods suggests that trade in particular final products between the industrialized nations will not grow in open-ended fashion, because factor costs are so similar. Instead, a predictable cycle seems more likely, one in which a company's or industry's competitive advantage impels a growing trade, followed by some improvement in the competitiveness of domestic firms and local

The balance of trade in manufactured goods in tonnage terms between the U.S. and most of its trading partners appears very likely to continue, indefinitely, to be weighted in favor of imports. The U.S. is likely to be exporting higher value products in virtually every category of non-bulk, manufactured product than it is importing and is likely to export more goods suitable for air shipment and information transfer. The imbalance in ocean traffic tonnage terms will therefore continue, even when the U.S. enjoys a favorable balance of trade in value terms.

Categories of manufactured goods where U.S. exports may well continue to grow and to exceed imports in tonnage include petroleum and chemical products, goods ordinarily shipped in bulk. The large refinery and chemical manufacturing capacity of the U.S. makes it likely that the U.S. will continue to export such products in increasing quantities, especially to developing and newly industrializing countries in this hemisphere who do not have the capital to develop these capital intensive industries rapidly. The Wharton/OTA forecast projects a significant increase in U.S. liquid bulk exports on this basis, with two-thirds of the exports going to Latin America. Expansion of U.S. exports of chemical and petroleum products is not a trend which is likely to continue indefinitely, however, and some reversal can be expected late in this century as oil exporting countries in the developing world increase their chemical and product exports.

A final issue to consider is the extent to which the U.S. will participate with world growth in trade of manufactured goods. The Wharton/OTA forecast raised this issue starkly by projecting a major growth in trade among the newly industrializing nations which would propel rapid growth in world trade in manufactures far outstripping the likely growth in the U.S. foreign trade in

2.3 COMMODITY FORECASTS

As previously noted, a large proportion of U.S. trade by tonnage is accounted for by a small number of bulk commodities. The number of vessels required to transport U.S. bulk trade is, therefore, determined to a large extent by the trade in these commodities. The trade patterns as well as the tonnage are important in forecasting the need for bulk vessels. As trade routes grow longer, the optimal vessel size, all else remaining equal, will increase. The more stable the trade is, the more likely that large and specialized vessels can be used.

2.3.1 Petroleum

The United States is the second largest producer (following the USSR) of crude oil, supplying 8.9 million barrels per day in 1983. Total U.S. petroleum production (crude oil plus natural gas plant liquids) in 1983 reached 10.5 million barrels per day. The U.S. is, in addition, the world's leading consumer of petroleum and petroleum products, requiring 15.7 million barrels per day (down from 18.9 million barrels per day in 1980). Consequently, the U.S. is also the world's leading importer of crude oil and products, demanding 4.3 million barrels per day in 1985.[14]

Because the U.S. relies on foreign sources for nearly 35 percent of its total supply, and because this reliance has, in the past, approached 50 percent of total consumption, the level and growth of U.S. trade has been a principal focus of public concern, especially since the oil embargo of 1973-74. This section will discuss recent historical developments in petroleum trade and consumption, highlight the role of petroleum in U.S. foreign

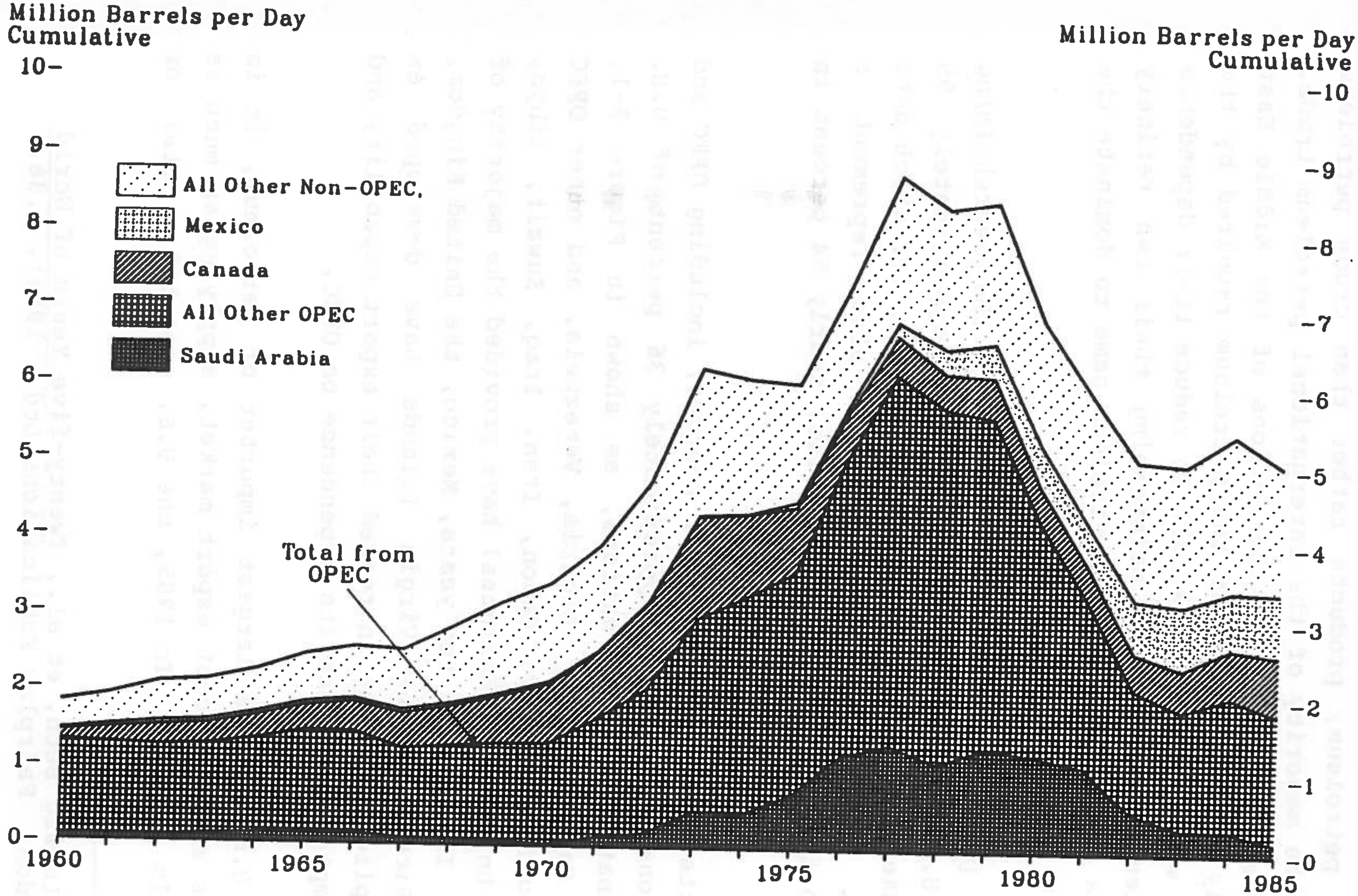
---

[14] Annual Energy Review 1983, DOE/EIA-0384(85) (Washington, DC: U.S. Dept. of Energy, Energy Information Administration, May 1986), p.79.

TABLE 2-3. ENERGY AND PETROLEUM PRODUCTION, CONSUMPTION AND TRADE, 1960-1985

YEAR	TOTAL ENERGY PRODUCTION Quad. Btu	PETROLEUM PRODUCTION % of Tot	TOTAL ENERGY CONSUMPTION Quad.Btu	PETROLEUM CONSUMPTION % of Tot	NET ENERGY IMPORT TRADE Quad.Btu	NET PETROLEUM IMPORT TRADE Quad.Btu
1960	41.49	35.98	43.80	45.48	2.74	3.57
1961	41.99	36.22	44.46	45.47	3.08	3.82
1962	43.58	35.61	46.53	45.24	3.53	4.20
1963	45.85	34.83	48.32	44.91	3.25	4.21
1964	47.72	33.86	50.50	44.16	3.65	4.53
1965	49.34	33.48	52.68	44.13	4.06	5.01
1966	52.17	33.66	55.66	43.84	4.32	5.21
1967	55.04	33.92	57.57	43.91	4.04	4.91
1968	56.81	33.99	61.00	44.23	4.90	5.73
1969	59.10	33.10	64.19	44.15	5.56	6.42
1970	62.07	32.87	66.43	44.44	5.72	6.92
1971	61.29	32.68	67.89	45.01	7.41	8.07
1972	62.42	32.12	71.26	46.24	9.32	9.83
1973	62.06	31.41	74.28	46.95	12.68	12.98
1974	60.84	30.56	72.54	46.51	12.19	12.66
1975	59.86	29.62	70.55	46.39	11.75	12.51
1976	59.89	28.82	74.36	47.30	14.65	15.20
1977	60.22	28.98	76.29	48.66	18.02	18.24
1978	61.10	30.16	78.09	48.62	17.33	17.06
1979	63.80	28.37	78.90	47.05	16.75	16.93
1980	64.76	28.18	75.96	45.02	12.25	13.50
1981	64.42	28.17	73.99	43.15	9.65	11.38
1982	63.89	28.66	70.84	42.67	7.46	9.05
1983	61.19	30.05	70.50	42.62	8.31	9.08
1984	65.85	28.63	74.11	41.90	8.96	9.89
1985	64.73	29.17	73.83	41.79	7.79	8.89

SOURCE: Dept. of Energy, Annual Energy Review 1985.



SOURCE: U.S. Dept. of Energy, Energy Information Administration, <u>Annual Energy Review 1985</u>.

FIGURE 2-1. U.S. IMPORTS OF PETROLEUM BY COUNTRY OF ORIGIN, 1960-1985

404,000 barrels per day to Puerto Rico and the Virgin Islands, Mexico, Japan and Canada (see Figure 2-2). Refined petroleum products accounted for more than 75 percent of total exports.[20]

Projections of U.S. Net Oil Imports, 1985-2000 -- The Energy Information Administration (EIA), in its Annual Energy Outlook for 1983, has projected that while primary energy consumption (in market economies) grows at an average of 2 percent annually, the share of primary energy supplied by oil will decline from 48 percent of the total in 1983 to 44 percent in 1995. The EIA also notes that over their forecast range, imported petroleum remains the marginal energy supply in the U.S. and that among sources of energy, petroleum displays the most price sensitivity.

Since the demand for petroleum is responsive to changes in price, it is important to note the major factors determining oil prices. DOE lists seven developments which could lower world oil prices:

- o greater than expected willingness of OPEC countries to expand oil production and make investments to expand long term production capacity;

- o higher than expected potential for oil conservation and switching to alternative fuels like natural gas, coal, renewables, and electricity;

- o no long-term permanent reduction in oil supply potential because of wars and other political or social events;

- o remaining undiscovered oil and gas resources in non-OPEC countries being at the upper end of current estimates;

- o lower than expected world economic growth with reduced demand for energy in general and oil in particular;

---

20 Annual Energy Review 1985, p.87.

o lower production costs and/or lower water, environmental, capital, or other production constraints, resulting in higher than expected market potential for direct substitutes for conventional oil, such as coal liquids; and

o no development of serious problems which inhibit the availability or use of non-oil fuels (for example, stricter pollution standards or the discovery of new energy-related health hazards).[21]

Both the Annual Energy Outlook and Energy Projections to the Year 2010 contain comparisons of government and industry forecasts of U.S. oil imports as summarized in Table 2-4. According to these projections, U.S. oil imports in 1995 will be within the range of 3.6 to 9.9 million barrels per day. A variety of factors explain the divergences among the estimates. Such differences include sources of data, definition of terms, selection of base year, method of trend fitting, underlying assumptions, and method for estimating future prices.

All four major end-use categories contribute to the projected rise in petroleum imports. Residential energy demand is expected to increase slowly, with reduction in energy use per household and increasing reliance on electricity nearly off-setting the rising number of households. A modest increase in commercial energy demand is anticipated as reductions in energy usage per square foot and increased use of electricity largely balance the increase in commercial floorspace. Industrial energy demand is projected to recover slowly during the late 1980s and to rise slightly above 1978 levels during the early 1990s. Transportation energy demand is composed almost entirely of petroleum products, and significant substitution of other fuels is unlikely over the forecast period. Fuel efficiency improvements in motor vehicles are expected to continue. Thus, although vehicles miles are projected to increase, gasoline

---

21 Energy Projections to the Year 2010, pp.7-8.

consumption should decline slightly. Diesel fuel, however, is expected to increase in importance, and the total of diesel and gasoline is forecast to rise above 1983 levels. Jet fuel consumption is also expected to climb, as increasing airline activity is not entirely balanced by improvements in energy efficiency.[22]

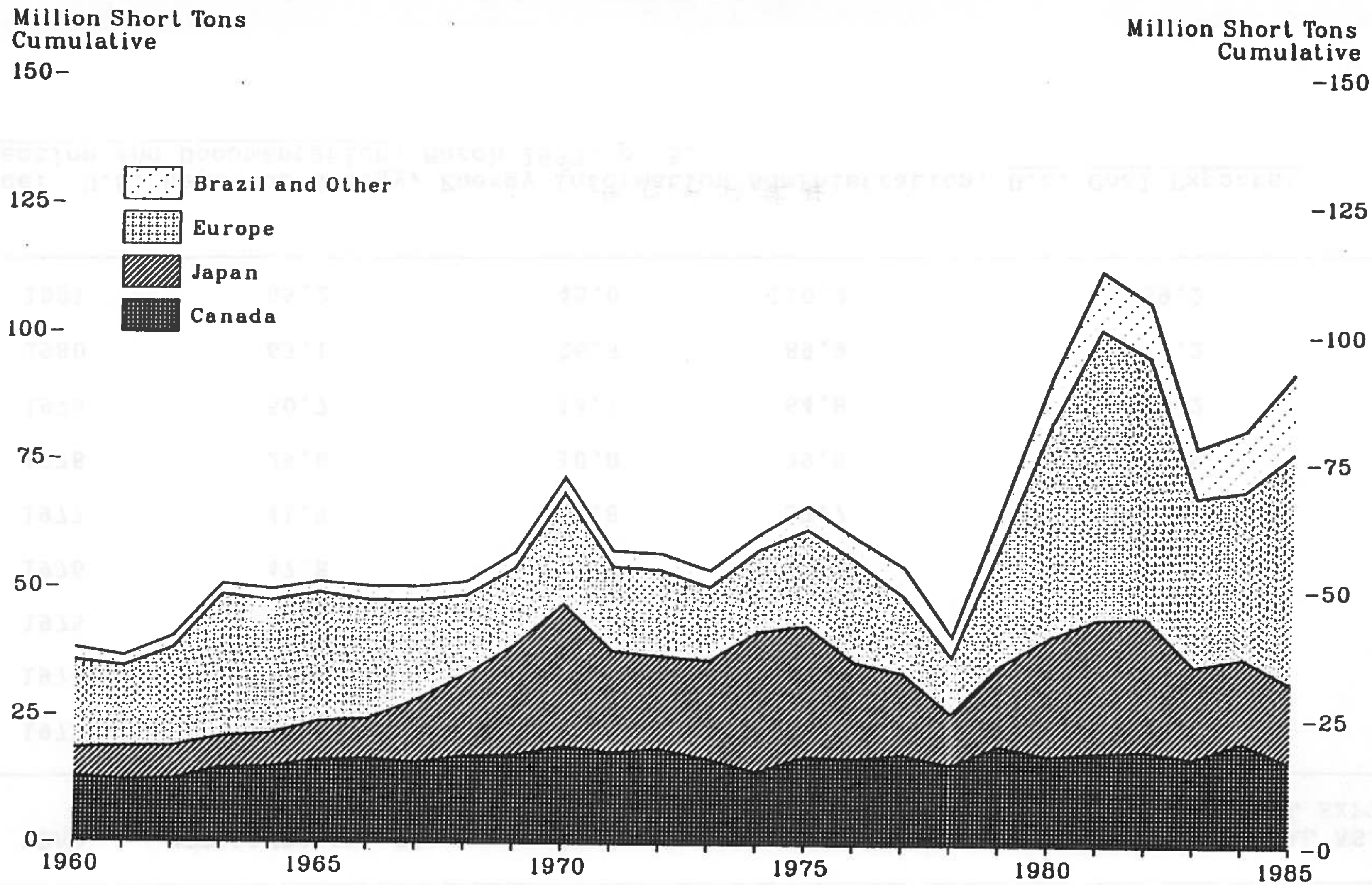
2.3.2 Coal

Coal is currently one of the dominant commodities, second in tonnage only to iron ore, in international dry bulk trade. It is also the second largest dry bulk export (following cereal and cereal preparations) of the United States. The U.S. is, in fact, the largest exporter of coal in the world. This section discusses historical developments in U.S. coal trade and production, identifies major trade patterns, highlights the key issues currently affecting development of the U.S. coal export trade, and reviews the principal forecasts of U.S. exports through the year 2000. The focus in this section is on bituminous coal, which for the past 25 years has accounted for more than 98 percent of U.S. coal production.

Historical Developments -- Coal was the principal source of energy in the United States from the second half of the 19th century until the middle of the 20th century. During that period, coal was consumed for residential and commercial energy, iron and steel production, transportation and electric utilities. By the end of World War II, however, coal was largely replaced as an energy source, as consumers turned increasingly to oil and natural gas for cleaner, less expensive, more convenient fuel supplies. The major markets for coal since 1950 have been the iron and steel and electric utilities industries. The amount

---

[22] Annual Energy Outlook 1983, DOE/EIA-0383(83) (Washington, DC: U.S. Dept. of Energy, Energy Information Administration, May 1984), pp. 45-75.



SOURCE: U.S. Dept. of Energy, Energy Information Administration, Annual Energy Review 1985

FIGURE 2-3. U.S. COAL EXPORTS BY COUNTRY OF DESTINATION, 1960-1985 capacity to substantially raise the level of their exports. The principal importers of coal are the nations of Western Europe and Japan.

The coal trade between the U.S. and Canada has remained relatively stable since 1960. The level of U.S. exports to Japan rose during the 1960's but declined in the late 1970's as Japan sought to diversify its sources and to obtain cheaper coal. Exports to Europe have fluctuated, depending upon the condition of Europe's steel industries and the availability of coal from other sources. Such trade patterns reflect the role of the U.S. as the marginal supplier of coal to Europe and Japan.

> On a delivered cost basis, the price of U.S. coal is not competitive with that of other suppliers, making the United States a marginal supplier to Western European and Far Eastern markets. Australia and South Africa have lower minemouth and inland transportation costs than does the United States; Australia is the least-cost supplier to the Far East, and South Africa is the least-cost supplier to Western Europe. The United States, however, has an advantage over other coal-exporting countries in that it is considered by coal importers to be the most secure and reliable source of quality coal in the world.[25]

In 1980, the delivered price per short ton of metallurgical coal from the U.S. to Japan was $72.97, 35 percent more than the cost of Australian coal (see Table 2-6). Despite these price differentials, the U.S. has consistently remained a leading coal exporter. The U.S. currently has sufficient excess capacity to increase production in response to demand changes abroad. Also, the U.S. experiences less severe labor difficulties and political disturbances than do other leading coal exporters. The sharp increase in U.S. exports in 1981 and 1982 reflects the ability of

---

25 Port Deepening and User Fees: Impact on U.S. Coal Imports, DOE/EIA- 0400(Washington, DC: U.S. Dept. of Energy, Energy Information Administration, May 1983), p. vii.

.S. coal producers to respond to increased demand abroad and to eplace supplies from other sources which are disrupted by labor r political disturbances.

ore than half of U.S. coal exports are shipped from the port of ampton Roads (see Table 2-7). Exports bound for Canada are hipped primarily from the port of Great Lakes. In 1982, 95 ercent of oceanborne coal exports (excluding exports to Canada) re shipped from Atlantic or Gulf Coast ports. This results in xtremely long trade route distances between the U.S. and Japan.

ssues -- In 1980, after the actions of the Organization of etroleum Exporting Countries (OPEC) had, for the second time, roused grave concerns about the supply availability and price tability of petroleum and petroleum products, a major eassessment was made of the outlook for coal as a principal nergy source. Since the future of oil appeared shaky and since uclear energy was not developing rapidly enough to replace etroleum, the oil importing nations began to search for an nergy source which would relieve their dependence on OPEC. Coal eemed to be the best interim solution, because of the tremendous ecoverable reserves of nations such as the U.S. Thus it seemed hat coal consumption would increase at a rapid pace while other nergy sources, including nuclear and geothermal, were developed.

transition from oil to coal, however, is not a simple or ostless operation. One reason for the earlier decline in coal onsumption relative to oil and gas was the growth of nvironmental concerns. On the production side, the problem of he reclamation of land after destructive surface mining was ddressed by the Surface Mining and Reclamation Act. On the onsumption side, the issue of pollution was addressed by the lean Air Act of 1963, which was amended in 1966, 1970 and 1977.

Electricity is an important energy source which can be produced from coal. However, it should be noted that

> although the use of electricity is pollution-free at the point of use, the generating plants, especially coal-fired plants, concentrate pollutants in a single, localized and usually highly visible source. The efforts to control environmental pollution in the coal-fired plants chiefly involve using scrubbers to desulfurize flue gas and precipitators to remove fly ash.[26]

Thus, the problems of environmental conservation would need to be considered at both the coal production and consumption stages.

Consideration of the prospects for U.S. coal exports must account for changes in the end-uses of coal. Historically, the majority of U.S. coal exports have been metallurgical coal. As the technology in iron and steel-making progresses, less coke is needed in the production process. Also, there will likely be a continuing shift in metallurgical coal exports, with the traditional markets decreasing their consumption and the industrializing nations in Latin America and the Pacific Rim increasing their demand. The demand for steam coal exports, to be used in the generation of electricity, is expected to continue to increase.

Two additional factors affecting the development of U.S. coal exports are port deepening plans and constraints on ship size. In order to handle ships with capacities of 100,000 deadweight tons (dwt) or more, port channel depths must exceed 49 feet. The controlling depth at Hampton Roads, the main U.S. export terminal, is 45 feet. Five of the seven leading U.S. export terminals have channel depths of 45 feet or less. Such ports are limited to handling ships of the Panamax class (generally 60,000

---

[26] Outlook for U.S. Coal, DOE/EIA-0333 (Washington, DC: U.S. Dept. of Energy, Energy Information Administration, August 1982), p.14.

routed most efficiently via the Panama Canal. This limits the size of the vessel because the canal can accommodate at most a fully-laden 65,000 dwt (Panamax) vessel.

Projections of U.S. Coal Exports, 1985-2000 -- A variety of groups and agencies produced forecasts of U.S. coal exports, particularly in the wake of the oil price rises in 1980. This section reviews some of these forecasts and compares them with the results of a simple linear regression (see Figure 2-4).

All of the forecasts project steady (and, in most cases, substantial) growth in coal exports over the 77.8 million short tons exported in 1983 (see Table 2-8). These projections may be broadly described by three classifications: those made prior to the OPEC disruptions, those made at the height of concern about the future of oil, and those made since the concerns about oil have lessened.

In 1979, the Maritime Administration sponsored a study performed by M. Rosenblatt and Son, Inc. on the "Development of a Standardized U.S.-Flag Dry-Bulk Carrier." This report included a section forecasting the demand for seaborne U.S. coal exports. This projection, prepared before the OPEC price increases and the sharp upturn in exports in 1981 and 1982, called for modest increases from 36 million tons in 1977 to 62 million tons in 1990 to 91 million tons in 2000.[29]

During the height of concern about the prospects for petroleum, the Department of Energy (DOE) and the Energy Information Administration (EIA) prepared a number of forecasts anticipating tremendous growth in coal exports. The findings of the World Coal Study and several private firms concurred in these

---

29 M. Rosenblatt & Son, Inc., Development of a Standardized U.S. Flag Dry-Bulk Carrier (New York, NY: U.S. Department of Commerce, Maritime Administration, January 1979), p.150.

TABLE 2-8. U.S. COAL EXPORTS: COMPARISON OF FORECASTS (MILLIONS OF SHORT TONS PER YEAR)

PROJECTION YEAR	EIA AEO 83 (MAY 83)	EIA AEO 81 (NOV 81)	EIA AEO 80 (JUN 80)	DOE NEPP (JUL 81)	WOCOL B (1980)	MARAD (JUN 79)
1985 FORECASTS						
Metallurgical	35	57	60	65	51	NA
Steam	47	51	25	45	35	NA
Total	83	108	85	110	92	57
1990 FORECASTS						
Metallurgical	49	62	70	70	62	NA
Steam	55	80	38	75	69	NA
Total	105	142	108	145	131	62
1995 FORECASTS						
Metallurgical	58	67	85	NA	NA	NA
Steam	58	104	58	NA	NA	NA
Total	116	171	143	NA	NA	76
2000 FORECASTS						
Metallurgical	NA	72	NA	70	72	NA
Steam	NA	152	NA	180	151	NA
Total	NA	224	NA	250	223	91

* = SEABORNE EXPORTS ONLY

ABBREVIATIONS:

NA = NOT AVAILABLE
EIA = ENERGY INFORMATION ADMINISTRATION
ARC = ANNUAL REPORT TO CONGRESS
NEPP = NATIONAL ENERGY POLICY PLAN
AEO = ANNUAL ENERGY OUTLOOK
DOE = DEPT. OF ENERGY
WOCOL = WORLD COAL STUDY
MARAD = MARITIME ADMINISTRATION

SOURCE: U.S. Dept. of Energy, Energy Information Administration, U.S. Coal Exports: Projection and Documentation, Annual Energy Outlook 1983, Annual Report to Congress, 1980-81; U.S. Dept. of Transportation, Maritime Administration, Development of a Standardized Dry-Bulk Carrier.

2.3.3 Grain

The United States accounts for almost 20 percent of world agricultural trade and is the world's largest agricultural exporter, supplying as much as two-thirds of all feed grain, half of all the soybeans and products, almost half of all the wheat, nearly a third of the cotton and one-quarter of all rice in international seaborne trade. Grain is the largest single commodity in U.S. dry bulk trade; oilseeds (principally soybeans) are also significant. This section reviews historical developments in U.S. agricultural trade, focusing particularly on grain. The structure of the grain exporting industry is described and the principal destinations for U.S. grain trade are identified.

Historical Developments -- Before the Second World War, U.S. had gone through a long, troubled period in which U.S. farm exports had seriously declined. U.S. agricultural exports were relatively strong during the First World War and its aftermath, but in the 1920s, as European agriculture recovered, world trade in agricultural products declined and U.S. agriculture went into a depression. The Great Depression further aggravated the situation. From 22 percent of farm sales revenue in 1922, U.S. farm exports had fallen to only 6 percent in 1940, the lowest point reached in the last sixty years.

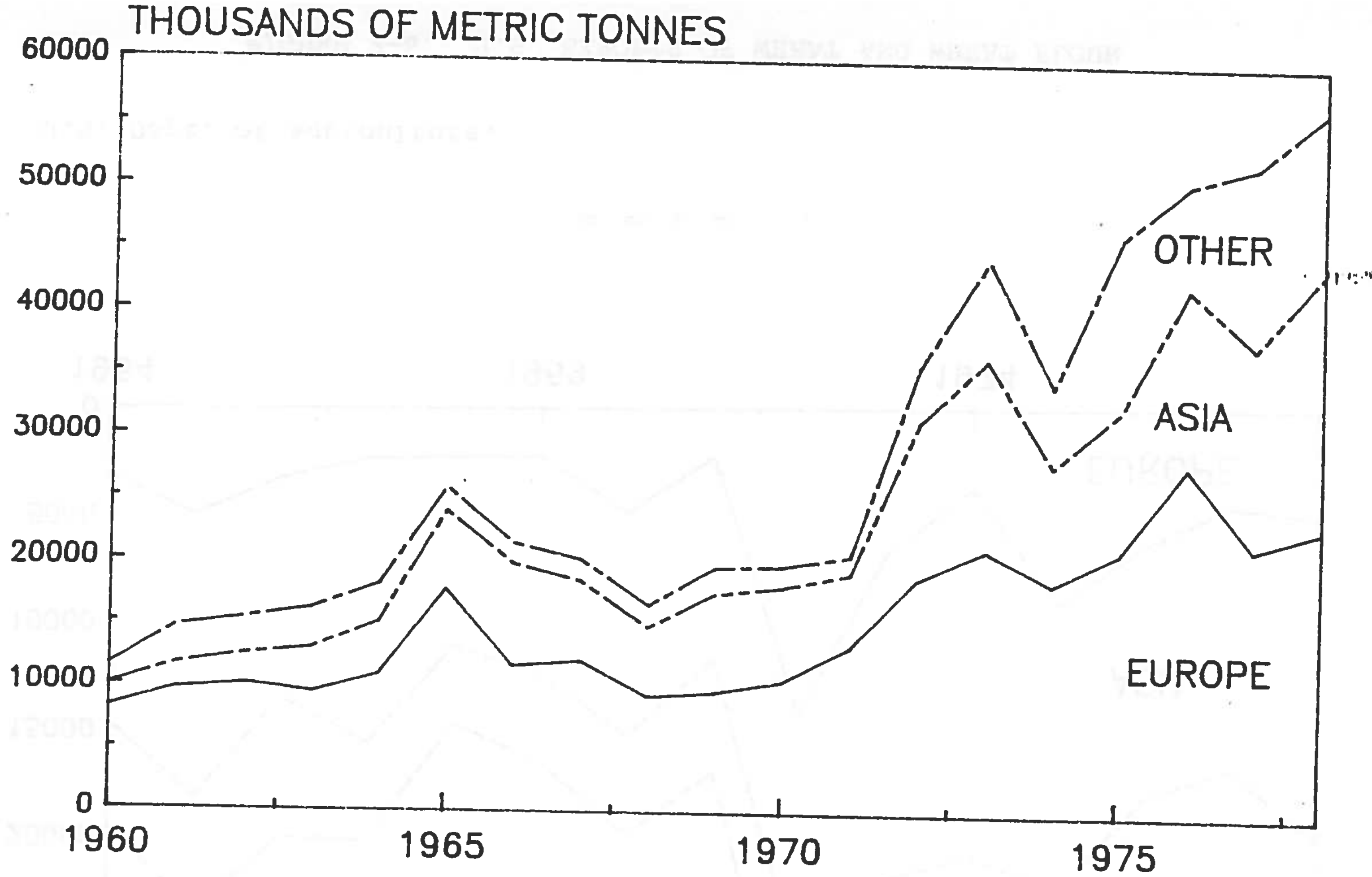
In the 1920s and 1930s, more than half of farm exports were industrial raw materials -- mainly cotton, tobacco, hides and tallow. Since the Second World War, food has dominated U.S. farm exports. The pattern of world grain trade has changed dramatically in the past fifty years, and the U.S. has increased its share as world trade has grown. In the 1930s, Western Europe was the major importing region, while Eastern Europe (including the USSR), North Africa and the Middle East, and Asia (excluding Japan and China) were all net exporters. This pattern began to change in the 1950s as the surplus in Eastern Europe began to

The international grain trade, however, is dominated by a small number of firms. The five groups currently controlling trade are: Bunge, Cargill, Continental, Louis Dreyfus and Carnac. Until recently, a sixth firm also belonged in this category. According to testimony at Congressional hearings in 1976, the six largest wheat firms controlled 96 percent of wheat exports, 95 percent of maize exports, 90 percent of oats exports and 80 percent of sorghum exports.[31]

Trade Patterns -- The grain trades historically have shown great, short-term instability; the volume of trade fluctuates greatly from year to year in response to political events (such as embargoes), weather conditions, and changes in economic conditions which may affect the incomes of consumers. This instability can be best understood as a reflection of the role of oceanborne grain trade in world food consumption. Grain is grown throughout the world and the vast bulk of all production is consumed domestically in the producing country. Only a fraction of grain production, from a handful of producing regions, enters into world trade. The grain in world trade is used to supply whatever demand remains unsatisfied by domestic production.

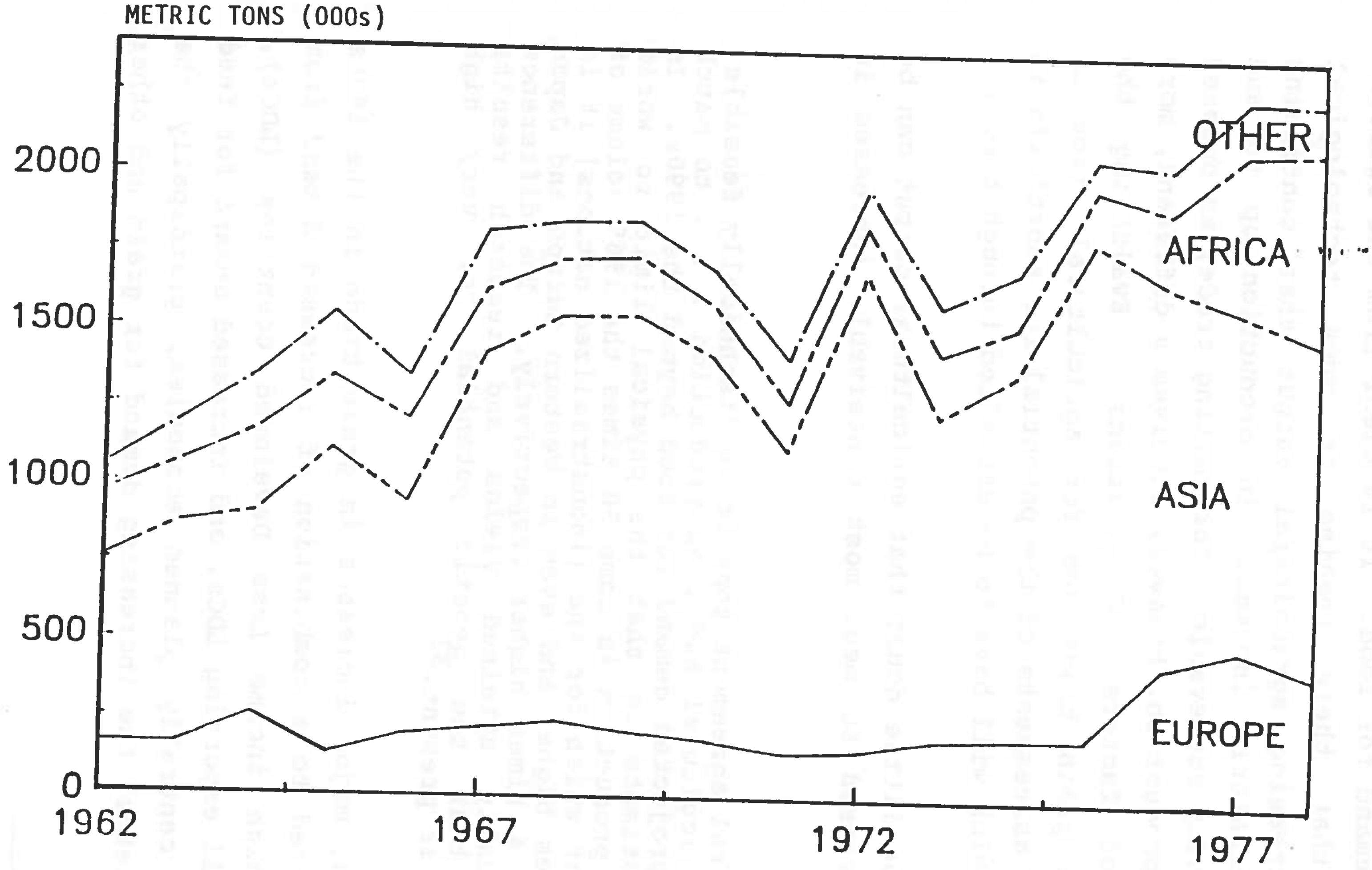
Demand for food grains, of course, is relatively insensitive to price and when domestic production is inadequate to satisfy demand, a rise in price tends to draw in grain imports while dampening demand only slightly. Thus, consumption of food grains has tended to be relatively stable worldwide, with variations in production accounting for most of the fluctuations. During the 1970's, as noted above, trade in feed grains grew substantially, absolutely and relative to food grains. The increasing importance of feed grains is affecting the pattern of instability in grain trade, because feed grain demand is far more sensitive

[31] Beth, p. 17.



SOURCE: U.S. Dept. of Agriculture.

FIGURE 2-5. U.S. EXPORTS OF FEED GRAIN



SOURCE: U.S. Dept. of Agriculture.

FIGURE 2-7. U.S. EXPORTS OF RICE

ricultural products will continue to outstrip local production s the central question identified by most recent attempts to orecast agricultural trade.

n a recent report the Organization for Economic Cooperation and evelopment reviewed a large number of forecasts and projections f agricultural trade. This review, with its comparisons of arious forecasts, stressed the wide range of uncertainty oncerning future prospects, but identified the import equirements of the LDC's and the CPE's as central to the future rend of grain and agricultural trade.

idely varying forecasts of the potential import requirements of he LDCs have been made, ranging from moderate decline by 1990 to ajor increases. Taken as a group, the LDCs are assumed to have ignificant potential to increase their own production, but this otential is constrained by the progress of economic development nd the growth of income to pay for the application of more roductive technology. Food demand in the LDCs, although pparently certain to grow fairly rapidly in response to opulation increases, is also thought to be very sensitive at the argin to income growth, with increases in meat consumption ikely to draw imports of feed grains. To the extent gricultural development fails to keep pace with general economic evelopment and income growth, food demand appears likely to utstrip local production, leading to trade growth. The LDCs are carcely an homogeneous group, of course, and economic and gricultural development would differ greatly from country to ountry, complicating the construction of any forecasting cenarios. The OECD found forecasts of LDC grain import equirements for 1990 which implied anywhere from a decline of 40 ercent to an increase of 100 percent from 1980/81. More oderate and considered forecasts ranged from no net increase by ears, other countries "less well-endowed with fertile land have ollowed the U.S. pattern of agricultural development by shifting o a more capital-intensive, science-based agriculture. A elative scarcity of land is no longer as severe a constraint on gricultural growth as formerly."[36]

t appears possible that in the very long-term, improved gricultural technology and its increased employment in what are ow the developing nations of the world will so increase the otential for local production as to significantly affect the atterns of trade. Just as European Community's Common gricultural Policy and the application of improved farming echniques has made Western Europe into a net exporter of many ommodities of which it was formerly an importer, similar evelopments elsewhere in the world may significantly affect gricultural trade.

---

36 Economic Report of the President (Washington, DC: ouncil of Economic Advisors, February 1984), p. 124.

ıe other significant development has been the rise of steel :oduction in the third world. In 1980, countries of the :ganization for Economic Cooperation and Development (OECD) :ill accounted for almost two-thirds of world steel production, ıt the developing countries' share of production had risen to 12 ercent. Brazil, India, PRC, Mexico, South Korea, North Korea, ıd Saudi Arabia have all built their own steelmaking acilities.[38]

he Structure of the Industry -- One of the most significant eatures of the iron ore industry is that oligopoly situations kist in every aspect of the industry. A small number of firms pecialize in the production of the ore, in the production of teel, and in the international ore trade.

n the United States, in 1983, fifteen companies operating 19 ines accounted for all domestic production. Of this, 96 percent as produced by seven firms operating eleven mines.[39]

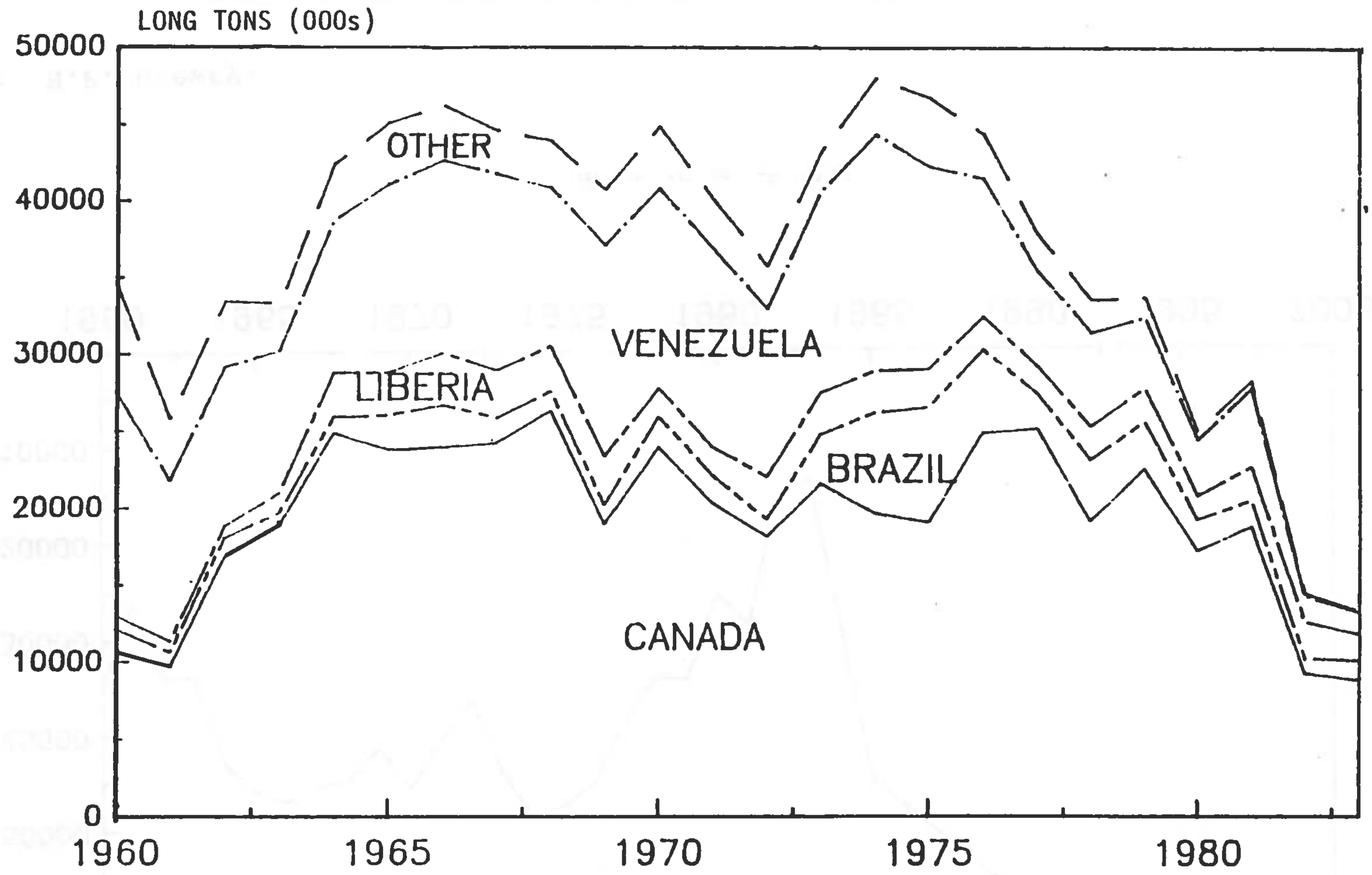
he steelmaking industry, in order to guarantee its supply of ron ore, has, to a great extent, integrated vertically. The ajor steel producers, such as Bethlehem and U.S. Steel, own or ave partial interests in mines and processing plants in the U.S. n order to insure their supply of imported ore, the steel ompanies also frequently acquire interests in foreign mining perations and enter into long term transport agreements.[40]

---

38 Ibid., p.13.

39 Mineral Commodities Summaries 1984 (Washington, DC: U.S. ept. of the Interior, Bureau of Mines, 1984), p.76.

40 M. Rosenblatt & Son, Inc., and H.P. Drewry (Shiping onsultants) Ltd., Development of a Standardized U.S. Flag Dry-ulk Carrier, Appendix A. (New York, NY: U.S. Department of ommerce, Maritime Administration, January 1979), p.167.



SOURCE: U.S. Dept. of Interior, Bureau of Mines.

FIGURE 2-8. U.S. SEABORNE IRON ORE IMPORTS BY COUNTRY OF ORIGIN

3. EVOLUTION OF THE MERCHANT FLEET

nterest in the organizational development of the merchant fleet ests on the notion that patterns in the variety of ship sizes nd types can be explained in terms of simple principles overning ship choice and efficiency. The accurate dentification of such principles and their working in the istorical development of the fleet would be a valid basis for rojecting future developments in ship size and type. This hapter is devoted to the identification of principles that can e used to explain the variety of ship size and type in the erchant fleet and to applying them in reviewing the historical evelopment of the merchant fleet.

istorical Trends -- Ocean shipping as we know it today emerged n the latter portion of the nineteenth century, as a need for aw materials and broader markets began to be felt in the ndustrialized countries. In the early days of ocean shipping, irtually all U.S. foreign trade was transported in general cargo hips. Most goods were packaged in some way, in barrels, or acks or boxes, while bulk cargoes were only occasionally hauled n place of ballast. The size of these ships increased slowly uring the nineteenth and early twentieth centuries, from a ypical capacity of 2,000 deadweight tons (dwt) in the mid-1800s o a maximum of about 7,000 dwt in 1900. During the first half f this century, oil replaced coal as the primary fuel for ceangoing vessels and ship size continued to increase to a aximum of about 15,000 dwt by the time of World War II.

eginning in the late nineteenth century, the potential economies f shipping some commodities exclusively in bulk led to the first xperiments with designing ships especially for this purpose. il tankers were the first bulk carriers. The economies of scale n handling cargoes in bulk meant that once technical engineering onstraints on ship size were lifted, very large ships would be conomical. It was not until the years following World War II,

TABLE 3-1. DEVELOPMENT OF THE MERCHANT FLEET

BULK CARRIERS

YEAR	NUMBER OF SHIPS	AVERAGE DEADWEIGHT
12/31/62	1,592	12,504
12/31/67	2,368	20,962
12/31/72	3,539	30,600
12/31/74	4,075	34,175
12/31/75	4,272	35,130
12/31/76	4,570	35,730
12/31/77	4,932	36,220
12/31/78	4,651	38,800
12/31/79	4,714	
1/01/81	4,798	38,625
1/01/82	4,987	38,975
1/01/83	5,215	39,915
1/01/84	5,384	40,205

TANKERS

YEAR	NUMBER OF SHIPS	AVERAGE DEADWEIGHT
12/31/62	3,408	20,502
12/31/67	3,704	28,220
12/31/72	4,581	42,100
12/31/74	5,121	51,050
12/31/75	5,311	56,900
12/31/76	5,383	62,350
12/31/77	5,333	65,625
12/31/78	5,233	65,890
12/31/79	5,260	
1/01/81	5,359	64,625
1/01/82	5,517	62,795
1/01/83	5,583	60,208
1/01/84	5,548	58,150

ntainer, which has been widely adopted by liner operators, who ve developed specialized container ships to carry them. The ecialized "intermodal" ships that have been built as part of rgo unitization have been much larger than general cargo eighters.

pecialization - Trade-offs may be made between functions (or heir subdivisions) to adapt an individual ship to operate fficiently in its own peculiar circumstances. A ship which must o proportionately more cargo handling than cargo hauling because, perhaps, it is on a short route) will be designed to erform that function more cost-effectively, perhaps trading off o some extent its hauling capability. A short-sea ro-ro ship or ferry), for example, is designed to load and discharge its argoes very quickly, but does not carry a very dense load ompared to other types of ships. A trade-off can exist between argo holding and hauling speed. Although the greater a given hip's speed, the greater the ship's effective hauling capacity ver time, the engineering economics of speed mean that a ship esigned for holding capacity with a full hull shape will be xpensive to move through the water rapidly, while giving a hip's hull the fine lines necessary for economic, high speed peration, cuts into the hull's holding capacity.

he trade-offs given as examples above imply a degree of pecialization to achieve greater efficiency. Specialization may e employed to improve the efficiency of a ship for a specific oute or type of cargo. Making a ship more efficient for one oute or cargo will make it less efficient for other routes and argoes, increasing the risk that changing patterns of trade will eave the ship both unemployed and unemployable. Stability of rade is often a prerequisite of specialization. Increasing pecialization in ship design and the development of new ship ypes has been an important trend in fleet development for many ears, and is a topic taken up in greater detail later in this hapter.

conomies of Scale - The cargo handling and cargo hauling unctions differ in respect to economies of scale. It is evident hat for cargo handling, there often will be decreasing returns o scale, while for the cargo hauling function, there appear to ecause the ports involved were only capable of employing elatively slow and costly methods), then the most efficient ship ight be relatively small.

asual observation of the world merchant fleet tends to confirm his analysis of the effects of economies and diseconomies of cale in different functions of ship operation. Large vessels end to be employed on long trade routes with relatively stable rade volume, carrying cargoes which can be handled efficiently n bulk. The largest ships employed, for example, are used to arry large volumes of crude oil, a cargo for which a very roductive handling technology has been developed, along often ery long, unimpeded routes -- for example, from the Persian Gulf round the Cape of Good Hope to Europe or across the Indian Ocean nd South China Sea to Japan. By contrast, smaller vessels are mployed on shorter routes, where trade volume fluctuates ignificantly, or carry cargo for which handling technology emains relatively unproductive. The break-bulk general cargo reighter, for instance, has traditionally been among the smaller lasses of ocean-going merchant ships. Loading and unloading reak-bulk cargo -- essentially packages of various dimensions -- y conventional means has always been regarded as time-consuming nd labor-intensive.

imensional Constraints - One of the most salient constraints on hip development during this century has been the dimensional imitations of certain frequently used canals and straits. Where canal or strait offers a significantly shorter, alternative oute, but with a limitation on ship size, a choice has to be ade between the economies of a shorter route and the economies f a larger ship. In some cases this choice may be complicated omewhat if the canal or strait can accommodate a ship of a given ize in ballast but not fully laden, so that the front haul and eginning of April through the middle of December, can ccommodate vessels of up to 23.2 meters(76 feet) in width, with rafts of up to 7.92 meters.[44]

ne channel depth and terminal facilities of many major ports mpose an additional constraint on vessel size. Only a small umber of ports possess the equipment necessary to load and nload the major bulk commodities. None of the major coal ports n the Atlantic Coast are able to accommodate vessels larger than anamax (generally 60,000 dwt or less). Only the Louisiana Off-hore Oil Port (LOOP) can accommodate very large crude carriers VLCCs). These port constraints have generated a great deal of iscussion about the need for dredging the major ports handling ulk commodities. In many cases, however, the impact of depth imitations can be diminished by using the large carriers and ightering them outside the port.

ole of Business Organization - Ships are the tools of business rganizations and their design and deployment may be adapted to ne requirements of different business strategies. raditionally, there were three classes of business organizations perating ships: liner, tramp and proprietary. Liner operators rovided scheduled, common carrier service to carry typically mall lots of general cargo. Tramp operators provided nscheduled, common carrier service, seeking primarily large lot nd shipload cargoes. Proprietary services were ones operated as art of an integrated industrial enterprise which needed shipping nd generally carried shipload cargoes. The business rganizations of these three archtypical shipping operations also ontrasted. The liner operator required a major staff to solicit nd track the cargoes of many customers. By contrast, the tramp perator typically employed a minimal staff, relying on brokers o obtain cargoes. The proprietary service operator, of course, as part of an integrated operation.

---

44 Alastair Couper, ed., Times Atlas of the Oceans (New ork, NY: Van Nostrand Reinhold Company, 1983), p.153.

pecialized. The dimensional limitations which may be imposed by mportant ports and waterways are also important, as are how usiness organizations might affect ship design and deployment. f any one conclusion could be drawn from the framework alone, it ould be that the merchant fleet is necessarily going to be quite iverse, adapted to a variety of circumstances and conditions, nd, further, that improvements in efficiency will tend to take he fleet further in the direction of diversity of ship design nd size. This framework also highlights the important role that argo handling technology may have in determining ship size, and t recognizes that forms of business organization have an nfluence over ship design and deployment.

twenty-five years in domestic shipping and over fifteen years in foreign trades, the full implications of containerization have not been realized. Containerization will continue to affect the development of ocean shipping and the merchant fleet for many years.

Perhaps no change in ocean shipping since the introduction of steam power has had such a prolonged and well anticipated implementation. Certainly, no change has generated so much debate and analysis. Hundreds of books, studies and articles have been written tracing the logical implications of containerization for every aspect of ocean shipping -- operational, economic, financial, strategic, and legal.

Containerization was one of several efforts to improve productivity in general cargo handling, all of which depended to some extent on forming units which could be handled uniformly. One of the first of these efforts to be widely adopted in general cargo handling was to consolidate cargo in slings that could be used to lift the cargo into the ship and left in the ship to be used again to unload the cargo. Another method centered on the use of pallets which could be lifted or moved with forklift trucks. The principle by which efficiency was improved was the same: With cargo consolidated into larger, uniform packages, loading and unloading the ship could be accomplished faster with fewer workers. The pallet had an advantage over the sling in that pallets could be usefully employed inside warehouses, trucks and railcars, extending the cargo handling economies along the transportation chain, and a disadvantage in that palletization generally took up more space aboard ship.

Containerization took unitization several steps further by employing what was essentially a truck trailer without a wheeled chassis as the basic unit. Several major economies were commonly associated with containerization:

at containerization would significantly increase the capital-tensity of the liner industry, requiring significant vestments in containers and container-carrying ships. It was so clear that the reduction in port time associated with ntainerization would allow fewer ships to carry a given volume trade. Third, the increased efficiency in cargo handling uld make larger ships efficient and it would make trans-ipment less expensive. Fourth, the use of containers which uld also be used as highway truck trailers or rail containers uld make possible through intermodal shipments from point to int rather than from port to port. Finally, the easy ansferability of containers between transportation modes would ke land-based competition with ocean transportation feasible.

asoning about these systems effects, industry participants and servers anticipated various developments that would alter the ructure of ocean liner shipping. For example, it was cognized early on that there would be a tendency for ntainerized liner operators to call at fewer ports, ncentrating instead on so-called load center ports where cargo ght be gathered by a combination of land transportation and ean feeder services from other ports. Very large and efficient ntainer ships could be used for these line-haul operations tween load center ports. It was also recognized very early at ocean shipping's relationship to land transportation would altered fundamentally. The potential competitive advantage of ing able to offer a shipper point to point services was cognized quickly, as was the possibility of using railroads to ke shortcuts on some key routes. Containerization, in the view many, would revolutionize the whole liner business, including e ways in which liner operators competed with one another and th non-liner businesses, and the ways in which liner operators iced and marketed their services. Consequently, a good deal of eculation has centered on the future of liner competition and e fate of such institutions as the liner conference.

Intermodalism - Containerization increased the feasibility of intermodal transportation, significantly enhancing the competitiveness of land-based transportation in some circumstances. As a result, some important shifts occurred in the pattern of liner trade. In one shift, liner trade out of the Great Lakes declined as cargoes that had previously gone by ship could now be transported overland by container to coastal ports, with a significant reduction in transit time. Great Lakes liner traffic, which was almost 9 percent of U.S. liner trade with the U.K. and Atlantic Europe in 1972, declined to less than 0.1 percent of that trade in 1982.

In an even more important and far-reaching shift, the proportion of the U.S. liner trade with the Far East routed through the Pacific Coast increased dramatically as a result of containerization. In a shipment between Japan and the eastern part of the U.S., substitution of rail transportation from the Pacific Coast for all-ocean service through the Panama Canal reduces the distance traveled by over 2,000 miles and transit time by several days. In 1972, only about 45 percent of liner trade with the Far East passed through the Pacific Coast. (Although as early as 1972, 75 percent of container cargo to and from the Far East passed through the Pacific Coast, less than half of all liner trade with the Far East was containerized.) By 1982, with liner trade 85 percent containerized, over 70 percent of U.S. liner trade with the Far East passed through the Pacific Coast. (79 percent of U.S. container trade with the Far East passed through the Pacific Coast.)

As traffic patterns have shifted with containerization, competitive conditions in the liner industry have also altered. The ability to offer land transportation services has become an essential competitive requirement. Most liner companies offer intermodal point to point service, contracting with railroads and trucking companies to complete movements. During the 1970s, the question of whether liner conferences could legally establish

TABLE 3-2. GROWTH IN WORLD SPECIALIZED GENERAL CARGO FLEET

DATE	CONTAINERSHIP	SEMI-CONTAINERSHIP	RO-RO	BARGE CARRIER
12/31/72	321	229	51	15
12/31/73	N/A	N/A	N/A	N/A
12/31/74	N/A	N/A	N/A	N/A
12/31/75	457	481	141	28
12/31/76	508	597	205	29
12/31/77	N/A	N/A	N/A	N/A
12/31/78	N/A	N/A	N/A	N/A
12/31/79	N/A	N/A	N/A	N/A
1/01/81	701	1,058	619	31
1/01/82	714	1,303	637	35
1/01/83	758	1,287	559	40
1/01/84	841	1,416	598	41

SOURCE: U.S. Dept. of Transportation, Maritime Administration, Merchant Fleets of the World, selected years.

The first ships used to carry containers in the trans-ocean foreign trade were generally unconverted break-bulk ships. In fact, some historians cite examples of containers of one sort or another in use before the Second World War. The establishment of regular container services using standard containers did not begin in earnest until Sea-Land announced in 1965 its intention to enter the trans-Atlantic trades. Even before Sea-Land could commence its service, already established competitors were offering container services aboard their break-bulk vessels. Relatively little was gained in efficiency by the use of containers aboard break-bulk vessels and when Sea-Land did begin its trans-Atlantic service in 1966, it used cargo ships converted to handle containers. Converted cargo ships define the first generation of container ships. Except for the cellular holds and reinforced decks intended to facilitate the carriage of containers, they were really not different from other, break-bulk cargo ships of their day. No larger and no faster at sea, they generally were able to carry from 750 to 1000 TEU. Many of the first purpose-built container ships were of similar configuration and capacity, and so, too, can be counted in the first generation.[48]

A second generation of container ships, designed in response to the economics of containerization to be larger and faster, soon followed. These ships, many built with steam turbines, ranged generally from 800 to 1,500 TEU and were for the most part, faster ships, reporting service speeds up to 23 knots. They began coming into service around 1969.

The third generation began to appear around 1972 and they were still larger and faster. Third generation development coincided with the containerization of the Europe/Far East trades. This very long route made very large ships particularly attractive,

48 Kendall, p.203.

more minor ship types, but it should not lead to the delusion that the development of container ships was an isolated, lineal development of a single type of ship. A very important, parallel and complementary development was the evolution of the deep-sea ro-ro ship.

The concept of roll-on, roll-off cargo handling is not, strictly speaking, a matter of unitization, like containerization. But, its development in deep-sea transport occurred almost simultaneously with containerization and has often taken on a complementary role. Ro-ro, as a concept in sea transport, is fairly old, dating back over a century to the first railcar ferries. However, until the 1960s it had remained confined to applications in the so-called short sea trades and most ro-ro vessels were simply ferries.

The most common motivating force in the development of deep-sea ro-ro vessels involved the development of a substantial trade in motor vehicles. Carriage in break-bulk vessels was expensive and the traditional lift-on, lift-off methods resulted in frequent damage to the vehicle. With the introduction of containerization, it was recognized that not all shipments would be readily containerizable, and that some more flexible methods of cargo handling might help secure an important niche in the market. The idea of combining containers and ro-ro was persuasive. In 1967, Atlantic Container Lines, formed two years earlier by five, formerly independent European shipowning companies, introduced four ro-ro/container ships in trans-Atlantic liner service. These ships carried containers in forward holds and on the weather deck, and had room for over a thousand cars. ACL introduced second generation ro-ro/container ships three years later which had proportionately more container capacity. The second generation, steam turbine vessels, are

The first ships employed exclusively to carry cars for manufacturers were bulk carriers converted by the installation of decks and ramps. Cars were lifted into these ships, however; this was a slow method and one prone to damage. The first ro-ro ship built to carry cars was probably one introduced into service around 1965 to carry Volkswagens to the U.S. The Japanese, who also were working on car carriers in the mid-1960s, went on to develop "pure" car carriers of very large size in the 1970s.

Barge Carriers - A third development in ship specialization which occurred concurrently with containerization and the evolution of deep-sea ro-ro vessels was the development of barge carrying systems. These systems are intended to reduce the time that a general cargo vessel must spend in port. The barges carrying the cargo can be released from the ship to travel along the inland waterways to their final destination. The systems are designed for use primarily at the outlets of major river systems such as the Mississippi. The barge carrier can unload its barges outside the port, thereby reducing the necessary port time. The first oceangoing vessel of this kind entered service in 1969. Three major variations on the barge carrying concept have been designed: LASH (Lighter Aboard Ship), Seabee, and BACAT (Barge Aboard Catamaran). The most successful version of the barge carrier has been the LASH. On LASH vessels, the rectangular barges are loaded onto the carrier by means of a gantry crane and lowered into their storage position. On Seabee carriers, the barges, larger than their LASH equivalents, are loaded by means of a hydraulic elevator and moved into their storage position on rails. In the BACAT system, the barges are carried between the hulls and on deck. These systems have not received widespread acceptance and are not likely to do so in future; the carriers are relatively expensive to build and awkward to use. In 1983, the world merchant fleet included only 41 barge carriers with steadily over the next five years at least. The reason for this is simply the elimination of many early generation container and ro-ro ships by much larger newbuildings and conversions. The largest, best established liner operators have been replacing their line-haul vessels with larger, more economical vessels to consolidate their competitive positions. In deployment, these vessels will replace smaller ships and, through competition, additionally displace other small, inefficient ships.

Despite the evident economies of scale introduced by unitization, and the general increase in size, the entire general cargo fleet will not gravitate toward Panamax dimensions. Only trans-Pacific trades, among strictly U.S. trades, combines sufficient cargo volume and distance to come near to justifying Panamax dimensions for a ship in liner service. Containerships in regular, trans-ocean, line-haul service to the U.S. are likely to range from 1,500 to 3,500 TEU in capacity, with only a salient few exceeding these capacities.

Future Developments in Ship Speed -- Considerable speculation has, in the past, centered on the trend of ship speed, especially among liner operators. In the early years of containerization, opportunities to benefit from substantially increasing ship speed were recognized. Combining the substantial reduction of time in port due to superior cargo handling rates with a reduction of time at sea could achieve a significant reduction in capital costs while improving the value of service. Regular service speeds of 28 knots were achieved. Petroleum price increases altered the economics of high speed, and ship speeds have generally been much lower in ships built in the late 1970s and early 1980s. The U.S. Lines ship, American New York, and other similar ships, reportedly have a service speed of 18 knots, a speed slow enough to arouse considerable comment in the trade press.

examples. A third case occurs when the goods are scheduled for very precise arrival and their being late (or early) will increase the consignee's cost significantly. Automobile parts for an automobile assembly plant, the lack of which might shut the plant down, can be taken as an example.

Air cargo shipping has been growing very rapidly, from an admittedly very small tonnage base, until it now accounts for a substantial fraction of the value of U.S. foreign trade. For a truly time-sensitive cargo, air shipment offers service in total transit time which is vastly superior to anything which could be provided oceanborne; one is measured in hours and days, the other in days and weeks. The result is that most cargoes which would benefit significantly from a marginal improvement in transit time of two to three days can obtain the benefit of one to three weeks by air. The most extremely time-sensitive cargoes are shipped by air and no conceivable improvement in ship speed would result in their capture by seaborne transport. Liner operators who can control very precisely the delivery of the cargo to its final destination, however, can compete with air transport for those many cargoes whose time-sensitivity is related, not to their inherent value, but to their role in a business or manufacturing process. Thus, the increasing importance of airlines in international commerce in competition with ocean shipping companies has the effect of diminishing the potential value of transit time as a competitive weapon for ocean liner operators in favor of an emphasis on reliability of schedules and the control of intermodal arrangements for delivery to final destination.

Evolution of General Cargo Shipping -- Containerization and related developments have altered the structural relations between different kinds of general cargo shipping services. The lines of division which formerly existed between liner and tramp shipping have broken down and a new structure has been emerging. While formerly, liner shipping was made distinct from tramp shipping by its schedules, its cargo solicitation (marketing)

The industry structure which eventually emerges will be a response to many of the same market conditions which existed before, transporting the same categories of commodities, coping with the inevitable variations in volume, and so on. Therefore, it is certain that there will have to be provision for cargoes which require special handling such as oversize items or refrigerated goods, for relatively inexpensive means of transporting low-value commodities, for providing extra capacity in times of peak demand, etc. The traditional division of responsibility between liner and tramp and among different categories of liner or tramp operators will not apply, however.

One area where this change in the division of labor is likely to become evident in the next decade is in the carriage of refrigerated cargos. The specialized transport of refrigerated goods was one of the first speciality services requiring specialized ships and dates back to the 1870s. The transport of refrigerated goods became concentrated in the hands of a few proprietary services and in a few large-scale tramp ship operations. The most important proprietary arrangements occur in the banana trade. The three largest firms in the business (United Brands, Castle & Cook, and Del Monte) all operate their own fleets of refrigerated ships.[54] Historically, the largest single operator of reefer tonnage was the tramp operator Salen Reefer Services, which controlled approximately 100 ships, either through direct ownership or time charters.[55] Salen suffered a financial collapse recently, but the former management continues to provide management and broker services through a newly formed company, and in this form continues as a major factor in the reefer market.

---

[54] Beth, p.90.

[55] Ibid.

variations on the traditional bilateral movements from A to B and back. These more complex deployments, theoretically, may yield greater efficiency in terms of maintaining a high degree of ship utilization throughout a voyage and providing options for reducing capacity to match falling cargo volumes in recessions without reducing perceived service levels.

Another possibility raised by the creation of container networks is that the company managing the network would not always be limited to using only its own fleet to provide transportation. The network manager, with extensive resources for soliciting and tracking cargoes, might well find it advantageous to use competing carriers to supplement their own services and, also, independent carriers in many instances, for feeder services, for services in inconvenient trades, or as an overflow alternative to its own fleet. Network managers might well wish to offer customers a range of services differentiated by price. They might be willing to offer the alternative of slower, cheaper transport for some of a customer's cargo, perhaps by way of a con-bulker operated by another company, if a larger business purpose is thus served through insuring customer loyalty, a larger market share, etc.

Containerization and a restructuring of general cargo shipping will not reduce the diversity of ship type and size evident in the world's fleet. Roles and niches will remain for relatively small ships and for specialized deployments. If the major liner operators adopt a strategy of relying on very large container ships for line-haul, trans-ocean service in either round-the-world or more conventional deployments, then they will also be relying on the existence of extensive short-sea feeder networks in many areas of the world, and intermodal rail or truck delivery systems, particularly in the U.S. Other liner operators will also have the option of providing direct, trans-ocean service to areas reached only via trans-shipment by line-haul/feeder/intermodal operators. To the extent that some

3.3 BULK CARRIER FLEET

Bulk carriers, as the name implies, are ships which carry cargo in bulk. The term "bulk cargo" encompasses both liquid and dry cargoes. Crude petroleum is the most important cargo carried in bulk in world trade and petroleum tankers are the most prominent bulk carriers. Dry bulk carriers have increased substantially in number since the early 1960's and now carry the largest portion of most kinds of dry bulk cargoes carried in international trade, including iron ore, coal, and grain. A substantial sector of the bulk carrier fleet is composed of combination ships that can carry oil or dry bulk cargoes. Many bulk carriers are fairly specialized, designed to carry a specific range or type of cargo. In the tanker sector, ships equipped to carry petroleum products and chemicals have been increasing in number in recent years. Highly specialized ships to carry liquefied natural gas have been built. Ore carriers, specially designed to carry dense cargoes such as iron ore, were among the first specialized dry bulk carriers. In recent years, specialized ships have been developed for the carriage of cargoes not previously considered bulk in nature, such as iron and steel products and forest products, as well as cargoes such as cement not previously shipped in sufficient quantities to justify dedicated bulk carriage.

The Maritime Administration estimates the world fleet of bulk carriers, including ships intended to carry either dry bulk or liquid bulk cargoes but excluding tankers, to have numbered some ,384 ships with an aggregate capacity of 216,468,000 dwt on anuary 1, 1984. Tankers numbered an additional 5,548 vessels ith an aggregate capacity of 322,617,000 dwt.[56] John I. Jacobs' orld Tanker Review estimates that the world fleet includes 139 re-oil carriers totaling 19,655,000 deadweight tons and 217 ther combination carriers totaling 21,737,000 deadweight tons.

---

56 Merchant Fleets of the World (Washington, DC: U.S. Dept. f Transportation, Maritime Administration, March 1985), p.3.

The very early developments in ship specialization occurred before World War I. The advent of the tanker was the first significant achievement in specialized design. In 1872, the first oceangoing tank steamer, the Vaderland, was built as a passenger/oil carrier, but was never permitted to transport oil. The first purpose-built petroleum tank steamer, the 2,300 dwt Gluckauf, was built in 1886 (see Table 3-4). Tanker cargo began to traverse the Suez Canal in 1892. Because a large proportion of the oil trade passed through the Canal, its depth was a major limitation on the growth of tanker size.

Prior to World War II, the typical petroleum tanker was a versatile, handy-size ship of 12,000 dwt, although a few vessels of 20,000 dwt were trading. When larger quantities of oil than could be moved by these vessels had to be transported during the war, the U.S. built more than 500 ships in the T-2 series of tankers with a capacity of 16,750 dwt.[59] The efficiency demonstrated by these tankers, together with the removal of the major technical constraints on ship size, provided the incentive for the rapid enlargement of tanker size. In 1947, 25,000 dwt tankers were introduced into service. In 1953, the first "supertanker," the 45,000 dwt Tina Onassis, vessel (with 60 percent more capacity than any previous tanker), was introduced. The increase in ship size continued rapidly in the decades following World War II, and by 1981, a handful of vessels in excess of 500,000 dwt were operating in the international oil trade.

In recent years, however, new buildings of tankers have tended to be of more conventional smaller size vessels and the use of these ultralarge crude carriers (ULCCs) and very large crude carriers (VLCCs) has diminished for several reasons. The actions of the OPEC nations have created incentives for oil importing countries

---

[59] Kendall, p.409.

to seek closer sources. As the trade route distance has declined in consequence, the optimum vessel size has decreased. The ULCCs are not efficient on the shorter trade routes. The total volume of the petroleum trade has stagnated during this period as well. Given the shorter trade routes, this means that overall ton-miles have fallen. The reopening of the Suez Canal has further diminished the importance of the VLCCs. With the Canal open, even the formerly long routes from the Middle East are shortened, but the maximum draft of vessels transiting the Canal is restricted, further limiting the usefulness of VLCCs.

Chemical Carriers - Certain cargoes, with sufficient volume to be carried in shipload quantities and which have special hauling or handling requirements, may be more efficiently transported in specialized vessels. For instance, chemical carriers which transport hazardous materials must be designed with particular emphasis on the safety features.

Chemical tankers became an important part of the merchant fleet in the years following World War II as the U.S. petrochemical industry developed. The early chemical tankers were converted T-2 tankers, such as Union Carbide's R.E. Wilson, which could carry a variety of incompatible chemicals in its center tanks and petroleum products in its wing tanks.[60]

Currently, as the aging fleet of converted chemical carriers becomes obsolete and the petrochemical industry continues to grow, the number of chemical carriers on order at the world's shipyards is increasing.

Product Tankers - Petroleum products are important commodities which typify the special ship requirements generated by certain cargoes. Petroleum products, which are characterized as "clean"

60 Michael Corkhill, Chemical Tankers: The Ships and the Market (London: Fairplay Publications Ltd., 1978), p.16.

ıantity of a bulk commodity efficiently and economically. In ıe 1950s and early 1960s, these vessels were generally small. 7 1961, there were only about 500 bulk vessels, of which only 60 ılk exceeded 25,000 dwt.[64]

lthough bulk carriers have grown substantially, both in number ıd size, they have not demonstrated the tremendous growth shown 7 tankers. There are the same economies in hauling dry bulk ırgoes as liquid bulk. Over long trade routes, large vessels :e desirable to haul the cargo efficiently. However, the evelopment of extremely large bulk carriers has been hindered by ıe difficulty in the cargo handling operation for such a vessel. ew approaches to loading and discharging needed to be developed) minimize the amount of time that these large ships spend in ort. Large specialized bulk carriers are limited in the number E ports they may serve by the channel depth in the port and by ıe available cargo handling equipment in the port. Unlike oil, ost dry bulk commodities cannot be conveniently transferred by ipeline to an offshore location, as is often done for the argest tankers, so dry bulk carriers must be able to enter orts. In addition, for the routes served by many bulk carriers, ıe most efficient routing requires passage through the Panama anal. The Canal can accommodate a maximum ship size of 274 eters long and 32.6 meters wide (roughly 60,000 to 80,000 tons eadweight). Finally, dry bulk commodities, with the exception E iron ore and coal, are not readily available in the same remendous quantities as petroleum.

espite these limitations, bulk carriers have become increasingly nportant in the transport of world trade. From 1972 to 1982, ıe quantity of the major dry bulk commodities (iron ore, coal, rain, bauxite, and phosphate) increased from 524 million metric ons to 759 million metric tons. Over the same period, the

---

[64]Beth, p.52.

TABLE 3-5. PERCENT OF MAJOR BULK TRADES TRANSPORTED IN LARGE BULK CARRIERS, TANKERS AND COMBINED CARRIERS

YEAR	GRAIN	COAL	IRON ORE
1973	13%	53%	73%
1975	31%	59%	80%
1977	41%	67%	85%
1979	39%	66%	90%
1981	50%	68%	93%
1983	58%	73%	91%

SOURCE: Fearnleys, World Bulk Trades, 1983.

ike the traditional tramp ship, to locate a cargo for their eturn trip.

here is some sacrifice in efficiency in designing for the ccommodation of alternative cargoes and combination carriers are enerally more expensive than simpler bulk carriers. There are lso operating costs associated with switching from one cargo ype to another. In general, combination carriers have been arge ships relative to most bulk carriers, and are able to offer conomies of scale to offset their disadvantages.

ombination carriers are prominent in the U.S. coal export trade nd the U.S. grain export trade. A study of combination carriers y H.P. Drewry indicates that 18 percent of cargoes for these essels are loaded on the East Coast of North America, while an dditional 14 percent is loaded elsewhere in North America.[68]

different kind of combination ship is the con-bulker, a ship ntended to carry both bulk cargoes and containers. The ationale for the con-bulk ship does not necessarily parallel hat of the combination bulk carrier. While the combination bulk arrier is designed to carry different bulk commodities as lternative cargoes, the con-bulk ship is intended to carry ontainers and bulk cargoes together as complementary cargoes. he basis for doing this is the low density of container cargo; implistically, bulk cargo can be carried in the hold while ontainers are carried on deck.

recent Maritime Administration report explored the potential or con-bulk ships in the U.S. foreign trades. Several existing on-bulk services were described and an attempt was made to dentify trades where additional potential existed. According to

---

68 H.P. Drewry (Shipping Consultants) Ltd., Outlook for re-Bulk-Oil (OBO) Carriers in Oil and Dry Bulk Trades, Economic tudy No. 97 (London, October 1981), p.32.

4. FORECASTING THE FLEET

1 SPECIFIC TRADE FORECASTS AND THE DEMAND FOR SHIPPING

ıe growth in the U.S. oceanborne trade in the last twenty years ıs been phenomenal, more than tripling between 1960 and 1982. ıis growth has been supported primarily by growth in a few of ıe commodities which dominate trade. Vastly increased imports : petroleum and exports of grain and agricultural products were ıe major factors supporting the increase in tons shipped. ıcreased imports of steel, automobiles, textiles, and, most ·cently, consumer electronics, have supported the increase in .e value of trade.

.e growth in U.S. foreign trade is widely expected to continue .to the foreseeable future, and this expectation is reflected in .rious forecasts of trade. Two recent econometric forecasts of e U.S. foreign trade are particularly notable for providing mmary projections of the future patterns of trade that broadly flect contrasting conventional views.

arton Econometrics prepared a trade forecast to 1992 for the ngressional Office of Technology Assessment. The forecast, mpleted in early 1983 and extended to 2000, projected a slow covery of the world and U.S. economies during late 1983 llowed by a growth cycle for the remainder of the decade. cording to this forecast, U.S. foreign trade will continue to ow, although at a somewhat lower rate. During the past twenty ars, seaborne imports, the more rapidly rising component of S. trade, consistently exceeded exports. This projection dicates that the growth of imports will level off, while ports rise dramatically (see Figure 4-1). The forecast dicates that the share of U.S. exports to Europe will decline roughout the forecast period, while those to South Asia will se rapidly. Trade in dry bulk commodities with developing untries also increases in importance over the forecast period.

n interesting feature of the Wharton/OTA forecast is that it reaks down its projection of trade into projections for three ategories -- liquid bulk, dry bulk and general cargo -- roughly orresponding to the Maritime Administration's three services -- anker, non-liner and liner. Combining the Maritime dministration's historical numbers with the Wharton/OTA rojections, as in Figure 4-2, illustrates the Wharton/OTA ssertions that liquid bulk (i.e. tanker) trade will grow slowly ver the next fifteen years. In turn, the dry bulk (i.e. non-iner) trade will continue to expand rapidly.

n a foreign trade forecast to 1990, completed for the Maritime dministration in 1985, Data Resources, Inc. (DRI) predicts that rade with the Far East will continue to predominate. Trade with he Caribbean/Mexico region will be the second largest trade area or the U.S. largely due to imports from this area. Europe will ontinue as the second largest recipient of U.S. exports (after he Far East). DRI also predicts no decline in export tonnage to ny area, but reductions in imports from the Middle East are not xpected to recover to 1973 levels by 1990. Figures 4-3 through -6 show trade flows for 1971, 1976, 1981 and 1988.[71]

he projected volume of U.S. foreign trade indicated in the trade orecasts has implications for the future ocean fleet beyond dentifying the level of tonnage which will have to be ransported. The amount of goods to be shipped alone cannot etermine the number of vessels required to serve the trade. emand for shipping also depends upon the distance over which hese goods must be transported. A greater number of ships (or,

---

[71] Data Resources, Inc. United States Oceanborne Foreign rade Forecasts (U.S. Dept. of Transportation, Maritime dministration, March 1984),pp. 8-15.

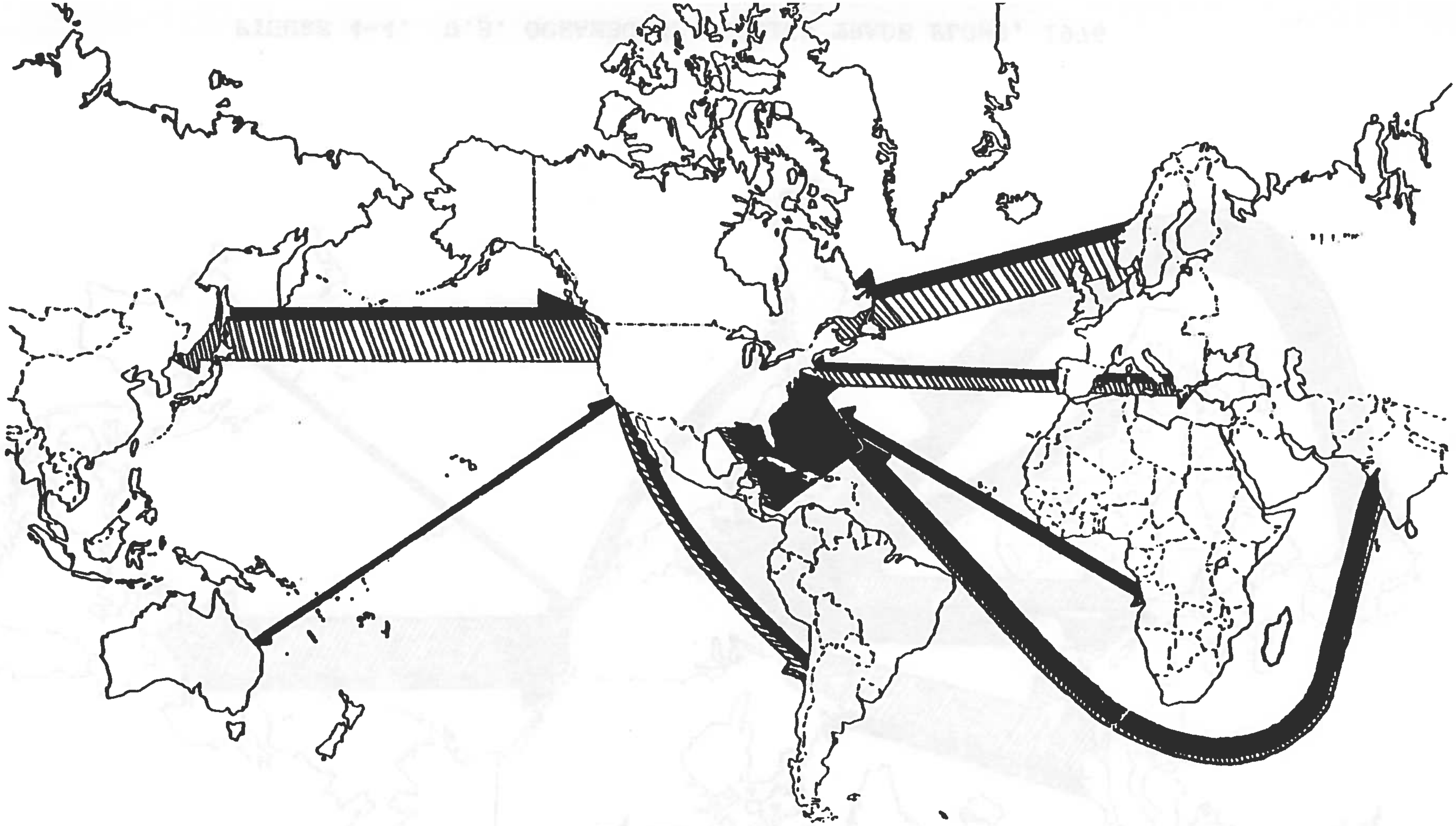


FIGURE 4-3. U.S. OCEANBORNE FOREIGN TRADE FLOWS, 1971

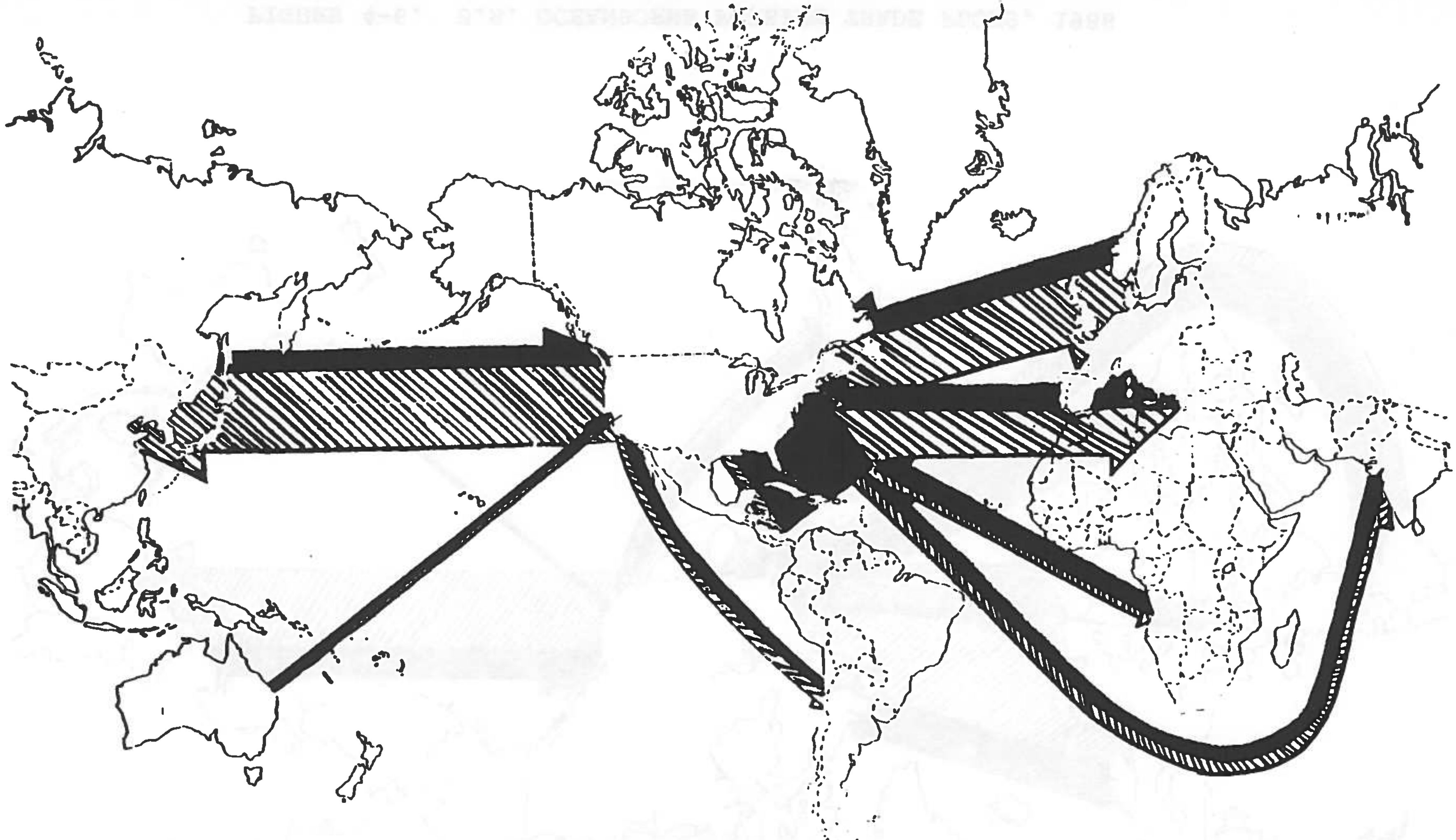


FIGURE 4-5. U.S. OCEANBORNE FOREIGN TRADE FLOWS, 1981

lternatively, larger ships) are needed to transport the same nount of tonnage over a relatively long distance than over a elatively short one. The shift in U.S. trade patterns toward an ncreasing reliance on trans-Pacific trade has dramatically ncreased the demand for shipping services. The rapid economic rowth and development in Japan, South Korea, Taiwan, Singapore nd Hong Kong have made possible this growth in trade. The far reater distances on the trans-Pacific routes mean that half jain as many ton-miles are generated transporting a given amount cargo to the Far East than to Europe.

ring the same period that the Far East trade was expanding, the ttern of the U.S. oil trade was shifting. In recent years, ade with the Middle East has become increasingly important as e U.S. has become more reliant on imported petroleum. Prior to rld War II, the United States was nearly energy independent, d as recently as 1960, only 20 percent of the petroleum quired in the U.S. came from foreign sources. The petroleum ade with the Persian Gulf region grew steadily throughout the 60s. Following the Arab oil embargo of the early 1970s, wever, the U.S. began to seek closer, more reliable sources. a result, during the period between 1973 and 1978, trade with e Persian Gulf fell. At the same time, trade with the much oser Caribbean region increased, as its oil trade with the U.S. panded dramatically. This shift has had the effect of reducing e ton-miles generated by the petroleum import trade.

bles 4-1 and 4-2 summarize the tonnage projections of the I/MARAD and Wharton/OTA projections. Along with these mmaries, there are estimates of the ton-mile implications lculated by the Transportation Systems Center. (Appendix A ntains more detail on the ton-mile calculation.) According to e DRI forecasts, total U.S. foreign trade by tonnage will crease by more than 90 percent between 1973 and 1990. Because

TABLE 4-1. GROWTH IN U.S. FOREIGN TRADE 1973 - 1990 (Continued)

IMPORTS

(MILLIONS OF TONS)

ORIGIN	TONS - 1973	TONS -1978	TONS - 1985	TONS - 1990	% CHANGE 1973-90
FAR EAST	15.00	20.90	27.99	33.12	+121%
U.K./N. EUROPE	19.21	26.75	46.34	48.26	+151%
MEDITERRANEAN	29.45	58.45	30.79	31.85	+ 8%
S. AMERICA	16.45	17.04	25.38	27.39	+ 67%
CARIBBEAN/MEXICO	52.49	103.78	137.78	151.16	+188%
INDIA/PERSIAN GULF	43.07	14.00	21.95	25.27	- 41%
AFRICA	30.40	33.05	28.20	28.53	- 6%
AUSTRALASIA	4.46	6.79	6.30	6.40	+ 43%
INDONESIA	10.28	23.91	18.30	24.14	+135%
SCANDINAVIA	2.48	2.05	2.19	2.34	- 5%

(BILLIONS OF TON-MILES)

ORIGIN	TON-MILES 1973	TON-MILES 1978	TON-MILES 1985	TON-MILES 1990	% CHANGE 1973-90
FAR EAST	153.74	215.71	211.88	251.24	+ 63%
U.K./N. EUROPE	81.41	126.69	200.22	208.94	+157%
MEDITERRANEAN	132.50	263.01	138.36	143.07	+ 8%
S. AMERICA	70.31	68.88	108.86	117.18	+ 67%
ARIBBEAN/MEXICO	103.59	184.55	245.27	268.99	+160%
INDIA/PERSIAN GULF	490.33	161.25	258.10	297.09	- 39%
AFRICA	160.19	185.15	158.65	159.92	-0.2%
AUSTRALASIA	37.05	56.80	48.73	49.61	+ 34%
INDONESIA	105.31	245.02	187.56	247.40	+135%
SCANDINAVIA	9.91	8.18	7.66	8.18	- 17%

TABLE 4-2. GROWTH IN U.S. FOREIGN TRADE, 1975-2000

EXPORTS

(MILLIONS OF TONS)

DESTINATION	TONS - 1975	TONS -1980	TONS - 1985	TONS - 1990	TONS - 2000	% CHANGE 1975-2000
JAPAN	47.44	65.12	86.53	114.38	166.07	+250%
SOUTH ASIA	32.73	53.53	70.28	99.59	210.29	+542%
C.P. ASIA	2.32	4.08	4.92	5.24	6.73	+190%
OCEANIA	3.49	4.07	4.93	5.62	7.89	+126%
U.K./N. EUROPE	66.03	93.25	97.93	110.46	141.27	+114%
OTHER EUROPE	37.74	59.02	68.15	79.44	110.83	+194%
LATIN AMERICA	22.44	45.04	52.47	72.45	138.26	+516%
MIDDLE EAST	16.70	25.06	30.47	40.26	71.04	+325%
AFRICA	16.31	26.41	30.55	39.45	65.02	+299%

(BILLIONS OF TON-MILES)

DESTINATION	TON-MILES 1975	TON-MILES 1980	TON-MILES 1985	TON-MILES 1990	TON-MILES 2000	% CHANGE 1975-2000
JAPAN	272.78	374.44	497.55	657.69	954.90	+250%
SOUTH ASIA	335.48	548.68	720.37	1,020.80	2,155.47	+542%
C.P. ASIA	13.34	23.46	28.29	30.13	38.70	+190%
OCEANIA	25.30	29.51	35.74	40.75	57.20	+126%
U.K./N. EUROPE	231.10	326.38	342.76	386.61	494.45	+114%
OTHER EUROPE	169.83	265.59	306.68	357.48	498.74	+194%
LATIN AMERICA	39.27	78.82	91.82	126.79	241.96	+516%
MIDDLE EAST	179.53	269.40	327.55	432.80	763.68	+325%
AFRICA	122.33	198.08	229.13	295.88	487.65	+299%

TABLE 4-2. GROWTH IN U.S. FOREIGN TRADE, 1975-2000 (Continued)

IMPORTS AND EXPORTS

(MILLIONS OF TONS)

ORIG./DEST.	TONS - 1975	TONS -1980	TONS - 1985	TONS - 1990	TONS - 2000	% CHANGE 1975-2000
JAPAN	59.38	79.29	103.13	134.02	192.55	+224%
SOUTH ASIA	84.99	105.51	130.59	170.75	308.10	+263%
C.P. ASIA	3.31	4.90	5.95	6.35	8.08	+144%
OCEANIA	14.80	14.41	16.72	19.16	24.45	+ 65%
U.K./N. EUROPE	89.36	129.39	156.73	179.47	229.33	+157%
OTHER EUROPE	48.43	73.04	88.98	104.56	144.41	+198%
LATIN AMERICA	159.21	170.53	173.30	202.85	285.95	+ 80%
MIDDLE EAST	77.33	105.50	96.82	111.62	151.92	+ 96%
AFRICA	98.86	139.26	117.01	133.07	171.28	+ 73%

(BILLIONS OF TON-MILES)

ORIG./DEST.	TON-MILES 1975	TON-MILES 1980	TON-MILES 1985	TON-MILES 1990	TON-MILES 2000	% CHANGE 1975-2000
JAPAN	341.44	455.92	593.00	770.62	1,124.41	+229%
SOUTH ASIA	871.15	1,081.48	1,338.55	1,750.19	3,158.03	+263%
C.P. ASIA	19.03	28.18	34.21	36.51	46.46	+144%
OCEANIA	107.30	104.47	121.22	138.91	177.26	+ 65%
U.K./N. EUROPE	312.76	452.87	548.56	628.15	802.66	+157%
OTHER EUROPE	217.94	328.68	400.41	470.52	649.85	+198%
LATIN AMERICA	278.62	298.43	303.28	354.99	500.43	+ 80%
MIDDLE EAST	831.30	1,134.13	1,040.82	1,199.92	1,633.14	+ 96%
AFRICA	741.45	1,044.45	877.58	998.03	1,284.60	+ 73%

SOURCE: Wharton/OTA Forecast; ton-miles claculated by the Transportation Systems Center.

4.2 A NOMINAL FLEET FORECAST

The increase in the average size of both bulk and (intermodal) general cargo ships leads to an important question: whether or not the number of individual ships needed to carry U.S. trade is likely to decline, even in the face of increases in the volume of trade. One 2500 TEU container ship can carry as much cargo in a year as a half dozen 12,000 dwt break-bulk ships. A single 250,000 dwt VLCC can transport as much oil in a year as a dozen T-2 tankers from the Second World War. The percentage of the world's major dry bulk commodities carried by bulk ships over 40,000 dwt has increased steadily, while many of the world's leading liner companies are reported to be building new container ships with 3000 TEU capacities and higher for their U.S. routes.

One way to analyze the impact of increasing ship size on overall numerical fleet size is to construct nominal fleets of notional configuration and capacity. The nominal fleet can be used to test the hypothesis that development of the fleet along certain predetermined lines will be sufficient to carry projected trade. Just such an analysis, using the Wharton/OTA forecast trade projections, is described below. The methodology, which is very simple, may be useful, with modification, in other forecasting efforts. It provides a systematic, reproducible way to represent and track the relationship between various assumptions about cargo volume, ship size and speed, route length and numbers of ships.

A ship's capacity to transport cargo over time is a function of its cargo space, unused deadweight, its sea speed, the time it spends in port, and the time it remains idle for routine repair. For the purposes of contructing a nominal fleet of notional ships, it was considered sufficient to take direct account of only the ship's carrying capacity, measured as some proportion of the ship's deadweight tonnnage (dwt), and the number of trips a

North-South sector (covering trade with South America and Africa). Each service had three or four unique sectors. For each service/sector, a "trips per year" factor was chosen to represent route distance, ship speed, and so on, for ships in that service in that trade.

The calculation of trade volumes for these eleven service/sectors from the Wharton/OTA trade projections is summarized in Table 4-3 through 4-5. "One-way" trade volumes are used to avoid the redundancy of projecting a need for potentially duplicative capacity to carry inbound trade plus outbound trade. The dominant leg was chosen in each case--imports of liquid bulk and general cargo and exports of dry bulk.

To establish a basis for comparison, the first case represents a nominal fleet made up entirely of notional ships of a single size. Table 4-6 presents the number of ships of 25,000 dwt necessary to carry the trade projected by Wharton/OTA, given an assumption about the number of trips that could be made per year in each bilateral sector and an assumption about how deadweight is related to cargo carrying capacity. These assumptions were made in accordance with rough estimates of how many trips a typical or average ship in the actual bilateral trade makes per year and how much cargo weight it carries as a

TABLE 4-4. CARGO VOLUMES: DRY BULK EXPORTS

Trade Sector	Destinations	1975	1980	1985	1990	2000
		(millions of tons)				
Trans-Atlantic		**100.0**	**146.8**	**166.3**	**192.0**	**266.4**
	U.K./N.Europe	54.14	75.52	81.47	89.47	111.80
	Other Europe	33.13	50.66	59.52	68.97	95.11
	Middle East	12.73	20.57	25.3	33.55	59.53
Trans-Pacific East Asia		**46.7**	**67.2**	**87.8**	**112.3**	**156.8**
	Japan	43.03	61.09	80.35	104.38	147.38
	C.P. Asia	2.22	3.99	4.84	5.13	6.53
	Oceania	1.41	2.15	2.60	2.80	2.90
Trans-Pacific South Asia		**27.1**	**46.1**	**60.3**	**85.3**	**171.3**
	South Asia	27.07	46.05	60.26	85.28	171.34
North/South		**28.3**	**47.3**	**57.7**	**76.0**	**131.4**
	Latin America	15.96	26.10	32.36	43.34	76.96
	Africa	12.32	21.18	25.30	32.62	54.45

SOURCE: Wharton/OTA Forecast.

proportion of its deadweight.[72] No further assumptions about distance travelled or ship speed were made to support a description of this notional ship beyond the specification of 25,000 dwt.

To review how the numbers in Table 4-6 were arrived at, take liquid bulk/trans-Pacific/1985 as an example. The number of 25,000 dwt ships required to carry the trade projected by Wharton/OTA has been calculated to be 153. Each of these notional ships would be making six trips across the Pacific in a year, carrying as cargoweight 90 percent of their deadweight. The number of 153 ships was arrived at by taking the cargo volume projected by Wharton/OTA--20.6 million import tons (see Table 4-3c)--and dividing first by 22,500, the amount a single notional ship would carry (25,000 dwt X 0.90), then dividing again by 6,

---

72 These "rough estimates" were based in large part on the reports of a detailed study of the fleet serving the U.S. foreign trade in 1974. This study was performed by Temple, Barker & Sloane under contract to the Maritime Administration as part of a fleet forecast. The data reported was not for actual 1974; the study constructed a model based on its study of the 1974 fleet and used it to "calculate" a 1975 fleet for use as a base year in the forecast. Nevertheless, the TBS fleet forecast contains the most detailed information available on the fleet serving the U.S. foreign trade and constitutes an important resource. Important data not published in the fleet forecast reports were reported in a paper submitted to the Society of Naval Architects and Marine Engineers. Thus, two sources need to be cited:

Henry S. Marcus, et al., "A Methodology for Forecasting the Fleets to Serve U.S. International Commercial Trade Until the Year 2000," Society of Naval Architects and Marine Engineers, Transactions, No. 11, 1976

Temple, Barker & Sloane, Inc., Merchant Fleet Forecast of Vessels in U.S. Foreign Trade, U.S. Dept. of Commerce, Maritime Administration, May 1978.

TABLE 4-6. NUMBER OF 25,000 DWT SHIPS REQUIRED TO CARRY THE PROJECTED TRADE

	Ship-trips per year	Capacity as a % of dwt	1975	1980	1985	1990	2000
General Cargo							
Trans-Atlantic	11		116	129	151	208	229
Trans-Pacific	6		249	327	393	473	766
North/South	8		26	36	39	46	59
Total		45%	391	492	583	727	1054
Dry Bulk							
Trans-Atlantic	10		471	691	783	903	1254
East Asia	6		366	527	689	881	1230
South Asia	5		255	433	567	803	1613
North/South	8		155	235	265	305	400
Total		85%	1247	1886	2304	2892	4497
Liquid Bulk							
Trans-Pacific	6		149	148	153	171	209
Europe	10		14	81	180	214	284
Africa/Mideast	9*		787	970	650	698	790
Latin America	20		253	234	217	232	263
Total		90%	1203	1433	1200	1315	1546

*To simulate the effect of opening the Suez Canal, 7 trips per year was assumed in 1975 and 8 trips per year in 1980 for liquid bulk carriers serving Africa/Mideast.

rate than the number of smaller ships. TSC did not use a predetermined algorithm or growth factor for each ship size. The goal was to test the general hypothesis that, within the Wharton/OTA trade forecasts, growth in average ship size was compatible with growth in numerical fleet size. Consequently, judgement was applied in each type of service to maintain a higher growth rate for the larger ships and to accommodate the cargo within a 95 percent tolerance based upon the cargo weight-to-dwt factor and the number of ship trips per year. The results in Table 4-7 represent only an informed best estimate; other variations of the fleet mix may be possible without violating the basic premises.

The numbers actually drawn for each of these scenarios reflect differing conditions in each of the three services. The Wharton/OTA forecast projects a temporary decline in oil imports in the early 1980s that must necessarily be reflected in a reduction in the number of ships required to carry the trade. The scenario for the general cargo fleet emphasizes the growth in the number of large ships deployed to the extent of limiting the number of smaller ships to a constant. Reported trends in new building are reflected, which have emphasized the introduction of much larger vessels in the U.S. liner trades, as well as some neo-bulk trades.

The numbers presented in Table 4-7 demonstrate that, given renewed moderate growth in the volume of U.S. trade, substantial increases in the number of larger ships serving the trade need not imply a substantial reduction in the number of smaller vessels serving the trade and that overall the number of vessels required can increase.

Special note may be taken of the figures provided on average vessel size. Comparison of Table 4-7 with Table 3-1 shows that the average tanker serving U.S. trades is substantially smaller than the average tanker in the world fleet, while the figures for general cargo carriers and dry bulk carrier are more nearly comparable. In Table 4-7, the average size of tanker increases, in accordance with the premises stated earlier; the actual trend for the world fleet (which may very well differ from that for the fleet serving the U.S. foreign trades) has been a decrease in average tanker size. It is not known what the actual trend is for the fleet serving the U.S. is, in terms of either average vessel size or numbers of ships.[74]

The average ship size and the number of vessels presented in Table 4-7 for 1975 have been compared with those reported or implied in the 1978 Temple, Barker & Sloane, Inc. fleet forecast for the same year. The TBS forecast model, far more complex in its methodology, also calculated a fleet of notional ships dedicated to bilateral trades. Their model, however, had been calibrated to a detailed study of the actual fleet in 1974, and so may be said to represent very accurately the situation in its base year of 1975. TBS did not report average ship size and did not use exactly the same categories to enumerate ships. Nevertheless, comparisons can be made with what the TBS study results imply about numbers of ships and average size.

For 1975, there is a fair correspondence between average ship size in each service category in Table 4-7 and the numbers reported for 1975 in the TBS fleet forecast. There is nearly an exact correspondence as well in terms of the total number of vessels reported for the tanker and dry bulk service categories.

---

[74] As noted in footnote 73, the general cargo fleet may be somewhat overestimated. If vessels on the Far East-West Coast route achieved nine round trips per year and the cargo-to-deadweight factor is 60 percent, the total number of general cargo vessels would be approximately 59 percent of the numbers shown in Table 4-7 and the total fleet would be approximately 84 percent of the total estimated fleet (the sum of general cargo vessels, dry bulk vessels and tankers shown in the Table.)

various terms on the open market have no dedicated employment. Even those which have dedicated or, at least, habitual, service patterns, often ply routes that are tri-angular or round-the-world, and some services may involve trans-shipment between line-haul and feeder vessels. Second, the world fleet cannot realistically be divided into three types, defined in terms of three services. The world fleet is composed of both narrowly specialized ships of a great many types, ships equipped with specialized features to handle several kinds of cargo as alternatives, ships specially designed to carry two or more kinds of cargo in combination, and ships intended to carry a variety of general cargo together. These ships are employed in a wide variety of services, ranging from long-term proprietary to voyage charter to scheduled, common carrier, with only a loose correlation among cargo, service and vessel type.

Vessel types vary significantly in their efficiency in moving cargo and the intensity with which they are utilized, and services differ in these respects as well. In the freighter category used above, for example, distinctions between fully cellular container vessels in liner service and the break bulk ships in tramp service would add greatly to the realism of the model, since the former are probably typically more intensely utilized ships than the latter--they are faster, scheduled for more trips, spend less time in port, etc. Such a level of detail could not be provided, however, because (1) there is not enough historical data to calibrate the model, and (2) the trade forecast used as detail for only three services. This methodology at its present level of detail can give no indication of the balance between dedicated ships and and tramp vessels in the U.S.-foreign trade; it cannot indicate the relative importance of scheduled services or proprietary bulk services or neo-bulk services, or the extent to which one may be increasing in importance over another. The numbers of ships given cannot be an indicator of the number of different ships actually in service carrying U.S. foreign trade to any particular region or in any particular service.

5. RESEARCH ISSUES

This report provides much useful information and background for anyone involved in a trade or fleet-forecasting activity, whether that activity supports the decision-making process of a port, a ship operator or a shipbuilder. It discusses the development of both international trade and the merchant fleet; it also includes a simplified notional fleet forecast. The original goal, however, was to use relatively modest resources to develop a report with a more complex and sophisticated fleet forecast outlining the probable future development of the fleet serving the U.S. foreign trade, using the Wharton/OTA and DRI/MARAD forecasts as a basis for trade developments. Unfortunately, this report could meet only the more modest of the original expectations. The information base and statistics needed for a detailed and sophisticated forecast simply does not exist. A maritime information deficit and its consequences for policymaking and planning are not generally recognized. This chapter was written to call attention to the problem.

For those with even a superficial acquaintance with the variety and quantity of maritime publications or with the vast databases maintained by the Federal Government on U.S. international trade, such a bald assertion that information does not exist may seem difficult to accept. Indeed, the study that resulted in this report was undertaken in the belief that the necessary information and statistics could be found and assembled. This belief survived even an unusually lengthy preliminary feasibility and plan development phase. It was only after several research and analytical approaches were tried and failed that a full appreciation of the problem was reached.

It is not that the raw data on U.S. trade and shipping goes uncollected, but that data is not processed into the kinds of information and statistics needed to describe and analyze how the U.S. foreign trade and fleet is developing. The appropriate service, for example, or on a proprietary basis or by a tramp operator on a spot basis); other factors included distances traveled from origin to destination and characteristics of the commodity. Trade data, as published, give few clues about how to properly analyze U.S. trade in relation to these factors. Such salient and elementary facts as how much grain is exported in bulk as opposed to sacked, or how much of imported petroleum is carried in ships owned by major oil companies as opposed to tramp operators, are not published in U.S. trade data.

Two trade forecasts were available to support the fleet forecasting effort: one prepared by Data Resources, Inc. for the Maritime Administration (DRI/MARAD) and one prepared by Wharton Econometrics for the Office of Technology Assessment (Wharton/OTA). Both of these forecasts were first efforts by the respective forecasting organizations in this area, and what may seem like sharp criticism should be read with this in mind. Both forecasts were prepared and presented with very little of the kind of explanation of their basis and meaning that would make critical acceptance of the data they contained possible. As discussed in Chapter 2, trade volume may be dominated by a few commodities or products whose weight or physical volume has little relation to value, and trade in which may be determined by a number of factors of which the business cycle is only one. Yet, Wharton/OTA supported its forecast with a lengthy exposition on its econometric methods and the attendant limitations of same, while DRI/MARAD provided lengthy discussions of the macroeconomic circumstances of a long list of foreign nations. Since the bulk trades are composed of only a very few commodities, Wharton/OTA might have been expected to support its forecast of enormous increases in the dry-bulk trades with some brief explanation of whether these increases were due to circumstances in the coal trades or the grain trades or some other. On this subject, they remained vague and contradictory when not being altogether silent.

First, there are some statistics available on the world fleet, prepared by the Maritime Administration and by private organizations based abroad such as Fearnley and Egers, Lloyd's, and H.P. Drewry. Statistics for the average age and vessel size of the world fleet are well known and accepted. Data on world movements of the major bulk commodities have been regularly estimated by Fearnley's. Information on particular types of vessels in the world fleet is usually sketchier and more anecdotal, put together ad hoc for only one type of ship for one particular study. Statistics for a particular type of vessel, such as reefers or iron ore carriers or deep-sea ro-ros, are not usually prepared using any standard definition or procedure and are not reconciled globally against any particular count of the total world fleet, although most are derived from Lloyd's Register. H.P. Drewry, Containerization International, Fairplay, and Cargo Systems all produce what are considered authoritative counts and analyses of particular types of vessels.

There are also good statistics on the U.S.-flag fleet and its deployment. These are virtually irrelevant, since U.S.-flag participation in the carriage of the U.S. foreign trade is insignificant outside of the liner trades. There are some statistics on the fleet of ships owned by U.S.-owned corporations, although not on the deployments of these vessels, most of which, it is commonly assumed, are engaged in the U.S. foreign trade.

The Maritime Administration publishes an analysis of the U.S. oceanborne trade into three "services"--liner, tanker and non-liner--showing trade in tons inbound and outbound, by leading commodity, and by "trade route." These statistics on the U.S. oceanborne trade are of high quality and quite detailed, but there are shortcomings. Of greatest importance for fleet forecasting, no data is published on the fleets associated with the three services, although the analysis into three services ınd other developments and trends, or fit the historical trend to ı curve of known function, estimating the parameters, and 3. project future values for the historical, statistical series ısing some combination of simple projections of current trends, based on assumptions and estimations about the shape of the trend curve, and complex projections, based on established correlations with other trends about which assumptions are made (in other words, based on some scenario). The projected values are defined in the same way as the historical statistics, so that their meaning is easily understood and comparisons of past and future can be conveniently made.

The best known examples of economic forecasting are the macroeconomic forecasts of the whole economy done by agencies of the Federal government, banks and private economic forecasting firms. These forecasts are usually based on the National Accounts as published by the Department of Commerce. Forecasters analyze the various statistics in the Accounts for relationships and for trends. Their assumptions about trends and relationships among variables are embodied in an econometric model which is used to generate forecasts. These forecasts take the same form as the National Accounts and are, in fact, simply projections of future values for those statistics, having the same definitions.

Ideally, to do a forecast of the fleet serving the U.S. foreign trade means following an analogous procedure to that followed in doing econometric forecasts for the national economy. The same econometric techniques might not be applied and other details would differ, but the three broad steps would have to be taken. Historical statistical series describing the fleet would be studied and trends in deployment as well as design, size, speed, draft, age and other characteristics of vessels could be identified. This information could be supplemented by and correlated with trade data and forecasts, as well as general economic and technology indicators. Projections could then be made in the same format as the historical data was presented, with the same definitions applying.

iewed. Knowing more about the fleet carrying our foreign trade ight well lead to new views about how well served this country s by our own and by the foreign merchant marine.

he creation of statistics to describe the fleet serving the U.S. oreign trade is not a trivial exercise, even though the raw data eeded to do it may already be collected. It is fully as complex task as the prepartion of accounting records and financial tatements from business receipts. Numerous vexing problems of efinition and accounting would have to be solved before useful tatistics describing the fleet serving the U.S. foreign trade ould be drawn from the raw Customs data. For example, evelopment is needed of methods, whether by weighting the bservations or some other means, of accurately portraying the ole of ships not dedicated to the U.S. trades but participating n them either regularly as part of multilateral movements or rregularly in tramp operations. A new typological system for hips might well be desirable, since many ships combining apabilities to carry different cargoes, defy conventional ategorization. A system for defining types of service, as well s types of ships, might also be desirable. Information athering procedures might need to be modified, and large uantities of historical data would have to be processed to test ut any new systems for deriving statistics and to establish a ase of historical information. Some of this work has already one on as a result of the Maritime Administration studies eferred to above and later database development work conducted y MARAD. Databases are in use internally at MARAD that make tatistical portraits of the development of the fleet serving the .S. foreign trade over a period of years much more feasible than hey were even a decade ago.

hen appropriate historical statistics are published by the ederal government--only the Government can publish them because nly the Government has the raw data--many private research rganizations are likely to step in to create the analyses and

BIBLIOGRAPHY

GENERAL INFORMATION

Abrahamsson, Bernhard J. International Ocean Shipping. Boulder, CO: Westview Press, Inc., 1980.

Ajaria, Shailendra J., et al. Developments in International Trade Policy. Washington, DC: International Monetary Fund, November 1982.

Alderton, Patrick M. Sea Transport: Operation and Economics. 2nd ed. London: Thomas Reed Publications Ltd., 1980.

An Assessment of Maritime Trade and Technology. Washington, DC: U.S. Congress, Office of Technology Assessment, OTA-0-220, October 1983.

Astle, W.E. Shipping and the Law. London: Fairplay Publications Ltd., 1984.

Beth, Hans Ludwig, et al. Twenty-five Years of World Shipping. London, England: Fairplay Publications Ltd., 1984.

Buffa, Elwood S. Meeting the Competitive Challenge. Homewood, IL: Dow Jones-Irwin, 1984.

Competition and Trade Policies, Their Interaction. Paris, France: Organisation for Economic Cooperation and Development, 1984.

Couper, Alastair, ed. The Times Atlas of the Oceans. New York, NY: Van Nostrand Reinhold Company, 1983.

Economic Report of the President. Washington, DC: Council of Economic Advisors, February 1984.

Greenwich Forum VI: World Shipping in the 1990s. Greenwich, England: Westbury House. Proceedings of a conference at the Royal Naval Conference, April 23-25, 1980.

Kendall, Lane C. The Business of Shipping. 4th ed. Centreville, MD: Cornell Maritime Press, 1983.

Morici, Peter. The Global Competitive Struggle: Challenges to the United States and Canada. Washington, DC: Canadian-American Committee, National Planning Association, 1984.

Nersesian, Roy L. Ships and Shipping. Tulsa, OK: PennWell Publishing Company, 1981.

Stanley, Timothy W., et al. U.S. Foreign Economic Strategies for the Eighties. Boulder, CO: Westview Press, Inc., 1982.

rewry, H.P., (Shipping Consultants) Ltd. Changes in 'Neo-Bulk' Trade, Transport and Handling. Economic Study No. 99. London, England: 1982.

________. The Chemical Carrier Trades. Economic Study No. 108. London, England: February 1983.

________. Independent Tanker Owners. Economic Study No. 78. London, England: November 1979.

________. Iron Ore Shipping and Trade Through to the 1980s. Economic Study No. 39. London, England: December 1975.

________. Ocean Transport of Timber and Forest Products. Economic Study No. 36. London, England.

________. Organisation and Structure of the Dry Bulk Shipping Industry. Economic Study No. 63. London, England: June 1978.

________. The Suez Canal and Its Impact on Tanker Trades and Economics. Economic Study No. 62. London, England: May 978.

________. U.S. Oil Imports, Policies, and Tanker Shipping. conomic Study No. 66. London, England: September 1978.

________. World LNG Trade and Shipping. Economic Study No. 42. London, England: April 1976.

. Rosenblatt & Son, Inc., Development of a Standardized U.S. Flag Dry-Bulk Carrier. Washington, DC: U.S. Dept. of Commerce, Maritime Administration, January 1979.

. Rosenblatt & Son, Inc. and H.P. Drewry (Shipping Consultants) Ltd. Development of a Standardized Dry-Bulk Carrier. Appendix A. Identification of Dry Bulk Commodities and Trades. Washington, DC: U.S. Dept. of Commerce, Maritime Administration, January 1979.

ESSELS AND VESSEL CHARACTERISTICS

aker, William A. Engine Powered Vessels. New York, NY: Grossett and Dunlap, 1965.

oyce, Jon, et al. Ro-Ro Ships and Their Market Role. London, England: Fairplay Publications Ltd., 1980.

orkhill, Michael. Chemical Tankers: The Ships and the Market. London, England: Fairplay Publications Ltd., 1976.

__________. Vessel Inventory Report. Washington, DC: selected years.

ORECASTS OF OCEAN SHIPPING AND MERCHANT FLEETS

Booz-Allen Applied Research Inc. Forecast of U.S. Oceanborne Trade in Dry Bulk Commodities. U.S. Dept. of Commerce, Maritime Administration, March 1969.

Data Resources, Inc. United States Oceanborne Foreign Trade Forecasts. U.S. Dept. of Transportation, Maritime Administration, March 1984.

Drewry, H.P. (Shipping Consultants) Ltd. Outlook for Ore-Bulk-Oil (OBO) Carriers in Oil and Dry Bulk Trades. Economic Study No. 97. London: October 1981.

Forecasting International, Ltd. Impact of the Future Merchant Fleet on Coast Guard Operating and Support Programs Over the Next 25 Years. U.S. Dept. of Transportation, U.S. Coast Guard, April 1981.

Litton Systems Inc. Oceanborne Shipping: Demand and Technology Forecast. U.S. Dept. of Transportation, Office of the Secretary, June 1968.

Marcus, Henry S., et al. "A Methodology for Forecasting the Fleets to Serve U.S. International Commercial Trade Until the Year 2000." Society of Naval Architects and Marine Engineers, Transactions, No. 11, 1976.

Temple, Barker & Sloane, Inc. Merchant Fleet Forecast of Vessels in U.S.-Foreign Trade. Final Report. U.S. Dept. of Commerce, Maritime Administration, May 1978.

__________. A Study of the Future Requirements for Ships That Will Be Engaged in the U.S. World Trade in Both the Short and Long Term. U.S. Dept. of Commerce, Maritime Administration, March 1976.

Wharton Econometric Forecasting Associates. Assessment of Maritime Trade and Technology. A report submitted to the Office of Technology Assessment in partial fulfillment of Contract No. 333-2040.0, March 1983.

GRICULTURE

ssues and Challenges for OECD Agriculture in the 1980s. Paris: Organisation for Economic Cooperation and Development, 1984.

ISTORICAL TRADE AND COMMODITY INFORMATION

P Statistical Review of World Energy. British Petroleum Company, June 1984.

isnyk, James A. The Ocean Shipping of Coal. Presented at Coal and Ports Seminar, American Association of Port Authorities, Feb. 16-19, 1981.

ational Coal Association. Coal Facts. Annual. Washington, DC: 1978-79.

.S. Dept. of Energy. Secretary's Annual Report to Congress. DOE/S-0010(83). Washington, DC: September 1983.

.S. Dept. of Energy, Energy Information Administration. Annual Energy Review. DOE/EIA-0384(82). Washington, DC: April 1983.

___________. Annual Report to Congress. DOE/EIA-0173(83). Washington DC: March 1984.

___________. Coal Data: A Reference. DOE/EIA-0064(80). Washington, DC: July 1980.

___________. Historical Overview of U.S. Coal Exports, 1973-1982. DOE/EIA-0413. Washington, DC: September 1983.

___________. International Energy Annual. DOE/EIA-0219(82). Washington, DC: September 1983.

___________. Petroleum Supply Annual. v.1. DOE/EIA-0340(83)/1. Washington, DC: June 1984.

___________. Petroleum Supply Monthly: March 1984. DOE/EIA-0109(84/03). Washington, DC: May 1984.

.S. Dept. of Interior, Bureau of Mines. Mineral Commodity Summaries. Annual. Washington, DC: 1984.

___________. Minerals Yearbook. Annual. v.1. Washington, DC: 1982.

.S. Dept. of Transportation, Maritime Administration. Containerized Cargo Statistics. Annual. Washington, DC: selected years.

APPENDIX A

TRADE ROUTE DISTANCES
(NAUTICAL MILES)

ADE ROUTE - O/D	ACTUAL DISTANCE	TBS BULK DISTANCE
R 1 U.S. ATLANTIC/EAST COAST S. AMERICA		4,500
NEW YORK - MONTEVIDEO	5,748	
BOSTON - RIO DE JANEIRO	4,718	
R 2 U.S. ATLANTIC/WEST COAST S. AMERICA		3,250
NEW YORK - VALPARAISO	4,631	
NEW YORK - BUENAVENTURA	2,370	
R 4 U.S. ATLANTIC/CARIBBEAN		1,750
NEW YORK - VERACRUZ	1,958	
R 5-7-8-9 U.S. NORTH ATLANTIC/WESTERN EUROPE		3,500
BOSTON - BORDEAUX	3,073	
NEW YORK - ROTTERDAM	3,572	
NEW YORK - BORDEAUX	3,241	
6 U.S. NORTH ATLANTIC/SCANDINAVIA AND BALTIC		
NEW YORK - GOTHENBURG	3,568	
R 10 U.S. NORTH ATLANTIC/MEDITERRANEAN		4,500
NEW YORK - LISBON	2,941	
R 11 U.S. SOUTH ATLANTIC/WESTERN EUROPE		3,500
PT. EVERGLADES - BORDEAUX	3,923	
NORFOLK - BORDEAUX	3,405	
R 12 U.S. ATLANTIC/FAR EAST		9,500
NEW YORK - KOBE	9,983	
PT. EVERGLADES - KOBE	9,228	
R 13 U.S. SOUTH ATLANTIC & GULF/MEDITERRANEAN		4,500
NEW ORLEANS - LISBON	4,362	
R 17 ATL., GULF, PAC./INDONESIA,MALAYSIA,SINGAPORE		10,250
NEW YORK - SINGAPORE	12,511	
PT. EVERGLADES - SINGAPORE	11,756	
NEW ORLEANS - SUNDA STRAIT	12,074	
MOBILE - SINGAPORE	13,349	
LOS ANGELES - SINGAPORE	7,669	
SEATTLE - SINGAPORE	7,062	

TR 41 U.S. ATLANTIC/WEST AFRICA		5,000
NEW YORK - LAGOS	4,870	
NEW YORK - MONROVIA	3,964	
TR 42 U.S. GULF/WEST AFRICA		5,750
NEW ORLEANS - LAGOS	5,754	
NEW ORLEANS - MONROVIA	4,851	
TR 51 U.S. ATLANTIC/SOUTH AND EAST AFRICA		7,500
NEW YORK - CAPE OF GOOD HOPE	6,814	
TR 52 U.S. GULF/SOUTH AND EAST AFRICA		8,000
NEW ORLEANS - CAPE OF GOOD HOPE	7,319	

APPENDIX B

NOMINAL FLEET FORECAST TABLES

ıis appendix presents further detail on the nominal fleet ›recast described in Chapter 4 and summarized in Table 4-7. The ıbles are Multiplan formats and show the nominal fleets broken ›wn by origin/destination. The format is explained below by ›otnote using an example from page B-2:

ANS-ATLANTIC[1]			31778[2]
,000 dwt ships			116[3]
		1975[4]	
SHIP SIZE[5]	TRIPS[6]	SHIPS	CAPACITY[7]
45000	11		0
35000	11		0
25000	11	35	9625
15000	11	50	8250
5000	11	275	15125
TOTAL		360	33000
error factor			0.95[8]
BALANCE		O.K.[9]	

---

[1] origin/destination route.

[2] trade inflated by the reciprocal of ship carrying ıpacity, which is assumed to be 45% of deadweight for general ırgo ships: trade (taken from Table 4-3) was 14.3 million tons; ,300 X (1/.45) = 14,300 X 2.222 = 31,778.

[3] number of notional 25,000 dwt ships required to carry rade in the route; corresponds to Table 4-6 in the text.

[4] year

[5] notional, in deadweight tons.

[6] round trips one ship can make in a year.

[7] in thousands of deadweight tons: e.g. 25000 X 11 X 35 = ,625,000.

[8] expresses the degree to which a difference is permitted etween trade and capacity; trade must be between 95% and 100% of apacity; this factor is introduced to permit use of integers in numerating the nominal fleet.

[9] Multiplan compares capacity and trade and calculates hether they are within the bounds permitted by the error factor.

DRY BULK CARRIERS

capacity as a percentage of deadweight 85%

TRANSPACIFIC

EAST ASIA/OCEANIA

	1975			1980			1985			1990			2000		
EAST ASIA/OCEANIA			54894			79094			103282			132125			184482
25,000 dwt ships			366			527			689			881			1230
SHIP SIZE	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY
125000	6	5	3750	6	20	15000	6	35	26250	6	55	41250	6	95	71250
70000	6	40	16800	6	65	27300	6	95	39900	6	115	48300	6	175	73500
35000	6	115	24150	6	120	25200	6	135	28350	6	145	30450	6	150	31500
15000	6	130	11700	6	135	12150	6	135	12150	6	145	13050	6	145	13050
TOTAL		290	56400		340	79650		400	106650		460	133050		565	189300
error factor			0.95			0.95			0.95			0.95			0.95
BALANCE		O.K.			O.K.			O.K.			O.K.			O.K.	

SOUTH ASIA

	1975			1980			1985			1990			2000		
SOUTH ASIA			31847			54176			70894			100327			201576
25,000 dwt ships			255			433			567			803			1613
SHIP SIZE	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY
125000	5	10	6250	5	30	18750	5	35	21875	5	60	37500	5	135	84375
70000	5	30	10500	5	55	19250	5	85	29750	5	105	36750	5	235	82250
35000	5	65	11375	5	65	11375	5	85	14875	5	115	20125	5	170	29750
15000	5	65	4875	5	65	4875	5	70	5250	5	85	6375	5	100	7500
TOTAL		170	33000		215	54250		275	71750		365	100750		640	203875
error factor			0.95			0.95			0.95			0.95			0.95
BALANCE		O.K.			O.K.			O.K.			O.K.			O.K.	

TRANS-ATLANTIC

	1975			1980			1985			1990			2000		
TRANS-ATLANTIC			117647			172647			195635			225873			313459
25,000 dwt ships			471			691			783			903			1254
SHIP SIZE	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY
125000	10	5	6250	10	10	12500	10	10	12500	10	25	31250	10	45	56250
70000	10	50	35000	10	95	66500	10	125	87500	10	135	94500	10	205	143500
35000	10	150	52500	10	190	66500	10	205	71750	10	205	71750	10	245	85750
15000	10	160	24000	10	185	27750	10	190	28500	10	195	29250	10	220	33000
TOTAL		365	117750		480	173250		530	200250		560	226750		715	318500
error factor			0.95			0.95			0.95			0.95			0.95
BALANCE		O.K.			O.K.			O.K.			O.K.			O.K.	

NORTH-SOUTH

	1975			1980			1985			1990			2000		
NORTH-SOUTH			33271			55624			67835			89362			154600
25,000 dwt ships			166			278			339			447			773
SHIP SIZE	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY	TRIP	SHIPS	CAPACITY
125000	8	0	0	8	5	5000	8	10	10000	8	15	15000	8	60	60000
70000	8	10	5600	8	15	8400	8	20	11200	8	45	25200	8	70	39200
35000	8	70	19600	8	115	32200	8	125	35000	8	135	37800	8	150	42000
15000	8	75	9000	8	100	12000	8	110	13200	8	110	13200	8	120	14400
TOTAL		155	34200		235	57600		265	69400		305	91200		400	155600
error factor			0.95			0.95			0.95			0.95			0.95
BALANCE		O.K.			O.K.			O.K.			O.K.			O.K.	

TOTAL

	1975		1980		1985		1990		2000	
	SHIPS	TOTAL DWT	SHIPS	TOTAL DWT	SHIPS	TOTAL DWT	SHIPS	TOTAL DWT	SHIPS	TOTAL DWT
125000	20	2500000	65	8125000	90	11250000	155	19375000	335	41875000
70000	130	9100000	230	16100000	325	22750000	400	28000000	685	47950000
35000	400	14000000	490	17150000	550	19250000	600	21000000	715	25025000
15000	430	6450000	485	7275000	505	7575000	535	8025000	585	8775000
GRAND TOTAL	980	32050000	1270	48650000	1470	60825000	1690	76400000	2320	123625000
AVG. SHIP		32704		38307		41378		45207		53287