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COST OF SHIPPING UNITED STATES GRAIN EXPORTS TO PRINCIPAL WORLD MARKETS

by

M. LeRoy Davis

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
MASTER OF SCIENCE

Major Subject: Agricultural Economics

Signatures have been redacted for privacy

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INTRODUCTION

The amount of heavy grain[1] exports from the United States to the world grain market is influenced by the cost of shipping grain by ocean vessels. Shipping costs and the pressure of increasing exports also affect the competition among the various exporting ports and producing areas.

For instance, before the opening of the St. Lawrence Seaway, exports of heavy grain from Great Lakes ports totaled 25.4 million bushels in 1958 (21). The competitive position of these ports was enhanced by the cost advantages brought about by the opening of the Seaway and as a result exports of heavy grains increased to 240 million bushels in 1966 (22).

Changes in transportation costs are an important factor in determining the routes over which grain should be shipped. This fact is demonstrated by the example of the Great Lakes ports before and after the opening of the St. Lawrence Seaway. The export routes determined by shipping costs, in turn, affect the routing of grain from the surplus producing areas of the United States to deficit regions throughout the world. Thus ocean transportation costs have an indirect effect on domestic routing of shipments and consequently on the geographic price surface for feed grains in the United States.

Since the cost of grain exports has an effect on domestic grain prices, it is desirable that grain be exported over an optimal shipping pattern. A least cost routing pattern for United States grain exports can be found with the help of the transportation model which will be explained in

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[1] Heavy grain: wheat, corn, sorghum grains, soybeans.

Chapter IV. However, before this technique can be used, it is necessary to determine the freight rates over each possible export route. Shipping rates from a port of origin to a port of destination cannot be found for all routes and those that are available do not lend themselves to analysis as can be seen from Table 1.

Purpose

Since using actual ocean freight rates does not give reliable data to use in determining an optimal shipping pattern for United States grain exports, the purpose of this thesis will be to determine the cost per ton shipping grain for three bulk grain vessel sizes from United States ports of origin to specific ports of destination. These cost data will then be used in a transportation model to determine a least-cost shipping pattern for United States grain exports. The amount available for export from each area will be estimated from 1966 United States grain exports. Likewise the distribution of exports among deficit areas of the world will be based on the 1966 experience. This will test the cost data estimated in the thesis and will also give the total outlay for transportation of United States grain into the world markets if it is transported at least cost and under the specific assumptions of the model.

In addition to estimating the cost per ton of grain shipments, the objectives of this thesis will be to analyze heavy grain shipments for the years 1958 and 1966, determine the types of costs involved in shipping grain, and develop background information concerning grain shipments, such as the types and sizes of ships used.

Table 1. Shipments from United States gulf ports, 1967[a]

		10,000 DWT[b]		20,000 DWT[b]		30,000 DWT[b]	
		Bombay	West Coast India	Bombay	West Coast India	Bombay	West Coast India
January	Foreign	9.80[c]	12.46	9.80			
	U. S.	29.74	29.60	29.50		29.00	
February	Foreign	9.10	11.40	8.40			
	U. S.	29.70		29.50			
			10.99	8.05			
March	Foreign	8.05	12.42	8.36			
	U. S.	29.70		29.70			
				29.25			
April	Foreign	8.40	13.65	8.40			
	U. S.	27.95		28.60			
			8.57				
May	Foreign	8.57	13.93	7.75		9.45	10.43
	U. S.	29.40		28.60		28.50	
June	Foreign		13.86				
	U. S.	29.40		28.00			
			14.70				
July	Foreign		16.10				
	U. S.	29.74		29.74			
August	Foreign	15.40	16.10				
	U. S.	29.74					
September	Foreign	18.55					
	U. S.						

[a] Maritime Research, Inc. (13).

[b] Deadweight tonnage.

[c] All rates are in dollars per ton.

Table 1 (Continued)

		10,000 DWT[b]		20,000 DWT[b]		30,000 DWT[b]	
		Bombay	West Coast India	Bombay	West Coast India	Bombay	West Coast India
October	Foreign	17.15	16.59	15.40			
	U. S.	33.24		29.74		29.74	
November	Foreign						
	U. S.						
				15.60			
December	Foreign	15.60	18.60	30.39			

Method

In order to determine the cost per ton of shipping grain between a port of origin and a port of destination a cost analysis of three vessel sizes was conducted. Total cost of owning and operating a vessel was classed as (1) vessel ownership expenses, (2) at-sea-expenses, and (3) port expenses. The economic-engineering approach was used to estimate costs for each of these categories. These costs plus profit should reflect average shipping rates (12).

Since shipping of grain from the United States is divided into two markets (9), two cost figures were calculated for each vessel size: one market is composed of United States-flag vessels competing with each other for the fifty percent of Government-sponsored grain cargoes which is guaranteed them by the Cargo Preference Act of 1954; the other market is made up of foreign flag vessels competing for private grain shipments and the remaining portion of United States Government sponsored grain cargoes. The

cost of shipping on United States-flag vessels is enough higher than the cost of shipping on foreign flag vessels that no direct competition exists between the two markets. Table 1 shows the cost of United States-flag shipments compared to foreign flag shipments.

The analysis of grain shipments was based on data obtained from unpublished Foreign Trade Statistics reports, SA705/705IT (21, 22). The following information for each shipment was collected: (1) United States Port Region, (2) United States port of origin, (3) country of destination, (4) commodity, (5) number of bushels, (6) dollar value, and (7) ship type. This data is analyzed in Chapter II.

The author corresponded with grain exporters, port authorities and the Maritime Administration to obtain information on the technology of grain shipping and cost of grain shipping. In addition, a publication by the National Research Council, "Maritime Transportation of United Cargo--A Comparative Economic Analysis of Break Bulk and United Load Systems" (14) and another by Harry Benford, "The Practical Application of Economics to Merchant Ship Design" (1) furnished useful information on shipping costs. These two articles were also used as the main sources of information for estimating shipping costs in Chapter III.

BACKGROUND INFORMATION

United States Grain Exports

In 1958 before the opening of the St. Lawrence Seaway, the United States exported 643 million bushels of heavy grain with a value of $1.05 billion (21). Since 1961, the value of exports of heavy grain have averaged over $2 billion annually (9). Exports of heavy grain totaled 1.9 billion bushels for a value of $3.5 billion in 1966 (22). Table 2 indicates the magnitude of United States exports of selected grains.

Of the 643 million bushels of heavy grain exported in 1958, 51.2 percent was wheat, 24.8 percent corn, 11.4 percent sorghum grain, and 12.6 percent soybeans. Wheat accounted for 43.7 percent, corn 28.4 percent, sorghum grain 15.1 percent, and soybeans 12.8 percent of the 1966 grain exports. The number of bushels and the percentages of shipments of wheat, corn, grain sorghums and soybeans for 1958 and 1966 are listed in Table 3.

Grain is exported in three vessel types: liners, tankers, and tramps. Tramp ships carried 71.6 percent of the heavy grain exports from the United States in 1958, and 80.0 percent in 1966. Table 4 lists the number of bushels exported by each vessel type for 1958 and 1966.

Reviewing ports

Exports from the United States originate in four port regions: the Atlantic Coast, the Gulf, the Pacific, and Great Lakes ports. During 1958, 140.6 million bushels were exported from the Atlantic Coast Ports. Exports from these same ports increased to 180 million bushels during 1966. Wheat accounted for 104.6 million bushels and corn 60 million bushels. The major ports were Baltimore, Norfolk, and Philadelphia. These three ports

Table 2. United States exports: quantity of selected agricultural commodities, 1952-1966[a]

Year	Barley grain	Oats grain	Corn grain[b]	Grain Sorghums	Feed grains and products (grain equiv.)[b]	Wheat Grain	Wheat and grain equiva. of flour[bc]	Soybeans
1952	36,026[d]	1,415[d]	99,988[d]	48,367[d]	5,313[e]	4,480[d]	410,922[d]	223,028[d]
1953	17,284	1,214	131,383	10,832	4,663	4	270,810	41,606
1954	21,538	991	76,836	17,250	3,437	1,075	231,253	43,547
1955	71,948	24,171	108,110	62,417	7,148	5,327	272,378	67,843
1956	82,367	31,402	117,707	55,272	7,672	10,656	471,697	69,372
1957	55,903	19,549	178,914	22,287	7,839	6,236	495,408	87,961
1958	120,425	24,679	180,619	73,794	10,930	7,289	412,895	84,333
1959	113,352	45,615	220,554	101,849	13,001	5,406	444,332	122,675
1960	90,655	32,330	222,767	96,750	12,175	4,882	602,108	148,088
1961	62,805	17,540	293,578	64,687	12,358	8,617	729,661	133,532
1962	96,943	27,969	427,141	109,958	18,171	15,583	629,587	160,878
1963	54,542	9,665	438,763	116,086	17,518	14,546	744,111	174,703
1964	71,780	3,905	479,572	100,264	18,653	5,649	852,311	209,507
1965	63,790	23,585	596,750	172,346	23,959	2,315	719,779	227,660
1966	60,965	28,760	612,121	291,146	27,776	4,237	901,102	245,723

[a]Source: U. S. Department of Agriculture (20).

[b]Includes food exports for relief or charity.

[c]Excludes foreign wheat milled in bond for export.

[d]Thousands of bushels.

[e]Thousands of short tons.

Table 3. Shipments by commodity type from the United States[a]

Commodity	1958		1966	
	Bushels	Percent	Bushels	Percent
Wheat	328,968,405	51.2	851,729,819	43.7
Corn	159,515,699	24.8	553,811,092	28.4
Sorghum	73,564,885	11.4	292,943,766	15.1
Soybeans	81,184,638	12.6	246,830,738	12.8

[a]U. S. Department of Commerce (21, 22).

Table 4. Shipments by type of transportation[a]

Vessel Type	1958		1966	
	Bushels	Percent	Bushels	Percent
Liner	141,679,942	22.1	99,919,920	5.1
Tanker	40,749,646	6.3	278,897,649	14.3
Tramp	460,804,039	71.6	1,566,497,846	80.6

[a]U. S. Department of Commerce (21, 22).

accounted for more than 75 percent of all grain exports from the Atlantic Coast in 1966.

Shipments from the Gulf Coast amount to more than the other three port regions combined. There were 382 million bushels of heavy grains exported from the Gulf in 1958. By 1966 this volume had grown to 1.3 billion bushels. Wheat amounted to 38.7 percent of the export total in 1966; corn, 28.3 percent; sorghum grain, 19.5 percent; and soybeans, 13.5 percent. The major ports are New Orleans, Destrehan, and Houston. These three ports exported 682 million bushels of heavy grain during 1966.

The Pacific Coast ports exported 95 million bushels of heavy grain in 1958. Wheat grown in Oregon and Washington accounted for 88.6 million bushels of this total. In 1966, Pacific ports exported 240.6 million bushels of heavy grain. Wheat from the Pacific Northwest was still the major export grain, accounting for 197.5 million bushels or 82 percent of the total exports from this region. Sorghum grain from Southern California was the second most important heavy grain export for the region, accounting for 41.8 million bushels. The major Pacific Coast ports are Long Beach, Portland, and Seattle.

Ports in the Great Lakes region exported only 25.4 million bushels of heavy grains in 1958. Corn and soybeans accounted for almost 100 percent of the total exports. However, with the opening of the St. Lawrence Seaway in 1959, the Great Lakes ports became an important grain exporting region. Over 240 million bushels of heavy grain were exported from these ports in 1966. This was a tenfold increase over the 1958 volume. Corn was the major grain exported, amounting to 54 percent of the total. Soybean exports accounted for 24.3 percent of the total and wheat 21.7 percent. Exports of

sorghum grain were insignificant.

Reviewing areas

The United States exported heavy grain to 124 foreign countries in 1966. For analysis purposes, these countries have been grouped into fourteen regions: Canada, Central America and the Caribbean Area, Western South America, Eastern South America, Northwestern and Central Europe, Northeastern and Southern Europe, Western Asia, Eastern Asia, Southern and Southeastern Asia, Australia and Oceania, North Africa, Western Africa, Eastern Africa, and Southern Africa.

Northwestern and Central European countries imported 28.1 percent of United States heavy grain exports. Next in importance was Southern and Southeastern Asia accounting for 18.5 percent of the total. India imported 302.6 million bushels out of a total of 359 million bushels for this area. Of the 302.6 million bushels, 209 million was wheat and 78.3 million was soybeans.

Eastern Asian countries imported 346.8 million bushels or 17.8 percent of the total. Japan imported 312.4 million bushels, which was the largest volume imported by any one country.

Northeastern and Southern Europe imported 287.7 million bushels or 14.8 percent of the total shipped from the United States in 1966. Spain, Italy, and Yugoslavia accounted for 83 percent of the heavy grain imports in the region. Table 5 lists the volume of heavy grain imported by each region and the percent of the total. There are complete tables in Appendix A listing each country and the volume of each grain imported. There are similar tables in Appendix B for the port regions in the United States listing each port and the number of bushels of each commodity exported for 1958

Table 5. Imports of heavy grains by world regions: 1966[a]

Region	Wheat	Corn	Sorghum grains	Soybeans	Total
Canada	19,472,831[b]	55,871,472	1,385,659	25,971,392	102,701,354
Central American and the Caribbean	8,764,723	3,260,609	303,976	334	13,067,441
Western South America	32,222,532	1,949,968	378,449	44,351	34,595,300
Eastern South America	62,321,338	1,214,008	447,862	1,099,596	65,082,804
Northwestern and Central Europe	103,472,295	242,383,920	98,760,043	101,920,431	546,536,689
Northeastern and Southern Europe	109,311,734	134,785,794	11,592,051	32,018,666	287,708,245
Western Asia	27,763,465	10,359,226	16,324,387	10,206,789	64,653,867
Eastern Asia	110,620,761	78,114,567	83,330,326	74,770,884	346,836,536
Southern and Southeast Asia	209,227,079	11,004,182	78,317,539	697,037	359,245,837
Australia and Oceania	0	32,482	0	20,016	52,498
North Africa	58,592,402	668,098	25,138	0	83,295,977
Western Africa	7,633,628	3,523,195	1,778,637	81,242	13,016,702
Eastern Africa	1,885,724	4,707,036	182,631	0	6,775,391
Southern Africa	15,693,168	5,936,537	117,068	0	21,746,773

[a]Source: U. S. Department of Commerce (21, 22).

[b]All amounts are in bushels.

Table 6. U. S. grain exports under government financed programs, including PL 480 and A.I.D. shipments[a]

Commodity	1958	1966
Wheat	239,357[b]	462,213[b]
Corn	47,227	41,020
Grain sorghum	17,437	94,928
Soybeans	5,664	37
Totals	309,685	598,198

[a]Source: U. S. Department of Agriculture (19).

[b]All amounts are in thousands of bushels.

and 1966 (21, 22).

Government sponsored grain shipments

United States exports of heavy grain under government sponsored programs totaled 309.685 million bushels in 1958 and 598.198 during 1966. The percent of the total grain exports under Government sponsorship was 48 in 1958 and 31 in 1966. The number of bushels of each of the four grains exported under Government programs is listed in Table 6. Table 7 lists the principal countries of destination for Government financed agricultural exports and the value of the shipments to these countries. The totals listed in Table 7 include United States agricultural exports under P.L. 480 and Mutual Security A.I.D. programs.

Shipping Costs

To determine the actual cost of shipments, it is necessary to consider

Table 7. Principal countries of destination for PL 480 and A.I.D. exports, 1966[a]

Country	Millions of dollars	Rank
India	546	1
South Viet Nam	122	2
Yugoslavia	93	3
Brazil	90	4
Egypt	62	5
Korea	52	6
Pakistan	50	7
Israel	35	8
Morocco	34	9
Formosa	33	10
Chile	32	11
Turkey	29	12
Indonesia	25	13
Colombia	21	14
Peru	19	15
United Kingdom	18	16
Greece	17	
Tunisia	17	
Congo	13	
West Germany	12	
Phillippines	11	
Japan	10	
Spain	7	
Poland	7	
Italy	2	
Netherlands	1	

[a]Source: U. S. Department of Agriculture (19).

all items of expense incurred by a ship which are required for its efficient operation in accordance with existing regulations and agreements such as U. S. Coast Guard Rules and Regulations for Bulk Grain Cargoes and Chapter VI of the Safety of Life at Sea Convention of 1960. Some of these items of expense are basic to the operation of all ships, regardless of the nationality of their flag and crew, and are determining factors in whether a ship can operate at a profit.

The major costs incurred in operating a ship are depreciation and interest, wages of officers and crew, maintenance and repair, insurance, and fuel. In determining cost of operation, consideration must also be given to ship design and speed. This is an indication as to the carrying capacity, speed, economy of operation, ease of loading and discharging, and crew requirement. In addition, costs per unit of cargo are affected by whether a ship carried a full or partial load of grain and the ultimate destination of shipment.[1]

Port Costs

Port location, facilities, and regulations also affect shipping costs. Access to some ports is difficult because they are located up rivers or because the vessel must traverse dangerous channels during restricted hours. The availability of docks, equipment, berths, labor and other facilities involved in port operations affects the costs incurred in connection with the receipt and delivery of cargo. Port regulations that permit a ship to

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[1] Winter, A. C. Maritime Administration, U. S. Dept. of Commerce, New York, New York. Data on shipping costs. Private communication. 1968.

enter or clear at all hours facilitate handling a vessel and thereby contribute to economy of operation.

There are certain basic and uniform charges, applicable in most domestic and foreign ports, which must also be considered in determining cost of shipping grain. Some of these are pilotage, towage, running lines, dockage, harbor dues, port fees, quarantine, customs, watchmen, water supply, bunkers, fuel oil, grain fittings, stevedore charges, labor handling equipment, surveyor's fees, agency fees, ship brokers fees, custom house brokers fees, freight brokers fees, warfage, handling, storage, grain elevator, lighterage,[1] weighing, and dunnage.[2]

The days a ship spends in port has a large effect on the total cost of the voyage. There is no standard number of days that a particular type of bulk grain vessel spends in a particular port. The variables involved in each individual loading are numerous; where a 50,000 DWT[3] vessel might load in six days, another identical ship could conceivably require twice that amount of time. This is understandable when the following factors are considered:[4]

1. A vessel's arrival in port does not necessarily mean that the ship is ready to receive the cargo or that the elevator is ready to deliver the grain to the vessel. By the

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[1]Lighterage: the loading or unloading of a ship, or transportation of goods, by means of a barge whenever shallow water prevents the ship from coming in to the shore.

[2]Dunnage: packing sacked grain on the loose cargo to prevent it from shifting.

[3]Deadweight tonnage.

[4]Levering, Leonard M., Jr. Maryland Port Authority, Baltimore, Maryland. Information on ships in port. Private communication. 1968.

same token, a vessel that has finished loading can conceivably remain in port for several days awaiting final sailing orders.

2. Time required for ship's cleaning and sealing prior to tendering notice of readiness.

3. Is the vessel to be loaded a tanker or a dry bulk vessel and is it self-trimming?

4. Availability of a berth at the elevator and prevailing weather conditions during loading period.

5. Elevator loading capacity and extent of elevator down time. Availability of grain in the elevator and/or rail cars affects loading time as does the type of grain being loaded.

6. Seasonality of grain harvest also affects time in port. For instance, grain shipments at Norfolk, Virginia, are seasonal and geared to harvest and choking off of mid-western grain when the Great Lakes and St. Lawrence are open for navigation. In the busy season, September to April, there is an average wait of two days for a berth.[1]

The time in port is made up of about one day for passing customs and quarantine, inspection of grain holds for suitability of loading and moving to and from berth. One to two days are spent waiting for a berth to become available and one to two days are needed to load. For example, a 15,000 ton vessel entering port at Norfolk, Virginia, requires one day for inspections, certifications, and movement, two days to load and in peak season, two days waiting for a berth to become available. Average days spent in port in major United States ports and principal foreign ports and the maximum draft of these ports are shown in Tables 8 and 9.

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[1]Melton, Arthur W. Export Forwarder, Cargill Grain Division, Chesapeake, Virginia. Information on ships in port. Private communication. 1968.

Table 8. Average Days in port to load by vessel size at principle United States grain ports[a]

Port	Draft[b]	Days in port loading		
		15,000 DWT vessel	30,000 DWT vessel	55,000 DWT vessel
Seattle	55	5	7	10
Portland	35	5	7	X[c]
Stockton	30	7	9	X
Los Angeles	55	7	10	15
Corpus Christi	36	4	7	X
Galveston	34½	4	7	X
Houston	40	4	5	7
Nola	40	4	5	7
Mobile	39	5	7	10
Charleston	35	5	7	X
Norfolk	34	5	7	X
Baltimore	35	5	7	X
Philadelphia	33	5	7	X
Albany	27	5	X	X
Chicago	26½	5	X	X
Duluth	26½	5	X	X
Toledo	26½	5	X	X

[a]Source: Cohee, George, Jr. Vice President, Algofaros Maritime Inc., New York, New York. Information on days in port. Private communication. 1968.

[b]Draft is measured in feet.

[c]"X" means that this size vessel cannot be loaded because of draft restrictions.

Table 9. Days at discharge in major grain port of country indicated[a]

Port	Draft[b]	Days at discharge		
		15,000 DWT vessel	30,000 DWT vessel	55,000 DWT vessel
Chile	30	10	20	X[c]
Peru	32	8	15	X
Brazil	30	10	20	X
Panama	41	15	25	55
Venezuela	30	13	25	X
Haiti	38	15	25	50
Japan	37	8	15	X
Philippines	30	15	25	50
Australia	40	5	12	20
W. C. India[d]	35	14	25	X
E. C. India[e]	30	14	X	X
South Africa	35	7	10	X
Kenya	32	12	25	X
Nigeria	27	15	X	X

[a]Source: Cohee, George, Jr. Vice President, Algofaros Maritime Inc., New York, New York. Information on days in port. Private communication. 1968.

[b]Draft is measured in feet.

[c]"X" indicates that this size vessel cannot be loaded because of draft restrictions.

[d]"W. C." is an abbreviation for West Coast.

[e]"E. C." is an abbreviation for East Coast.

Table 9 (Continued)

Port	Draft[b]	Days at discharge: 15,000 DWT vessel	30,000 DWT vessel	55,000 DWT vessel
Italy	32	10	15	X
United Kingdom	32	7	10	X
Netherlands	60	3	5	5
Belgium	40	5	7	7
Germany	40	5	7	7
Norway	33	5	10	X

U. S. Flag vs. Foreign Flag

Another factor affecting the cost of exporting grain from the United States is whether the ship flys a foreign or a United States flag. The Cargo Preference Act of 1954 (68 Stat. 832) requires that at least fifty percent of Government sponsored shipments be made on United States flag ships. United States flag vessels have much higher costs of operation due mainly to higher crew requirements and wage rates than do foreign flag vessels. Therefore, fifty percent of Public Law 480 grain exports must be transported at a higher cost than would be necessary if minimum cost was the overriding objective.

Grain Transportation Vessels

Grain is exported on three types of ships: cargo liners, tankers, and tramp vessels.

Liners

Cargo liners accounted for 22.1 percent of the United States heavy grain exports in 1958 but only five percent of the heavy grain exports in 1966 (21, 22). Shipments of heavy grain on liners have not been significant in past years since these ships have freight rates that are not competitive with other types of grain carrying vessels.

Cargo liners publish rates for manufactured goods and for small quantities of bulk commodities. Their rates for large quantities of bulk commodities are termed open rates and are determined by negotiation between the ship owners and prospective shippers. These carriers usually offer a scheduled service, called berth or liner service, with regular ports-of-call; the bulk commodities which they carry are known as liner parcels.

Tankers

Tankers accounted for only 6.3 percent of United States heavy grain exports in 1958 whereas fifteen percent of grain exports in 1966 were transported in tankers (21, 22). Tankers engaged in the carriage of bulk grain must meet requirements of the United States Coast Guard and National Cargo Bureau, Incorporated before grain can be loaded (6).

Tankers are usually much larger than typical grain carrying vessels and thus take advantage of economies of large scale. Economies of increasing ship size rest on three principles (4):

1. As cargo capacity is increased, the capital outlay per ton of payload decreases. This is accompanied by a proportionate reduction in ton per mile costs for insurance on hull and machinery and in the reserves which must be provided out of freight earnings to cover depreciation and capital charges.

2. Management and operational charges per ton of cargo capacity do not increase proportionately to increases in

ship size.

3. At constant speeds, fuel costs per ton per mile decline as ship tonnage is increased.

The advantages of tankers are minimized and may even be entirely offset by excessive turn-around times in loading and/or discharging (2). Most ports importing grain have an unloading capacity of only 1000 tons per day (23). Under these conditions a 100,000 ton tanker would be compelled to spend three months in port to unload. Ports must also be able to offer safe deep water anchorage for the big ships. A "Liberty" size vessel requires twenty nine feet draft; a 100,000 ton vessel needs fifty feet draft; and a 500,000 ton ship will draw about ninety feet (4).

These big bulk carriers will become important in the exporting of grain only when ports can offer high discharge rates and safe deep water anchorage.

Tramps

Ocean carriers offering irregular service with no fixed ports-of-call are known as tramp steamers, or tramps. Bulk commodities such as grain, coal, and fertilizers, are their chief cargoes. Their rates are determined by negotiations between the shipper and the carrier, with a shipbroker usually serving as an intermediary. The agreement that stems from these negotiations is referred to as a charter party.

Tramp vessels accounted for 71.6 percent of the heavy grain exports from the United States in 1958 and 80 percent during 1966. Grain charterings on tramp ships averaged forty-five million tons a year in 1963 to 1964. In 1966 the total was forty-seven million tons, accounting for 58 percent by volume of the total of all classes of cargo for which bookings were made

on the tramp market (9).

Chartering Grain Cargo Vessels

When cargoes are suited to shipload lots, the entire capacity of the ship is furnished under a charter party, or as the document is more generally called, a charter. Charters are contracts for the use of an entire vessel or of its cargo-carrying capacity. There are three forms of charters in general use. They are demise (bareboat) charters, time charters, and voyage charters. The three forms have essential differences as stated below (12).

A demise or bareboat charter is a contract for the use of a bare boat, and the charterer is required to supply the crew, stores and supplies, and to perform functions normally performed by the owner.

A time charter is a contract for the use of the cargo-carrying space in a vessel over a specified period of time. The shipowner pays expenses incident to the operation of the vessel, e.g., wages, insurance, and food, while the charterer is responsible for fuel and expenses connected with the cargo.

As its name implies, a voyage charter, the most frequently used, is a contract for the carriage of cargo not for a period of time but at a stipulated rate per ton, on one voyage between two ports on a fixed range of ports. The charterer assumes no responsibility whatever for the navigation of the vessel or the custody or safety of the cargo. Bulk cargoes are usually carried under this type of contract.

Customary procedure in the chartering of ocean grain freight is to fix the charter on the basis of "free discharge" or "free-in and out". The

expression "free discharge" means that the cargo will be unloaded at destination free of expense to the shipowners. The expression "free-in and out" means that stevedore charges at both loading point and discharge point will be paid by the charterer rather than the shipowner.

ESTIMATION OF SHIPPING COST

Measurement of Volume and Cost

The relationship that exists between volume and cost can be measured in two ways. One method is the statistical approach. When a problem is analyzed statistically, a relatively large number of observations are needed. This is because the larger the number of degrees of freedom the more reliable are the results. In a statistical analysis the input data are taken as observed and a production function is computed by the use of regression techniques and its coefficients subjected to a test of significance and by establishing confidence limits.

Another method is the engineering approach. In the application of this method, the input values are determined by use of engineering data. These engineering data are used in constructing hypothetical, but not necessarily average plants (an ocean vessel in this case). These hypothetical plants are constructed for various volume ranges, and at each volume the hypothetical plant is considered to have an optimum combination of inputs.

Cost relationships were estimated for this study using the economic-engineering approach described above. The vessels simulated in this thesis have been selected to be as similar to grain transportation vessels in use for each size and flag as was possible from available data.

Assumptions

The costs of transporting heavy grain was calculated for three vessel sizes. The cost of operation under both the United States flag and under a foreign flag of convenience was estimated for each of the ship sizes. This

was necessary because of the large difference in cost of operation between the two and because of the necessity of shipping fifty percent of United States government sponsored grain shipments on United States-flag vessels. Fixed and variable costs were calculated for each ship on the basis of the following assumptions:

1. The three vessel sizes studied are a 15,000 DWT vessel, a 30,000 DWT ship, and an 80,000 DWT bulker. The 15,000 DWT ship was chosen since this size may be "ideal" for the tramp of the future. Many shipbuilders are now constructing ships of this size to replace the "Liberty" ships built during World War II (16). The two larger ship sizes were studied because they are representative of the larger bulk carriers and tankers being used in the transportation of grain (10, 11).
2. The vessels are chartered on the basis of "free-in and out." This means that stevedore charges are paid by the charterer and are not included in the expenses of the shipowner.
3. The 15,000 DWT ship utilizes 90 percent of available cargo space outbound and can obtain 60 percent of a normal full load on the return trip (14). The two larger vessels utilize 95 percent of cargo space outbound and can obtain 60 percent of a full load on the return voyage.[1]

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[1] Finlayson, John. Cooke and Company, Grain Division, Memphis, Tenn. Data on shipping costs. Private communication. 1968.

4. Return on investment was assumed to be twelve percent after taxes on the valuation of the ship (averaged over the last three years).[1] The ships were assumed to have a twenty year life and a mean age of ten years.

5. United States flag ships will be constructed without the aid of the construction differential subsidy. Although under the 1936 Maritime Administration Act, Construction Differential Subsidy (C.D.S.) may be granted to any vessel that is to be used in the foreign commerce of the United States, C.D.S. has not been available for the construction of bulk carriers. If funds were appropriated and available, the amount of subsidy would represent the difference in the actual United States price and the estimated price in a low cost shipbuilding center such as Japan. The subsidy is presently limited however to a maximum of 55 percent of construction cost.[2]

6. The ships will be constructed solely with borrowed capital. Capital can be obtained at seven percent interest.[3]

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[1] Dulick, J. M. Acting Maritime Administrator, Maritime Administration, U. S. Dept. of Commerce, Washington, D. C. Data on shipping costs. Private communication. 1968.

[2] McGowan, John J. Chief, Division of Estimates, Office of Ship Construction, Maritime Administration, U. S. Dept. of Commerce, Washington, D. C. Data on shipping costs. Private communication. 1968.

[3] McGowan, John J. Chief, Division of Estimates, Office of Ship Construction, Maritime Administration, U. S. Dept. of Commerce, Washington, D. C. Data on shipping costs. Private communication. 1968.

7. Each ship spends 350 voyage days per year in commercial operation with an expected fifteen days per year required for vessel lay-up and repairs (14).
8. Each of the three ship sizes will spend the number of days in port loading and unloading as given in Tables 8 and 9 of Chapter II.
9. Physical characteristics of each ship size are listed in Table 10. The same characteristics are assumed for United States-flag vessels and foreign flag vessels except where differences are indicated.
10. The formulas and cost items used in the calculations are based on information contained in "Maritime Transportation of Unified Cargo--A Comparative Economic Analysis of Break-Bulk and Unified Load Systems" (14), and in a publication by Harry Benford titled "The Practical Application of Economics to Merchant Ship Design" (1). These two independent studies showed similar results when the various cost items were calculated. When there was a difference, Benford's publication (1) was used as the more accurate source since it was the most current source available.

The Model

Costs of owning and operating a vessel can be classed under the following categories:

1. Vessel ownership expenses

Table 10. Characteristics of bulk grain vessels by flag and size

Flag	U. S.	Foreign	U. S.	Foreign	U. S.	Foreign
Deadweight, Long Tons	15,000	15,000	30,000	30,000	80,000	80,000
Total construction cost	$10.0 mil.[a]	$3.4 mil.[a]	$13.0 mil.[a]	$4.5 mil.[b]	$23.0 mil.[a]	$8.5 mil.[b]
Shaft horsepower	8600[c]	7500[b]	13,500[c]	11,000[b]	23,000[c]	20,500[b]
Crew and officer complement	35[c]	30[b]	35[c]	30[b]	35[c]	30[b]
Speed at sea (in knots)	14[d]	14[d]	15[c]	15[b]	15[c]	15[b]
Fuel consumption at sea	.39 #/shp/hr.[c]	29.5 L.T./day[b]	.38 #/shp/hr.[c]	42 L.T./day[b]	.37 #/shp/hr.[c]	62.5 L.T./day[b]
Fuel consumption in port	1.5 L.T./day[b]	1.5 L.T./day[b]	2 L.T./day[b]	2 L.T./day[b]	2.5 L.T./day[b]	2.5 L.T./day[b]

[a] McGowan, John M. Chief, Division of Estimates, Office of Ship Construction, Maritime Administration, U. S. Dept. of Commerce. Data on grain ship characteristics. Private communication. 1968.

[b] Asimakopulos, Nicholas J. Greenwich Marine, Inc., New York, New York. Data on grain vessel characteristics. Private communication. 1968.

[c] Lowry, Robert. Chief, Division of Production, Office of Ship Construction, Maritime Administration, U. S. Dept. of Commerce. Data on grain vessel characteristics. Private communication. 1968.

[d] National Academy of Sciences-National Research Council (14).

Table 10 (Continued)

Flag	U. S.	Foreign	U. S.	Foreign	U. S.	Foreign
Deadweight, Long Tons	15,000	15,000	30,000	30,000	80,000	80,000
Cubic number	15,400[d]	15,400[d]	24,900[e]	24,900[e]	65,500[e]	65,500[e]
Power	diesel	diesel	diesel	diesel	diesel	diesel
Grain capacity, tons	13,500	13,500	28,500	28,500	76,000	76,000

NOTE: When more than one source was available for the characteristics listed, an approximate average was used.

[e]Mack-Forlist, D. M. and R. Hettena (11).

2. At-sea expenses

3. Port expenses

Vessel ownership expenses

Expenses included in this category are depreciation and interest, crew wages, insurance, maintenance, stores and supplies, subsistence, in-port fuel, administration and miscellaneous expenses.

Depreciation and interest This item is composed of depreciation and interest expenses. The assumptions necessary to calculate the annual expense are:

1. Vessel life (new construction) = 20 years.
2. Scrap value at the end of the twenty year period = 2.5 percent of total construction cost.
3. "Straight-line" method of depreciation is used, i.e., the ship is depreciated in equal amounts over its assumed twenty year life.
4. Seven percent interest is payable annually on the undepreciated investment of the vessel.

The value to be depreciated can be expressed as

$$\text{Value to be depreciated} = (100\% - 2.5\%)(\text{T.C.C.}).^{1}$$

Average depreciation expense in dollars per voyage day can then be expressed as

$$\text{Average depreciation expense} = \frac{\text{Value to be depreciated}}{(20 \text{ years})(350 \text{ voyage days/year})}$$

$$= \frac{(.975)(\text{T.C.C.})}{7000}$$

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[1] T.C.C. refers to Total Construction Cost.

The calculations for interest are as follows:

Interest payment, first year = (0.07)(T.C.C.)

Interest payment, twentieth year = $(0.07)\left(\frac{\text{T.C.C.}}{20}\right)$

Average annual interest payment

$$= \left[\left(.07 + \frac{.07}{20}\right) / 2\right] \left[(\text{T.C.C.})\right]$$

$$= \left[\frac{(.07 + .0035)}{2}\right] \left[(\text{T.C.C.})\right]$$

$$= (0.0367)(\text{T.C.C.})$$

Then the average interest expense per voyage day can be calculated as follows:

Average interest expense per voyage day

$$= \frac{(.0367)(\text{T.C.C.})}{350 \text{ voyage days/year}}$$

$$= (0.000105)(\text{T.C.C.})$$

Average annual depreciation and interest expense per voyage day can then be summed as follows:

Total Amortization = Depreciation plus Interest

Amortization expense per voyage day

$$= \left(\frac{0.975}{7000} + 0.000105\right)(\text{T.C.C.})$$

$$= (0.000139 + 0.000105)(\text{T.C.C.})$$

$$= (0.000244)(\text{T.C.C.})$$

Depreciation and interest expenses calculated from the above relationship are listed in Table 11 for each of the three ship sizes and by foreign flag and United States flag.

Table 11. Depreciation and interest expense by vessel size and flag

Size	15,000 DWT		30,000 DWT		80,000 DWT	
Flag	U. S.	Foreign	U. S.	Foreign	U. S.	Foreign
Expense[a]	$2440	$830	$3172	$1098	$5612	$2074

[a]Dollars per voyage day.

Crew wages Total crew wages include straight-time, overtime, premium pay, and seafaring fringe benefits, e.g., welfare, pension, employment security, and vacation payments. The average annual crew cost for a United States-flag ship, including benefits, is about $12,500 per crew member at the present time (1). Wages on a foreign flag vessel are approximately 25 percent of comparable United States wage levels (1). Therefore, the average annual crew expense would be $3,125 per crew member for a foreign flag vessel. Total crew expense per voyage day can be calculated as below.

$$\text{Total crew expense per voyage day} = \frac{\text{Crew Complement} \times \text{Average Annual Crew Expense}}{\text{350 voyage days per year}}$$

Crew expenses per voyage day by vessel size and flag are listed in Table 12.

Subsistence An average figure for subsistence expense is $770 per person per year at United States-flag ship cost levels (1). Subsistence on a foreign flag ship is 15 percent lower than on a United States-flag vessel (1). Subsistence expense on a foreign flag ship amounts to approximately $655 per person. Total subsistence per voyage day is calculated as

Table 12. Total crew expense per voyage day by ship size and flag

Size	15,000 DWT		30,000 DWT		80,000 DWT	
Flag	U. S.	Foreign	U. S.	Foreign	U. S.	Foreign
Expense[a]	$1250	$ 268	$1250	$ 268	$1250	$ 268

[a]Dollars per voyage day.

Total subsistence per voyage day

$$= \frac{\text{Crew Size x Average Subsistence per Man}}{\text{350 voyage days per year}}$$

Subsistence expenses by ship size and flag are listed in Table 13.

Insurance Marine insurance rates depend on many factors which vary widely among ship operators. These include fleet size, trade route, company loss experience, degree of self-insurance, and numerous intangibles of management, i.e., reputation and experience of the operator, port captain, port engineer, ship's masters, and other key personnel (14).

There are two major classes of marine insurance: (1) "protection and indemnity insurance" and (2) "hull and machinery insurance." Protection and indemnity insurance protects the owner against lawsuits, most of which arise from his own crew. Although rates are quoted on a gross tonnage basis, there is a logic in estimating protection and indemnity insurance costs in terms of the crew complement. Annual cost of protection and indemnity insurance has been estimated by the following relationship (1):

Annual cost of protection and indemnity insurance

= ($965) (Number of Crew)

Hull and machinery insurance protects the owners from loss or damage to the ship. Rates vary with the owner's past record (14). Benford (1)

Table 13. Total subsistence expense by vessel size and flag

Size	15,000 DWT		30,000 DWT		80,000 DWT	
Flag	U. S.	Foreign	U. S.	Foreign	U. S.	Foreign
Expense[a]	$ 77	$ 56	$ 77	$ 56	$ 77	$ 56

[a]Dollars per voyage day.

estimates the annual cost of hull and machinery insurance as follows (1):

Annual cost of hull and machinery insurance

= $10,000 + 0.007 (Total Construction Cost)

War risk insurance is sometimes necessary depending on world conditions and the trade route over which the ship is operated. The annual cost of war risk insurance is about 0.1 percent of invested cost (1). Since the expense is quite small when compared with indemnity insurance or hull and machinery insurance and since the world situation does not usually threaten ships at sea, the cost of war risk insurance has been omitted.

The total insurance expense has been calculated as follows:

Insurance expense per voyage day

$$= \frac{\text{Protection and Indemnity Insurance + Hull and Mach. Ins.}}{\text{350 voyage days per year}}$$

$$= \left[(\$965)(N_c)^{1} + \$10{,}000 + 0.007\ (\text{T.C.C.})^{2}\right] \div 350$$

Insurance expense per voyage day is listed in Table 14 by ship size and flag.

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[1]N_c represents crew number.

[2]T.C.C. refers to total construction cost.

Table 14. Marine insurance expense by ship size and flag

Size	15,000 DWT		30,000 DWT		80,000 DWT	
Flag	U. S.	Foreign	U. S.	Foreign	U. S.	Foreign
Expense[a]	$ 325	$ 179	$ 385	$ 201	$ 585	$ 281

[a]Dollars per voyage day.

Maintenance and repair Actual costs of maintenance and repair vary widely and are influenced by such diverse factors as trade-route weather conditions, bow shape, owner's standards, and initial extra cost for reliability. Variation also arises in that many owners assign much maintenance work to the crew, and thereby disguise that cost under such headings as wages, subsistence, and supplies. Benford (1) proposes the following relationships to estimate the midlife averages of maintenance and repair expense (1):

Annual cost of hull maintenance and repair

$$= \$10{,}000 \left(\frac{\text{C.N.}}{1000}\right)^{2/3}$$

and

Annual cost of machinery maintenance and repair

$$= \$4{,}500 \left(\frac{\text{shp}}{1000}\right)^{2/3}$$

These relationships give an estimation of United States-flag vessel

[1]C.N. refers to Cubic Number which is computed as 1/100 of the product of length at water line, breadth, and depth to weather deck.

[2]Shaft horsepower.

maintenance and repair expense. Foreign flag vessel maintenance and repair expense has been approximated by using 70 percent of United States flag cost levels (1).

Maintenance and repair expense per voyage day was estimated as follows:

$$\text{Maintenance and repair expense per voyage day} = \frac{\$10{,}000\ (\frac{\text{C.N.}}{1000})^{2/3} + \$4500\ (\frac{\text{shp}}{1000})^{2/3}}{350 \text{ voyage days per year}}$$

The figures for each size ship and flag are listed in Table 15. Foreign flag ship expenses for maintenace and repair are calculated as 70 percent of United States-flag ship cost levels (1).

Stores and supplies The category of stores and supplies comprises paint, cleaning materials, and lubricating oil. Most of these items are for shipboard maintenance and are used by the crew. Hence the annual cost is largely a function of the crew complement and has been approximated as follows (1):

$$\text{Cost of stores and supplies per voyage day} = \frac{\$80\ (\frac{N_c}{10})^{4}}{350 \text{ voyage days per year}}$$

The figures resulting from this relationship are listed in Table 16. Foreign flag vessel stores and supplies are calculated as 80 percent of United States-flag ship cost levels (1).

Overhead and miscellaneous expense Overhead and miscellaneous costs

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[1] N_c represents crew number.

Table 15. Maintenance and repair expense by ship size and flag

Size	15,000 DWT		30,000 DWT		80,000 DWT	
Flag	U. S.	Foreign	U. S.	Foreign	U. S.	Foreign
Expense[a]	$ 231	$ 162	$ 339	$ 237	$ 561	$ 393

[a]Dollars per voyage day.

Table 16. Stores and supplies expense by vessel size and flag

Size	15,000 DWT		30,000 DWT		80,000 DWT	
Flag	U. S.	Foreign	U. S.	Foreign	U. S.	Foreign
Expense[a]	$ 34	$ 27	$ 34	$ 27	$ 34	$ 27

[a]Dollars per voyage day.

Table 17. Overhead and miscellaneous expense by vessel size and flag

Size	15,000 DWT		30,000 DWT		80,000 DWT	
Flag	U. S.	Foreign	U. S.	Foreign	U. S.	Foreign
Expense[a]	$ 274	$ 82	$ 328	$ 98	$ 560	$ 168

[a]Dollars per voyage day.

include fleet management, communications, crew transportation, survey fees, and so forth. This expense item has been approximated by the following relationship (1):

$$\text{Cost of overhead and miscellaneous expense per voyage day} = \frac{\$65{,}000 + \$2\ (\text{Cubic Number})}{350 \text{ voyage days per year}}$$

Overhead and miscellaneous expense for the six ships studied are listed in Table 17. Foreign flag ships operate at 30 percent of United States-flag ship cost levels for overhead and miscellaneous expense (1).

In-port fuel A ship actively engaged in trade, whether alongside the pier, maneurvering in port, or underway, will maintain a certain minimum of power available. It follows that there is a minimum daily expense for fuel required to maintain this power. This minimum can be considered as contributing to the fixed expenses of vessel ownership. In-port fuel expense is taken as this base or minimum, and the additional fuel consumed at sea is treated incrementally under the "At-Sea Expenses" category.

In-port fuel consumption is listed in Table 10: Characteristics of Bulk Grain Vessels. Fuel costs range from $17.00 per long ton for intermediate oil # 15 to $25.00 per long ton for marine diesel. Diesels of the low speed, heavy duty type, operate on the heavy fuel, but higher speed geared diesels generally require the lighter, more expensive fuel.[1] The ships studied in this thesis have been assumed to use the heavy, less expensive fuel. In-port fuel expenses are listed for the six vessels in Table 18.

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[1]Krause, Robert N. Cargo Carriers, Inc., Minneapolis, Minn. Data on shipping costs. Private communication. 1968.

Table 18. In-port fuel expense by vessel size and flag

Size	15,000 DWT		30,000 DWT		80,000 DWT	
Flag	U. S.	Foreign	U. S.	Foreign	U. S.	Foreign
Expense[a]	$ 25	$ 25	$ 34	$ 34	$ 42	$ 42

[a]Dollars per voyage day.

Return on investment Twelve percent return on investment after taxes on the valuation of the ship (averaged over the last three years) was calculated assuming the vessels had a twenty year useful life and a mean age of ten years.

Return on investment

$$= 2^{1}\left\{12\%\left|\frac{(\text{T.C.C.}^{2}-\frac{8}{20}\text{T.C.C.})+(\text{T.C.C.}-\frac{9}{20}\text{T.C.C.})+(\text{T.C.C.}-\frac{10}{20}\text{T.C.C.})}{3}\right|\right\}$$

$$= 2\left|12\%\ (\text{T.C.C.}-\frac{9}{20}\ \text{T.C.C.})\right|$$

$$= 2\left|12\%\ (\frac{11}{20}\ \text{T.C.C.})\right|$$

$$= 2\left|(\frac{33}{500}\ \text{T.C.C.})\right|$$

$$= 0.132\ (\text{T.C.C.})$$

$$\text{Return on investment per voyage day} = \frac{0.132\ (\text{T.C.C.})}{350 \text{ voyage days per year}}$$

Return on investment for the six vessels is listed in Table 19.

The total vessel ownership expenses and return on investment for the

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[1]Assumes a corporation with taxable income over $1,000,000.

[2]Total construction cost.

Table 19. Return on investment by vessel size and flag

Size	15,000 DWT		30,000 DWT		80,000 DWT	
Flag	U. S.	Foreign	U. S.	Foreign	U. S.	Foreign
Expense[a]	$3771	$1282	$4902	$1697	$8674	$3206

[a]Dollars per voyage day.

Table 20. Vessel ownership expenses[a] by ship size and flag

Size	15,000 DWT		30,000 DWT		80,000 DWT	
Flag	U. S.	Foreign	U. S.	Foreign	U. S.	Foreign
Depreciation and interest	$2,440	$ 830	$ 3,172	$1,098	$ 5,612	$2,074
Crew wages	1,250	268	1,250	268	1,250	268
Subsistence	77	56	77	56	77	56
Insurance	325	179	385	201	585	281
Maintenance and repair	231	162	339	237	561	393
Stores and supplies	34	27	24	27	34	27
Overhead and misc.	274	82	328	98	560	168
In-port fuel	25	25	34	34	42	42
Return on investment	3,771	1,282	4,902	1,697	8,674	3,206
Total	8,427	2,911	10,521	3,716	17,395	6,315

[a]Dollars per voyage day.

Table 21. At-sea fuel expense by ship size and flag

Size	15,000 DWT		30,000 DWT		80,000 DWT	
Flag	U. S.	Foreign	U. S.	Foreign	U. S.	Foreign
Expense[a]	$ 611	$ 476	$ 934	$ 680	$1550	$1020

[a]Dollars per day at sea.

six ships simulated are listed in Table 20.

At sea expenses

This category includes only one item, at-sea fuel. The preceding discussion includes total crew wages under the "Vessel Ownership Expenses" category.

In calculating at-sea fuel expenses, the price of intermediate oil #15 is assumed to be $17.00 per long ton as it was for in-port fuel.

It should be recalled that a minimum daily expense per voyage day is already allowed for in-port fuel. Hence, in the calculation procedure used, that amount must be deducted from total at-sea fuel expense; otherwise a portion of total fuel expense would be counted twice. This calculation procedure thus emphasizes the additional fuel expense which varies with the number of voyage days which the ship spends at sea.

Fuel consumption at sea is given in Table 10. At-sea fuel expense is listed in Table 21.

Port expenses

Port charges have been divided into two groups: "per call" and "per day."

The first group includes those expenses charged to the ship on a "per

Table 22. Port expenses per day and per call

Size	15,000 DWT		30,000 DWT		80,000 DWT	
Flag	U. S.	Foreign	U. S.	Foreign	U. S.	Foreign
Per day	$ 146	$ 146	$ 224	$ 224	$ 557	$ 557
Per call	$ 529	$ 529	$ 712	$ 712	$1494	$1494

call" basis, regardless of the actual time spent in port. These fixed costs per port call comprise such items as pilotage, tuggage, line-handling, quarantine inspection, and a pro-rata share of tonnage tax.

The second group is composed of those charges which reflect the number of days spent in port. These include charges for use of a pier, fresh water, shoreside power and other utilities, watchmen, and agency fees.

Wharfage is excluded because of the considerable variations, both foreign and domestic, in assessment practices and dues (14). In addition, since wharfage can be considered as a storage charge against the cargo, it is not directly related to the maritime transportation segment considered in this study.

Port expenses have been calculated from the following expressions (1):

$$\text{Port expenses per call} = \$233 + \$19.25 \left(\frac{\text{C.N.}}{1000}\right)^{1}$$

plus

$$\text{Port expenses per day} = \$20 + \$8.20 \left(\frac{\text{C.N.}}{1000}\right)$$

Port expenses "per day" and "per call" are listed in Table 22, by ship

[1] Cubic number.

size and flag.

Voyage cost

The total cost per voyage has been calculated as:

$$\left[\text{Vessel Ownership Expenses (Number of voyage days) + At-Sea Expenses (Number of sea days) + Port Expenses per call (Port Calls) + Port Expenses per day (Days in Port)} \times (1.4)\right]^{1}$$

The total cost per ton may be expressed as:

$$1.4\left[\text{Vessel Ownership Expenses (Number of voyage days) + At-Sea Expenses (Number of sea days) + Port Expenses per call (Port Calls) + Port Expenses per Day (Days in Port)}\right] \div \text{Cargo Tonnage}$$

The number of voyage days are calculated as at-sea days plus days in port. Days in port are given in Table 8 and Table 9 in Chapter II. Days at sea have been calculated for certain routes by dividing the distance between ports by the number of miles each ship travels during one day. (For example, a ship traveling at fourteen knots will travel 336 nautical miles a day.)

The total cost per ton for each of the six ships is calculated from the following six relationships:

1. 15,000 DWT U. S. flag: $\text{T.C./ton} = 1.4\left[\$8427 \text{ (No. of Voy. Days)} + \$611 \text{ (No. of Sea Days)} + \$529 + \$146 \text{ (Days in Port)}\right] / 13{,}500 \text{ tons}$

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[1] The 1.4 is calculated from the assumption of 60 percent of a normal full load on the return trip.

Table 23. Calculated transportation rates for a 15,000 DWT foreign flag vessel over selected routes

	Baltimore	New Orleans	Portland	Chicago
Port-au-Prince, Haiti				
Days at sea[a]	3.9	3.6	14.9	12.1
Days in port	20	19	20	20
Rate[b]	$ 7.76	$ 7.33	$11.62	$10.64
Callao, Peru				
Days at sea	10.8	9.3	13.7	19.0
Days in port	13	12	13	13
Rate	$ 7.96	$ 7.11	$ 8.98	$10.84
Rio de Janeiro, Brazil				
Days at sea	14.3	15.4	25.7	20.2
Days in port	15	14	15	15
Rate	$ 9.82	$ 9.89	$13.82	$11.89
Rotterdam, Netherlands				
Days at sea	10.8	14.7	25.9	14.1
Days in port	8	7	8	8
Rate	$ 6.38	$ 7.43	$11.68	$ 7.54
Naples, Italy				
Days at sea	13.3	16.5	27.4	16.8
Days in port	15	14	15	15
Rate	$ 9.47	$10.28	$14.42	$10.70
Tel Aviv, Israel				
Days at sea	16.8	19.0	31.7	19.4
Days in port	15	14	15	15
Rate	$ 9.47	$11.16	$15.93	$11.61

[a]Days at sea assumes: (1) Suez Canal is open, (2) ship speed of 14 knots, and (3) all canal routes require one additional day at sea.

[b]Rate is in dollars per ton of cargo.

Table 23 (Continued)

	Baltimore	New Orleans	Portland	Chicago
Bombay, India				
Days at sea	26.1	29.3	28.7	29.7
Days in port	19	18	19	19
Rate	$15.23	$16.04	$16.14	$16.49
Yokohama, Japan				
Days at sea	29.7	28.2	12.9	37.9
Days in port	13	12	13	13
Rate	$14.59	$13.75	$ 8.70	$17.47
Sydney, Australia				
Days at sea	29.7	28.1	20.1	36.9
Days in port	10	9	10	10
Rate	$13.64	$12.76	$10.27	$16.17
Alexandria, Egypt				
Days at sea	15.7	20.1	30.6	18.3
Days in port	15	14	15	15
Rate	$10.31	$11.54	$15.54	$11.22
Lagos, Nigeria				
Days at sea	15.0	17.1	27.4	19.8
Days in port	20	19	20	20
Rate	$11.65	$12.07	$16.01	$13.34
Mombasa, Kenya				
Days at sea	26.1	29.2	33.1	29.6
Days in port	17	16	17	17
Rate	$14.60	$15.37	$17.06	$15.83
Capetown, S. A.				
Days at sea	20.6	21.7	31.9	25.4
Days in port	12	11	12	12
Rate	$11.08	$11.16	$15.05	$12.76

Table 24. Calculated transportation rates for a 15,000 DWT United States-flag vessel over selected routes

	Baltimore	New Orleans	Portland	Chicago
Port-au-Prince, Haiti				
Days at sea	3.9	3.6	14.9	12.1
Days in port	20	19	20	20
Rate	$21.48[a]	$20.31	$31.79	$29.17
Callao, Peru				
Days at sea	10.8	9.3	13.7	19.0
Days in port	13	12	13	13
Rate	$21.73	$19.43	$24.45	$28.52
Rio de Janeiro, Brazil				
Days at sea	14.3	15.4	25.7	20.2
Days in port	15	14	15	15
Rate	$26.78	$26.93	$37.46	$31.43
Rotterdam, Netherlands				
Days at sea	10.8	14.7	25.9	14.1
Days in port	8	7	8	8
Rate	$17.28	$20.04	$31.43	$20.32
Naples, Italy				
Days at sea	13.3	16.5	27.4	16.8
Days in port	15	14	15	15
Rate	$25.84	$27.96	$39.05	$29.12
Tel Aviv, Israel				
Days at sea	16.8	19.0	31.7	29.4
Days in port	15	14	15	15
Rate	$29.12	$30.30	$43.08	$31.84
Bombay, India				
Days at sea	26.1	29.3	28.7	29.7
Days in port	19	18	19	19
Rate	$41.39	$43.50	$43.83	$44.77

[a]Rates are in dollars per ton of cargo.

Table 24 (Continued)

	Baltimore	New Orleans	Portland	Chicago
Yokohama, Japan				
Days at sea	29.7	28.2	12.9	37.9
Days in port	13	12	13	13
Rate	$39.44	$37.14	$23.70	$47.12
Sydney, Australia				
Days at sea	29.7	28.1	20.1	36.9
Days in port	10	9	10	10
Rate	$36.77	$34.38	$27.27	$43.51
Alexandria, Egypt				
Days at sea	15.7	20.1	30.6	18.3
Days in port	15	14	15	15
Rate	$28.09	$31.33	$42.05	$30.53
Lagos, Nigeria				
Days at sea	15.0	17.1	27.4	19.8
Days in port	20	19	20	20
Rate	$31.88	$32.96	$43.50	$36.38
Mombasa, Kenya				
Days at sea	26.1	29.2	33.1	29.6
Days in port	17	16	17	17
Rate	$39.61	$41.63	$46.17	$42.00
Capetown, S. A.				
Days at sea	20.6	21.7	31.9	25.4
Days in port	12	11	12	12
Rate	$30.02	$30.16	$40.61	$34.52

2. 15,000 DWT Foreign flag: T.C./ton = $1.4 [\$2911 (No. of Voy. Days) + \$476 (No. of Sea Days) + \$529 + \$146 (Days in Port)] /13,500 tons$

3. 30,000 DWT U. S. flag: T.C./ton = $1.4 [\$10,521 (No. of Voy. Days) + \$934 (No. of Sea Days) + \$712 + \$224 (Days in Port)] /28,500 tons$

4. 30,000 DWT Foreign flag: T.C./ton = 1.4 [$3716 (No. of Voy. Days) + $680 (No. of Sea Days) + $712 + $224 (Days in Port)] /28,500 tons

5. 80,000 DWT U. S. flag: T.C./ton = 1.4 [$17,395 (No. of Voy. Days) + $1550 (No. of Sea Days) + $1494 + $557 (Days in Port)] /76,000 tons

6. 80,000 DWT Foreign flag: T.C./ton = 1.4 [$6315 (No. of Voy. Days) + $1020 (No. of Sea Days) + $1494 + $557 (Days in Port)] /76,000 tons

The equations for a 15,000 DWT foreign flag ship and a 15,000 DWT United States-flag ship were used to set up a transportation rate matrix to be used to find the optimal shipping routes for United States grain exports. The equations were rewritten as follows so that the variables were number of days at sea and number of days in port:

Total Cost per Ton 15,000 DWT foreign flag ship = 1.4 [days in port ($2911 + $146) + at-sea days ($2911 + $476) + $529] /13,500 tons

= 1.4 [$3057 (days in port) + $3387 (at-sea days) + $529] /13,500 tons

= [4279.8 (days in port) + 4741.8 (at-sea days) + 740.6] /13,500 tons

= 0.317 (days in port) + 0.351 (at-sea days) + 0.055

Total Cost per Ton 15,000 DWT U. S.-flag ship = 0.889 (days in port) + 0.937 (at-sea days) + 0.055

Days at sea, days in port, and the estimated transportation rate per ton for a 15,000 DWT foreign flag ship and a 15,000 DWT United States-flag ship calculated from the above equations are listed in Tables 23 and 24.

TRANSPORTATION MODEL: DERIVATION AND ANALYSIS

Background

In order to test the transportation rates developed in the previous chapter, the transportation model was used to determine a least cost shipping pattern.

The transportation model is a subclass of a linear programming problem for which computational procedures have been developed which take advantage of the special structure of the model. The transportation problem was first developed by Hitchcock and Koopmans (8). Hitchcock applied the procedure to the problem of minimizing the cost of distributing a product from several factories to a number of cities. He used a geometric approach to solve the problem. His technique closely resembled the simplex method developed by Dantzig in 1947.

In 1951, Dantzig formulated the transporation problem as a special linear-programming problem and then developed a special form of the simplex technique for solving these problems (5).

Charnes and Cooper developed an alternative known as the "stepping stone method" of solving the transportation problem in 1954 (3). The "stepping stone" method has special merit in explaining both the structure of the problem and the relationship of the transportation technique to the general simplex technique. They also formalized the procedure suggested by Dantzig for obtaining an initial feasible solution to the problem. This method was called the "northwest-corner rule."

Other methods for solving the problem have since been developed. Two of these are "forming the square" and MODI (U. S. Army abbreviation for

Methods of Distribution Inland) (7). The transportation problem can also be solved as a linear programming minimization problem using the simplex technique.

Assumptions of the Model

The transportation model is a special form of a linear programming model involving more restrictive assumptions than problems solved by the simplex algorithm. The assumptions necessary for application of the transportation model are (7):

1. Resources and products are homogeneous. This means that the supply or product of any one region or origin serves equally well to satisfy the demands of any consuming sector.
2. The supplies of resources or products available at the various origins and the demands of the various destinations are known or fixed; and total demand is equal to total supply. As a practical matter, demand and supply may be equated by including a dummy origin or pseudo demand or destination. This is similar to the disposal activities of the simplex method. The dummy activities may be used to represent surpluses which move into inventories or storage.
3. The cost (or profit) of (or from) converting resources to products or moving the commodity from origins to destinations is known and is independent of the number of units moved or converted.

4. There is an objective to be maximized or minimized. The usual objective is to minimize costs.
5. Transportation from origins to destinations, or transformation from resources to products, can be carried on only at non-negative levels. This assumption corresponds closely to the "simplex" assumption that activities cannot be produced in negative amounts.
6. The entire region may be represented by a point in that region. There are no additional charges in assembly of surplus supplies to the point of origin or distribution of supplies from the point representing the deficit region.

Mathematical formulation

Suppose there are m factories supplying n warehouses. The factories produced goods at levels $a_1, a_2, \ldots, a_m$ and the quantity demanded at the warehouses for these goods is $b_1, b_2, \ldots, b_n$. The problem now becomes one of determining the shipping pattern which minimizes the total transportation cost if the unit cost of shipping from factory i to warehouse j is c_{ij}.

When x_{ij} is the amount shipped from factory i to warehouse j, the mathematical statement of the problem is as follows:

$$(1) \quad \sum_{j=1}^{n} x_{ij} = a_i \qquad i = 1, 2, \ldots, m$$

The sum of what leaves each factory for various destinations is equal to what is produced at that factory.

$$(2) \quad \sum_{i=1}^{m} x_{ij} = b_j \qquad j = 1, 2, \ldots, n$$

The sum of what arrives at each warehouse from the various origins is

equal to the demand at that warehouse.

$$(3)\quad \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij} = \text{minimum}$$

Statement (3) is the objective function which is to minimize total transportation cost.

$$(4)\quad x_{ij} \geq 0 \text{ for all } i, j$$

Negative shipments have no physical meaning.

Then summing equations (1) and (2) over i and j respectively we have

$$\sum_{i=1}^{m}\sum_{j-1}^{n} x_{ij} = \sum_{i=1}^{m} a_i$$

and

$$\sum_{j=1}^{n}\sum_{i=1}^{m} x_{ij} = \sum_{j=1}^{n} b_j$$

This gives equation (5).

$$(5)\quad \sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$$

Equation (5) states that total production just equals total demand.

Since $\sum_{j=1}^{n} x_{ij} = a_i$ and $\sum_{i=1}^{m} x_{ij} = b_j$ gives a set of m + n restrictions, and since $\sum_{i=1}^{m} z_i = \sum_{j=1}^{n} b_j$, the number of independent restrictions must be m + n - 1.

Using the model

The transportation model is concerned with the least-cost allocation of known supplies in surplus markets or regions to deficit markets or regions within the market area. Constructing and using the transporation model involves the following steps (23).

1. Collection of data and estimation of regional supply, demand, and transportation costs.

2. Definition of regions and base points in the market areas.
3. Definition of surplus or deficit regions.
4. Determination of a first feasible approximation of product flows.
5. Iteration of product flows to derive an optimum shipment pattern.

There is no set method of determining regional boundaries or basing points. The basic criterion is that the regions selected provide a meaningful basis for analysis of the specific problem under study. Choosing a base point requires consideration of 1) location relative to production or consumption concentrations within the region, 2) rail, highway, and ocean vessel transportation facilities, and 3) a point through which shipments occur or might occur without overestimating or underestimating the total shipment costs to the many actual shipping points within the region (17).

Data needed for a transportation model is probably the biggest shortcoming of using this analytical technique. Production and consumption estimates or actual figures are needed for the product under investigation. Bringing additional or intermediate marketing steps into the analysis increases the data collection problem. Estimates of the quantities available and quantities demanded at each location must be made if the data are unavailable.

A transportation rate is needed between each possible pair of locations to be considered. In many cases, transportation rates are not readily available and estimates have to be made based on the distance between basing points and the average cost per mile.

Determination of Optimal Shipping Patterns

Definition of regions and base points

For analysis purposes United States grain exporting ports were grouped into four surplus regions. A base point through which all shipments would be made was chosen for each of these regions. The surplus regions and base points used in the analysis were (1) Atlantic Coast: Baltimore, Maryland, (2) Gulf Coast: New Orleans, Louisiana, (3) Pacific Coast: Portland, Oregon, and (4) Great Lakes: Chicago, Illinois.

Countries importing grain from the United States were grouped into thirteen deficit regions and a base point was chosen through which all shipments would occur. The following deficit regions and base points were used in the analysis.

1. Central America and the Caribbean Area (CAC): Port au Prince, Haiti
2. Western South America (WSA): Callao, Peru
3. Eastern South America (ESA): Rio de Janeiro, Brazil
4. Northwestern and Central Europe (NCE): Rotterdam, Netherlands
5. Northeastern and Southern Europe (NSE): Naples, Italy
6. Western Asia (WA): Tel Aviv, Israel
7. Southern and Southeastern Asia (SSA): Bombay, India
8. Eastern Asia (EA): Yokohama, Japan
9. Australia and Oceania (AO): Sydney, Australia
10. Northern Africa (NAF): Alexandria, Egypt
11. Western Africa (WAF): Lagos, Nigeria

12. Eastern Africa (EAF): Mombasa, Kenya

13. Southern Africa (SAF): Capetown, South Africa

The ports and countries grouped into the surplus and deficit areas can be found in Appendix A and Appendix B. These regions and their representative base points are outlined in Figure 1.

Definition of regional supply and demand

The bushels of heavy grain available for export from each surplus region and the amount of deficit in the thirteen market areas were based on the actual amounts shipped from or received at these regions during 1966. The heavy grain surplus by port region for 1966 is listed in Table 25. The deficit of heavy grain by market area for 1966 is listed in Table 26.

Definition of transportation costs

The solutions to the models described later were determined by assuming all shipments were made on either a 15,000 DWT foreign flag ship or a 15,000 DWT United States-flag ship. Transportation rates were estimated from the equations developed in Chapter III. The costs per ton of shipping on either of the two ships are listed in Tables 23 and 24 in Chapter III.

Definition of developing areas

Since the Cargo Preference Act (Appendix E) requires that fifty percent of United States government sponsored shipments by region be transported on United States-flag ships, it was assumed that all shipments to developing regions were Government sponsored shipments. Developing regions were defined to be those regions with predominately low and medium income per capita. Countries are listed by region and income class in Table 27. From this information it was assumed that shipments to all regions except Northwestern and Central Europe, Northeastern and Southern

Figure 1. Surplus and deficit areas

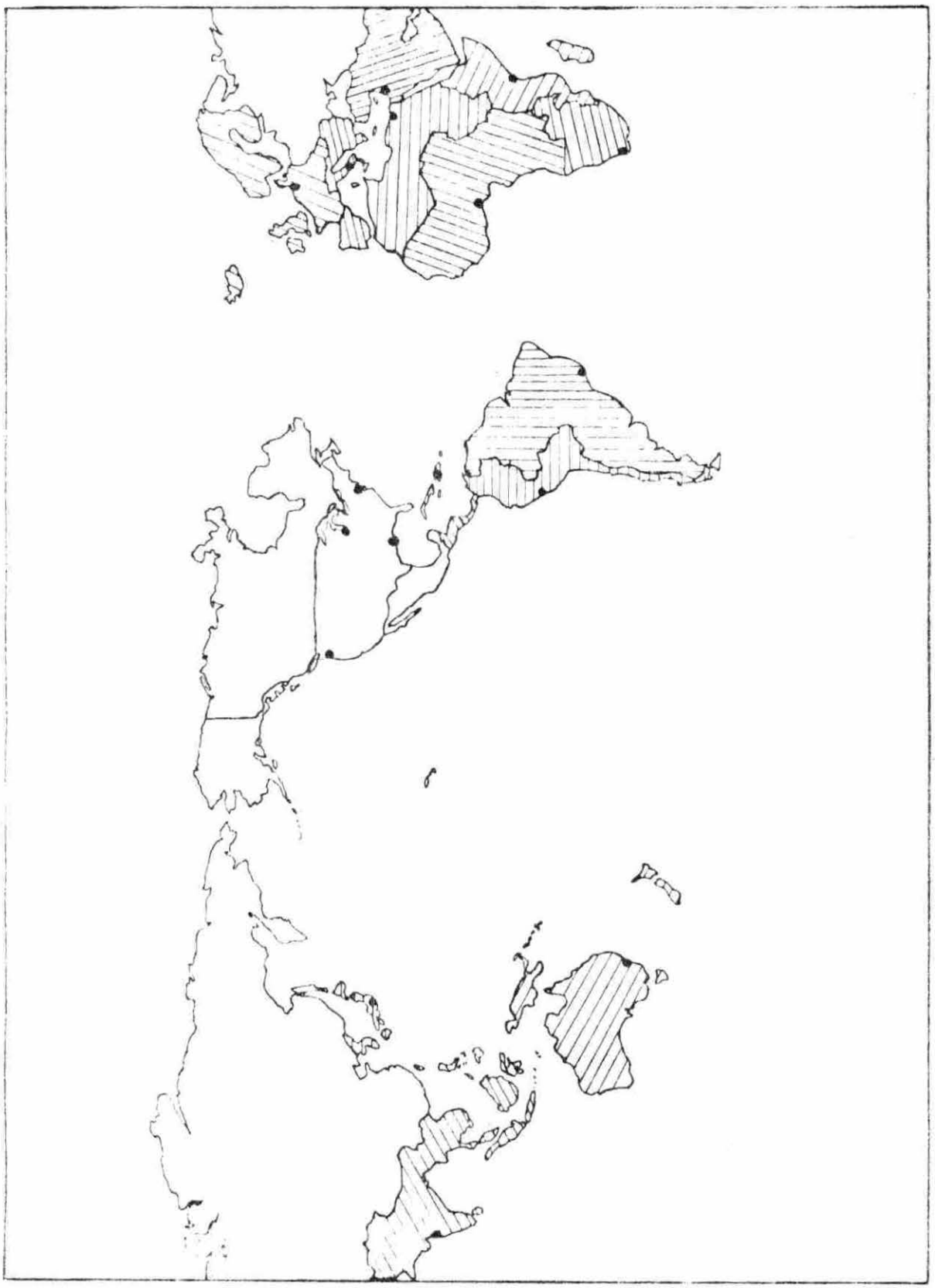

Table 25. Heavy grain surplus by port region[a]

Region	Wheat	Corn	Grain Sorghums	Soybeans
Atlantic	104,558,687[b]	59,881,699	684,224	14,921,513
Gulf	497,537,352	363,372,298	250,188,454	173,466,016
Pacific	197,465,444	1,305,831	41,817,868	1,270
Great Lakes	52,168,336	129,251,264	253,220	58,441,939

[a]U. S. Department of Agriculture (22).

[b]All amounts are in bushels.

Europe, Eastern Asia, and Australia and Oceania were United States government sponsored. The models required that fifty percent of the shipments to these developing regions be made at United States-flag vessel rates.

Models developed

Optimal shipping patterns and the total cost of transportation was determined for four models. The first three models required some shipments on United States flag vessels. The effects of growth in United States grain exports were analyzed in these models. Model IV was defined the same as Model I except that all shipments were made on foreign flag vessels. The additional cost of transportation required by the Cargo Preference Act could be determined in this manner. The models are defined as follows:

Model I Surplus and deficit amounts were the same as those in 1966. These amounts for the port regions and market areas are listed in Tables 25 and 26 by commodity. Fifty percent of the shipments to developing areas were made on United States-flag vessels.

Table 26. Heavy grain deficit by world region[a]

Region	Wheat	Corn	Grain sorghum	Soybeans
Central America and the Caribbean	8,764,723[b]	3,260,609	303,976	334
Western South America	32,222,532	1,949,968	378,449	44,351
Eastern South America	62,321,338	1,214,008	447,862	1,099,596
Northwestern and Central Europe	103,472,295	242,383,920	98,760,043	101,920,431
Northeastern and Southern Europe	109,311,734	134,785,794	11,592,051	32,018,666
Western Asia	27,763,465	10,359,226	16,324,387	10,206,789
Eastern Asia	269,227,079	11,004,182	78,317,539	697,037
Southern and Southeastern Asia	110,620,761	78,114,567	83,330,326	74,770,884
Australia and Oceania	0	32,482	0	20,016
North Africa	58,592,402	668,098	25,138	0
Western Africa	7,633,628	3,523,195	1,778,637	81,242
Eastern Africa	1,885,724	4,707,036	182,631	0
Southern Africa	15,693,168	5,936,537	117,068	0

[a]U. S. Department of Agriculture (22).

[b]All amounts are in bushels.

Table 27. Aggregates of countries by region and income class[a]

Region	Country	Income class[b]
Central America and Caribbean	British Honduras	medium
	Costa Rica	medium
	Cuba	medium
	Dominican Republic	low
	El Salvador	low
	Guatemala	low
	Haiti	low
	Honduras	low
	Jamaica	medium
	Nicaragua	low
	Panama	medium
	Trinidad and Tobago	medium
Western South America	Colombia	low
	Ecuador	low
	Peru	low
	Bolivia	low
	Chile	medium
Eastern South America	Venezuela	medium
	British Guiana	low
	Surinam	low
	Brazil	low
	Paraguay	low
	Uruguay	medium
	Argentina	medium
Northwestern and Central Europe	Sweden	high
	Norway	high
	Finland	high
	Denmark	high
	United Kingdom	high
	Ireland	medium
	Netherlands	high

[a]United Nations (18).

[b]Income class: $0-$300 per capita income, low; $300-$800 per capita income, medium; over $800 per capita income, high.

Table 27 (Continued)

Region	Country	Income class[b]
	Belgium	high
	France	high
	West Germany	high
	East Germany	high
	Austria	high
	Czechoslovakia	medium
	Hungary	medium
	Switzerland	high
Northeastern and Southern Europe	Poland	medium
	Russia	high
	Spain	medium
	Portugal	medium
	Italy	medium
	Yugoslavia	medium
	Greece	medium
	Rumania	medium
	Bulgaria	medium
	Turkey	low
	Cyprus	medium
Western Asia	Syria	low
	Lebanon	low
	Iraw	low
	Iran	low
	Israel	high
	Jordan	low
Eastern Asia	South Korea	low
	Taiwan	low
	Japan	medium
Southern and Southeastern Asia	Afghanistan	low
	India	low
	Pakistan	low
	Thailand	low
	South Viet Nam	low
	Malaysia	low
	Indonesia	low
	Phillipines	low

Table 27 (Continued)

Region	Country	Income class[b]
Australia and Oceania	Australia	high
	New Zealand	high
North Africa	Morocco	low
	Algeria	low
	Tunisia	low
	Libya	low
	Egypt	low
	Sudan	low
Eastern Africa	Ethiopia	low
	Uganda	low
	Kenya	low
	Tanzania	low
	Mozambique	low
	Malagasy Republic	low
Western Africa	Cameroon	low
	Senegal	low
	Sierra Leone	low
	Ivory Coast	low
	Ghana	low
	Nigeria	low
	Angola	low
	Liberia	low
	Congo	low
	Burundi and Rivanda	low
Southern Africa	Republic of South Africa	medium
	Zambia	low
	Rhodesia	low
	Malawi	low

Table 28. Increases in heavy grain shipments from 1958 to 1966 by port region and deficit area[a]

Commodity:	Wheat	Corn	Sorghum	Soybeans
Port region				
Atlantic	1.3	1.3	5.3	1.01
Gulf	3.1	3.7	3.5	3.1
Pacific	2.2	-3.2	17.9	∞
Great Lakes	1491	8.6	∞	5.7
Deficit area				
CAC	1.6	No change	1.7	2
WSA	4.6	2.2	2.4	∞
ESA	3.4	187	207	30
NCE	1.6	2.4	1.7	3
NSE	2.3	15.7	7.2	29
WA	2.8	7.8	16.3	2.9
EA	1.7	5.2	47	2.3
SSA	1.9	4.2	25	9.8
AO	No change	41	No change	∞
NAF	31	339	∞	No change
WAF	27	4.1	6.4	∞
EAF	2.4	∞	∞	No change
SAF	42	∞	∞	No change

[a]U. S. Department of Commerce (21, 22).

Model II This model tested the effect of growth in United States grain exports on the optimal shipping pattern determined in Model I. Surplus and deficit amounts were based on the 1966 data listed in Tables 25 and 26. This data was adjusted for trends shown over the nine year period from 1958 to 1966 (Table 28). Those port regions and market areas showing a small increase from 1958 to 1966 were assumed not to change from the amounts exported or received in 1966. Those areas showing large increases over the nine year period were adjusted for growth by the following multiples of the 1966 amounts.

	Wheat	Corn	Sorghum	Soybeans
Atlantic	No change	No change	10	No change
Gulf	2	2	3	2
Pacific	2	No change	5	10
Great Lakes	10	5	10	2
CAC[1]	No change	No change	No change	No change
WSA	2	2	2	2
ESA	2	10	10	5
NCE	No change	No change	No change	No change
NSE	No change	2	No change	2
WA	No change	2	5	No change
EA	No change	2	7	No change
SSA	No change	No change	4	2
AO	No change	10	No change	10
NAF	5	10	10	No change
WAF	5	No change	2	10
EAF	No change	10	10	No change
SAF	5	10	10	No change

Fifty percent of the shipments to developing areas were made on United States-flag vessels. Transportation rates were the same as those calculated in Chapter III.

Model III The effect of future growth in United States grain exports on the optimal shipping pattern was again tested by adjusting the

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[1]The abbreviations used for the market areas are given in the section defining the deficit regions.

1966 data for the trends shown in Table 28. However, it was assumed that there would be an increase in exports to almost all areas. The port regions and deficit areas were adjusted by the following multiples of the 1966 data given in Tables 25 and 26.

	Wheat	Corn	Sorghum	Soybeans
Atlantic	No change	No change	10	No change
Gulf	2	2	3	2.5
Pacific	2	No change	5	10
Great Lakes	10	5	10	4
CAC[1]	1.5	1.5	1.5	1.5
WSA	2	2	2	2
ESA	2	10	10	5
NCE	No change	1.5	No change	1.5
NSE	1.5	5	2	5
WA	1.5	2	5	1.5
EA	No change	2	7	1.5
SSA	1.5	2	4	2.5
AO	No change	5	No change	5
NAF	5	10	10	+100,000bu.
WAF	5	2	2	10
EAF	1.5	10	10	+100,000bu.
SAF	5	10	10	+100,000bu.

Fifty percent of the shipments to the developing areas were shipped on

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[1]The abbreviations used for the market areas are given in the section defining the deficit areas.

United States-flag vessels. Transportation rates were the same as those estimated in Chapter III for 15,000 DWT vessels.

Model IV To determine the effect on the total cost of transportation of having to transport fifty percent of Government sponsored shipments on United States-flag ships, it was assumed that all shipments were transported on a 15,000 DWT foreign flag vessel. Surplus and deficit amounts of the four commodities were assumed to be the same as in Model I.

Optimal[1] shipping patterns

Optimizing the models described in the last few pages provided two types of output that are of interest: (1) the optimum shipping pattern and (2) total cost of transportation. All the results, of course, are dependent on the transportation rates estimated in Chapter III and the assumptions for each model.

The cost of transportation for the four models are as follows:

Model I: $ 729,881,836

Model II: $1,523,599,704

Model III: $2,257,505,597

Model IV: $ 529,610,936

It can be concluded from examining Model I and Model IV that the Cargo Preference Act increases the cost of transportation by about $200 million annually. This amount will increase substantially if United States grain exports increase as in Models II and III.

In general, the first three models gave similar routing patterns.

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[1]Optimal in the sense that the shipping patterns give the least cost transportation routings given the restrictions.

Analysis of the first three models showed the following similarities.

Atlantic Coast region

Deficit areas receiving shipments from the Atlantic were (1) Western South America: soybeans, (2) Northern Africa: wheat, (3) Southern and Southeastern Asia: wheat, corn, grain sorghum, and soybeans, and (4) Western Asia: wheat. Increasing the quantities demanded in Models II and III had very little effect on the optimal routing pattern.

Gulf Coast region

The Gulf Coast was the principal export region in the United States in all four models. In general, all commodities were shipped to all regions except Northern Africa. The regions that did not receive shipments of a specific commodity from the Gulf were (1) Southern and Southeastern Asia: corn, (2) Eastern Asia: wheat in Model I, (3) Western South America: soybeans, and (4) Northwestern and Central Europe: wheat and corn in Model IV.

Pacific Coast region

Eastern Asia (Japan) was the principal market for shipments of all four commodities from Pacific Coast ports. Wheat was exported to Southern and Southeastern Asia in Model III. No other regions received shipments from the Pacific.

Great Lakes region

The Great Lakes region exported to only four market areas: (1) Northwestern and Central Europe, (2) Southern and Southeastern Asia, (3) Northern Africa, and (4) Northeastern and Southern Europe. Increases in the amount available for shipment and increases in the quantity demanded at various market areas in Model II and Model III had the most effect on this region.

Shifts in the commodities exported and the region of destination occurred in Models I to III.

Detailed commodity flow patterns for these models are presented in Appendix C. Actual flow patterns for 1966 are given in Appendix D. These can be compared to the optimal flows derived for Model I presented in Appendix C.

SUMMARY AND RECOMMENDATIONS

Summary

Objectives of this thesis were to (1) determine the cost per ton of shipping grain from a United States port of origin to specific ports of destination in the world market, (2) analyze heavy grain exports from the United States during 1958 and 1966, (3) determine the costs involved in shipping grain, and (4) analyze specific models of United States grain exports using the transportation rates calculated under objective 1.

Objective 1

Transportation rates per ton can be approximated by the following equations for each of the six ships studied:

1. 15,000 DWT Foreign Flag Ship

   Cost/Ton = 0.317 (Days in Port) + 0.351 (Days at Sea) + 0.055

2. 15,000 DWT United States Flag Ship

   Cost/Ton = 0.889 (Days in Port) + 0.937 (Days at Sea) + 0.055

3. 30,000 DWT Foreign Flag Ship

   Cost/Ton = 0.193 (Days in Port) + 0.216 (Days at Sea) + 0.035

4. 30,000 DWT United States Flag Ship

   Cost/Ton = 0.528 (Days in Port) + 0.563 (Days at Sea) + 0.035

5. 80,000 DWT Foreign Flag Ship

   Cost/Ton = 0.126 (Days in Port) + 0.135 (Days at Sea) + 0.027

6. 80,000 DWT United States Flag Ship

   Cost/Ton = 0.331 (Days in Port) + 0.349 (Days at Sea) + 0.027

Days in port are given in Table 8 and Table 9 in Chapter II. Days at sea can be estimated by dividing the distance between ports by the number

of miles traveled per day by each ship. An additional day at sea should be added for all canal routes.

With this information, the cost per ton can be approximated for each of the six ships simulated. A transportation model can then be used to describe and predict grain flows among the origins and destinations, regional differences in transportation rates, and locational advantages of particular regions relative to others.

Objective 2

Heavy grain exports from the United States increased threefold from 1958 to 1966. Wheat exports increased by 578 million bushels; corn, by 394 million bushels; grain sorghum, by 219 million bushels; and soybeans, by 166 million bushels.

Increases in exports over the nine year period from the four port regions in the United States were as follows: Atlantic Coast, 40 million bushels; Gulf Coast, 918 million bushels; Pacific Coast, 146 million bushels; and Great Lakes, 215 million bushels. The Great Lakes region showed the largest percentage growth caused by the opening of the St. Lawrence Seaway.

Gulf Coast ports exported more grain than the other three regions combined in 1958 and 1966. Probable reasons for this are their advantageous location in respect to the Midwest grain producing area, availability of barge transportation on the Mississippi River, rail rate advantages of the Midwest production area to the Gulf Coast ports, and the availability of port facilities capable of rapid handling of large volumes of grain.

Objective 3

The major costs incurred in operating a ship are depreciation and

interest, wages of officers and crew, maintenance and repair, insurance, and fuel. (Port location, facilities, and regulations affect shipping costs.)

One of the major factors affecting the cost of exporting grain from the United States is whether the ship flys a United States or a foreign flag. Fifty percent of Government sponsored grain shipments must be carried on United States-flag ships which have higher costs of operation than do foreign flag ships.

Grain is exported by three vessel types: cargo liners, tankers, and tramp ships. Tramp vessels carry the majority of grain exports. Tramp ships are usually chartered under a voyage charter on the basis of "free discharge" or "free-in and out."

Objective 4

Optimal routing patterns were determined for four models. Model I assumed that surplus and deficit amounts were the same as in 1966. The 1966 data was adjusted for future growth in specific areas in Model II. Adjustments were made for growth in most surplus (exporting) areas as well as most deficit (importing) regions in Model III. Fifty percent of the shipments to developing areas in these first three models were required to be shipped on United States-flag vessels. Transportation rates estimated in Chapter III for 15,000 DWT vessels were used in the analysis.

These three models showed similar results except for the total cost of transportation. The Gulf region was the principal exporting region in the United States. The other three regions exported to a few selected market areas.

The fourth model was the same as Model I except that all shipments were

made on a foreign flag ship. This showed that over $200 million dollars a year could be saved in transportation costs if fifty percent of Government sponsored shipments did not have to be carried on United States-flag vessels.

Recommendations for Further Study

The volume of grain shipped from the United States and received by world market areas was assumed to be the amounts that were shipped during 1966. This data should be brought up to date when the information becomes available.

This study does not take into account the cost of transportation from various production centers in the United States to the exporting ports. A similar study should be made of transportation within the United States so that a rate matrix could be set up from production areas to the world consuming areas. An optimal shipping pattern could then be developed which would move grain from the field to the world markets at minimum cost.

This study could also be expanded to take into account the entire world grain market. Given that there are a number of grain producing and consuming regions in the world trading a homogeneous product and separated by transportation costs, with each region a single distinct market and regional supply-demand functions and surplus-deficit position known, models similar to the ones used in this study could be developed to describe and predict such things as commodity flows among regions, regional price differentials, and locational advantages of particular regions relative to others.

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APPENDIX A. 1958 AND 1966 IMPORTS OF HEAVY GRAIN FROM THE UNITED STATES BY COUNTRY AND REGION

Table 29. Canada: 1966 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Canada	19,472,831[b]	55,871,472	1,385,649	25,971,392	102,701,354
					5.3%

[a]U.S. Department of Commerce (22).

[b]All amounts in bushels.

Table 30. Central America and Caribbean Area: 1966 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Guatemala	1,398,942[b]	4,014	3,241	252	1,406,449
British Honduras	0	5,287	0	0	5,286
El Salvador	1,104,571	4,037	590	0	1,109,198
Honduras	8 0,835	4,995	557	0	826,387
Nicaragua	371,563	60,692	4,035	0	436,290
Costa Rica	0	27,792	1,633	0	29,425
Panama	628,522	621,643	0	0	1,250,165
Canal Zone	0	234,799	0	0	234,799
Bermuda	0	10,514	0	0	10,514
Bahamas	116,721	120,263	341	0	237,325
Jamaica	578,996	997,391	213,610	0	1,788,997
Haiti	1,069,793	3,861	0	0	1,073,624
Dominican Republic	2,222,217	1,589	1,393	0	2,225,199
Leeward and Windward Is.	0	39,095	0	0	39,095
Barbados	0	6,605	18,853	0	25,458
Trinidad and Tobago	1,191,393	1,045,781	58,643	82	2,295,899
Netherlands Antilles	0	62,619	1,080	0	63,699
French West Indies	0	9,632	0	0	9,632
Total	8,764,723	3,260,609	303,976	334	13,067,441
					.7%

[a]U.S. Department of Commerce (22).

[b]All amounts in bushels.

Table 31. Western South America: 1966 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Colombia	8,001,825[b]	40,752	36,599	1,081	8,080,257
Ecuador	1,590,382	64	5,986	0	1,596,432
Peru	8,902,808	96,097	335,864	43,270	9,378,039
Bolivia	292,457	3,420	0	0	295,877
Chile	13,435,060	1,809,635	0	0	15,244,695
Total	32,222,532	1,949,968	378,449	44,351	34,595,300
					1.8%

[a]U.S. Department of Commerce (22).

[b]All Amounts in bushels.

Table 32. Eastern South America: 1966 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Venezuela	15,821,055[b]	890,145	11,251	1,097,707	17,820,158
British Guiana	28,500	95,773	0	0	124,273
Surinam	108,374	20,411	0	0	128,785
Brazil	44,970,567	205,070	410,292	307	45,586,236
Paraguay	1,392,842	0	0	0	1,392,842
Uruguay	0	123	0	0	123
Argentina	0	2,486	26,319	1,582	30,387
Total	62,321,338	1,214,008	447,862	1,099,596	65,082,804
					3.3%

[a]U.S. Department of Commerce (22).

[b]All amounts in bushels.

Table 33. Northwestern and Central Europe: 1966 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Iceland	10,021[b]	108,492	0	0	118,514
Sweden	97,761	116,706	0	6,246	220,713
Norway	6,791,190	3,423,313	3,450,832	4,516,501	18,181,836
Finland	791,925	325,191	0	298,174	1,415,290
Denmark	0	443,177	0	12,961,347	13,404,524
United Kingdom	30,590,440	69,838,410	5,069,498	4,811,287	110,304,635
Ireland	1,703,148	4,361,015	2,011,612	0	8,075,775
Netherlands	23,018,955	62,031,661	31,428,068	35,011,004	151,489,688
Belgium	5,991,580	32,988,619	27,102,239	8,512,679	74,595,117
France	9,614,373	3,671,770	71,064	1,750,403	15,107,610
West Germany	16,264,189	45,894,210	9,741,106	32,628,976	104,528,481
East Germany	0	7,749,461	4,679,029	0	12,428,490
Austria	135,300	1,715,026	122,857	0	1,973,183
Czechoslovakia	0	6,018,678	12,537,909	699,978	19,256,565
Hungary	0	200,197	2,388,571	436,800	3,025,567
Switzerland	8,463,413	3,497,993	162,258	287,036	12,410,700
Total	103,472,295	242,383,920	98,760,043	101,920,431	546,536,689 28.1%

[a]U. S. Department of Commerce (22).

[b]All amounts in bushels.

Table 34. Northeastern and Southern Europe: 1966 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Poland	5,860,122[b]	2,041,000	5,213,171	0	13,114,293
Russia	0	4	0	0	4
Azores	280,560	0	0	0	280,560
Spain	229,433	56,714,580	2,641,384	18,578,161	78,163,558
Portugal	3,114,368	3,315,217	2,280,422	0	8,710,007
Malta and Gozo	0	325	79,168	0	79,493
Italy	10,247,367	60,943,655	79,517	13,418,700	84,689,239
Yugoslavia	76,786,907	154,584	0	0	76,941,491
Greece	306,590	11,310,794	1,295,200	0	12,912,584
Rumania	0	0	0	21,805	21,805
Bulgaria	0	0	3,189	0	3,189
Turkey	12,486,387	231,000	0	0	12,717,387
Cyprus	0	74,635	0	0	74,635
Total	109,311,734	134,785,794	11,592,051	32,018,666	287,708,245 14.8%

[a]U. S. Department of Commerce (22).

[b]All amounts in bushels.

Table 35. Western Asia: 1966 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Syria	5,042,689[b]	2,649	8,298	0	5,053,634
Lebanon	4,644,488	2,113,021	325,854	0	7,083,363
Iraq	0	7,449	0	0	7,449
Iran	5,240,392	388,398	0	421	5,629,211
Israel	10,020,574	6,765,619	15,990,235	10,206,368	42,982,796
Jordan	2,295,498	978,495	0	0	3,273,993
Kuwait	0	24,804	0	0	24,804
Saudi Arabia	519,826	54,123	0	0	573,949
Arabia Peninsula States	0	4,825	0	0	4,825
Aden	0	13,927	0	0	13,927
Bahrain	0	5,916	0	0	5,916
Total	27,763,465	10,359,226	16,324,387	10,207,789	65,653,867
					3.3%

[a]U.S. Department of Commerce (22).

[b]All amounts in bushels.

Table 36: Eastern Asia: 1966 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Korea	16,270,814[b]	160,317	0	0	16,431,131
Hong Kong	668,721	165,731	39,368	12,638	886,458
Taiwan	10,276,410	408,687	0	4,887,267	15,572,362
Japan	82,065,097	77,329,400	83,258,958	69,739,186	312,392,641
Nansei and Nampo Is.	1,339,719	50,432	32,000	131,793	1,553,944
Total	110,620,761	78,114,567	83,330,326	74,770,884	346,836,536
					17.8%

[a]U.S. Department of Commerce (22).

[b]All amounts in bushels.

Table 37. Southern and Southeastern Asia: 1966 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Afghanistan	5,495,838[b]	0	0	0	5,495,838
India	220,373,444	4,004,803	78,242,377	0	302,620,624
Pakistan	24,346,802	5,155,660	492	0	29,502,954
Nepal	3,343	0	0	0	3,343
Ceylon	0	150,229	0	0	150,229
Thailand	237,067	4,968	0	0	242,035
South Viet Nam	0	1,483,299	55,556	0	1,538,855
Malaysia	168,000	11,377	0	0	179,377
Singapore	436,600	12,002	0	0	448,602
Indonesia	0	66,664	0	0	66,664
Phillipines	18,165,985	115,180	19,114	697,037	18,997,318
Total	209,227,079	11,004,182	78,317,539	697,037	359,245,837
					18.5%

[a]U.S. Department of Commerce (22).

[b]All amounts in bushels.

Table 38. Australia and Oceania: 1966 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Australia	0[b]	29,082	0	19,164	48,246
New Zealand and Samoa	0	3,104	0	0	3,104
French Pacific Islands	0	224	0	852	1,076
Trust Territory of the Pacific Islands	0	72	0	0	72
Total	0	32,482	0	20,016	52,498
					.003%

[a]U.S. Department of Commerce (22).

[b]All amounts in bushels.

Table 39. North Africa: 1966 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Morocco	13,867,087[b]	320,649	0	0	14,187,736
Algeria	24,034,373	685	0	0	24,035,058
Tunisia	3,587,179	275,803	0	0	3,862,982
Libya	0	3,753	0	0	3,753
Egypt	39,274,318	67,208	25,138	0	39,366,664
Sudan	1,839,784	0	0	0	1,839,784
Total	58,592,402	668,098	25,138	0	83,295,977
					4.3%

[a]U.S. Department of Commerce (22).

[b]All amounts in bushels.

Table 40. West Africa: 1966 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Canary Islands	1,419,016[b]	2,916,295	237,961	81,242	4,654,514
Cameroon	184	14,754	0	0	14,938
Senegal	83,408	235,134	833,416	0	1,151,958
Sierra Leone	0	1,127	0	0	1,127
Ivory Coast	0	25,764	3,961	0	29,725
Ghana	0	274,039	174,302	0	448,341
Nigeria	5,381,210	13,427	19,814	0	5,414,451
Western African States	0	13,909	507,501	0	521,410
Madeira Islands	443,400	0	0	0	443,400
Angola	292,000	8,482	1,682	0	302,164
Liberia	0	6,604	0	0	6,604
Congo	14,410	11,783	0	0	26,193
Burundi and Rwanda	0	1,877	0	0	1,877
Total	7,633,628	3,523,195	1,778,637	81,242	13,016,702
					.7%

[a]U.S. Department of Commerce (22).

[b]All amounts in bushels.

Table 41. Eastern Africa: 1966 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Ethiopia	402,661[b]	7,522	101,863	0	512,046
Uganda	344	5,811	0	0	6,155
Kenya	1,350,098	4,299,832	357	0	5,650,287
Tanzania	112,000	385,547	80,411	0	577,958
Mozambique	0	8,324	0	0	8,324
Malagasy Republic	20,621	0	0	0	20,621
Total	1,885,724	4,707,036	182,631	0	6,775,391
					.3%

[a]U. S. Department of Commerce (22).

[b]All amounts in bushels.

Table 42. Southern Africa: 1966 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Republic of South Africa	14,728,475[b]	5,935,902	117,068	0	20,781,445
Zambia	270,442	0	0	0	270,442
Rhodesia	694,251	0	0	0	694,251
Malawi	0	635	0	0	635
Total	15,693,168	5,936,537	117,068	0	21,746,773
					1.1%

[a]U. S. Department of Commerce (22).

[b]All amounts in bushels.

Table 43. Canada: 1958 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Canada	105,097[b]	10,567,746	0	9,938,735	20,611,578
					3.2%

[a]U.S. Department of Commerce (21).

[b]All amounts in bushels.

Table 44. Central America and Caribbean Area: 1958 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Mexico	0[b]	14,231,969	1,201	226,961	14,460,131
Guatemala	946,314	71,964	0	0	1,018,278
British Honduras	15,100	334	0	0	15,434
El Salvador	93,475	398,924	0	0	492,399
Honduras	192,009	3,598	10,087	0	205,694
Costa Rica	128,184	0	901	0	129,085
Panama	0	0	40,000	0	40,000
Canal Zone	0	17	218	0	235
Bahamas	0	4,306	0	0	4,306
Cuba	3,425,991	2,453,555	65,823	168	5.945,537
Jamaica	333	445,990	56,653	0	502,976
Haiti	462,141	0	0	0	462,141
Dominican Republic	49,538	0	0	0	49,538
Leeward and Windward Is.	1,670	714	0	0	2,384
Barbados	2,358	0	0	0	2,358
Trinidad and Tobago	8,416	10,146	3,946	0	22,508
Netherlands Antilles	0	40,486	0	0	40,486
Total	5,325,529	17,662,003	178,825	227,129	23,393,490
					3.6%

[a]U.S. Department of Commerce (21).

[b]All amounts in bushels.

Table 45. Western South America: 1958 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Colombia	2,610,237[b]	5	395	0	2,610,636
Ecuador	507,308	0	0	0	507,308
Peru	3,624,759	887,824	157,471	0	4,670,054
Bolivia	184,863	0	0	0	184,863
Total	6,927,166	887,829	157,866	0	7,972,861
					1.2%

[a]U.S. Department of Commerce (21).

[b]All amounts in bushels.

Table 46. Eastern South America: 1958 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Venezuela	1,933,529[b]	5,305	1,911	36,721	1,977,466
British Guiana	0	556	0	0	556
Surinam	0	107	0	0	107
Brazil	16,379,898	0	0	0	16,379,898
Uruguay	0	401	0	0	401
Argentina	0	122	251	0	373
Total	18,313,427	6,491	2,162	36,721	18,358,801
					2.8%

[a]U.S. Department of Commerce (21).

[b]All amounts in bushels.

Table 47. Northwestern and Central Europe: 1958 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Sweden	1,959,673[b]	436,103	978,023	0	3,373,799
Norway	1,750,619	1,886,098	2,210,886	990,890	6,838,493
Denmark	1,032,789	760,492	6,622,018	4,524,997	12,940,296
United Kingdom	24,136,577	55,565,776	13,825,253	1,709,136	95,236,742
Ireland	876,659	235,433	0	0	1,112,092
Netherlands	6,509,448	22,306,061	17,047,121	11,228,420	57,091,050
Belgium and Luxembourg	3,386,639	9,619,581	11,565,135	3,299,148	27,870,503
France	0	1,618,116	24,607	1,602,855	3,245,578
West Germany	20,643,768	4,821,537	4,045,178	9,866,730	39,377,213
Austria	1,167,461	4,562,379	0	0	5,729,840
Czechoslovakia	0	13,130	0	74,666	87,796
Hungary	0	32,490	18	0	32,508
Switzerland	268,797	84,518	238,000	392,936	984,251
Finland	2,171,482	178	0	0	2,171,660
Total	63,903,912	101,941,892	56,556,239	33,689,778	256,091,821
					39.8%

[a]U. S. Department of Commerce (21).

[b]All amounts in bushels.

Table 48. Northeastern and Southern Europe: 1958 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Poland and Danzig	11,804,233[b]	1,939,692	791,977	349,133	14,885,035
Spain	0	1,631,007	777,780	0	2,408,787
Portugal	115,100	309	0	119	115,528
Malta, Gozo, and Cypress	368,600	0	0	0	368,600
Italy	372,400	58,780	1,853	766,162	1,199,195
Yugoslavia	23,227,923	25,986	0	0	23,253,909
Greece	2,920,081	3,204,869	0	0	6,124,950
Rumania	0	82,072	1,206	0	83,278
Bulgaria	0	1,178	0	0	1,178
Turkey	9,686,333	1,625,183	0	0	11,311,516
Total	48,494,670	8,569,076	1,572,816	1,115,414	59,751,976 9.3%

[a]U. S. Department of Commerce (21).

[b]All amounts in bushels.

Table 49. Western Asia: 1958 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
United Arab Republic	0[b]	360	0	0	360
Lebanon	1,576,141	144	0	0	1,576,285
Iraq	0	541	0	0	541
Iran	593,510	0	0	0	593,510
Israel	7,220,561	1,328,307	9,188,930	3,528,482	21,266,280
Jordan	496,533	200	772,520	0	1,269,253
Saudi Arabia	51,382	1,045	0	0	52,427
State of Bahrain	0	200	0	0	200
Total	9,938,127	1,330,797	9,961,450	3,528,482	24,758,856
					3.8%

[a]U.S. Department of Commerce (21).

[b]All amounts in bushels.

Table 50. Eastern Asia: 1958 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Korea	17,258,880[b]	932,640	1,755,266	5,474	19,952,260
Hong Kong	357,649	232	0	31,808	389,689
Taiwan	8,456,738	31,496	0	3,754,643	12,242,877
Japan	38,868,704	14,114,726	0	28,784,639	81,768,069
Nansei and Nampo Is.	375,399	380	0	837	376,616
Total	65,317,370	15,079,474	1,755,266	32,577,401	114,729,511
					17.8%

[a]U.S. Department of Commerce (21).

[b]All amounts in bushels.

Table 51. Southern and Southeastern Asia: 1958 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Afghanistan	723,966[b]	0	0	0	723,966
India	80,664,964	2,614,150	3,102,051	0	86,381,165
Pakistan	25,781,922	0	0	0	25,781,922
Thailand	0	96	0	0	96
Colony of Singapore and British Borneo	0	712	2,011	0	2,723
Republic of the Philippines	394,017	96	0	70,978	465,091
Total	107,564,869	2,615,054	3,104,062	70,978	113,354,963
					17.6%

[a]U. S. Department of Commerce (21).

[b]All amounts in bushels.

Table 52. Australia and Oceania: 1958 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
New Zealand	0[b]	783	0	0	783

[a]U. S. Department of Commerce (21).

[b]All amounts in bushels.

Table 53. North Africa: 1958 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Morocco	754,530[b]	1,316	0	0	755,846
Algeria	0	539	0	0	539
Tunisia	1,073,629	0	0	0	1,073,629
Libya	55,115	119	0	0	55,234
Total	1,883,274	1,974	0	0	1,885,248
					0.3%

[a]U. S. Department of Commerce (21).

[b]All amounts in bushels.

Table 54. West Africa: 1958 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Canary Islands	0[b]	654,200	0	0	654,200
Spanish Africa	0	54	0	0	54
Fr. West Africa and Republic of Toga	370,500	108	276,195	0	646,803
Ghana	0	197,980	0	0	197,980
Total	370,500	852,342	276,195	0	1,499,037
					0.2%

[a]U. S. Department of Commerce (21).

[b]All amounts in bushels.

Table 55. Eastern Africa: 1958 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
British East Africa	0[b]	238			238
Mozambique	787,132	0	0	0	787,132
Total	787,132	238	0	0	787,370
					0.1%

[a]U. S. Department of Commerce (21).

[b]All amounts in bushels.

Table 56. Southern Africa: 1958 imports of heavy grain from the United States[a]

Country	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Federation of Rhodesia and Nyasaland	37,332[b]	0	0	0	37,332

[a]U. S. Department of Commerce (21).

[b]All amounts in bushels.

APPENDIX B. 1958 AND 1966 SHIPMENTS OF HEAVY GRAIN FROM THE UNITED STATES BY PORT AND PORT REGION

Table 57. Atlantic Coast ports: 1958 shipments of heavy grains[a]

Origin Port	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Portland, Maine	93,333[b]	418,000	0	0	511,333
Boston	6,467,774	2,852,698	0	0	9,320,472
Buffalo	105,097	100,000	0	0	205,097
New York	6,860,378	1,160,266	11,604	76,339	8,108,587
Albany	14,972,859	1,188,765	0	0	16,161,624
Philadelphia	16,194,563	6,163,917	0	1,118,377	23,476,857
Baltimore	19,959,655	13,580,388	0	6,372,808	39,912,851
Norfolk	16,739,758	18,573,774	1,224	7,202,128	42,516,884
Newport News	0	200	0	20,014	20,214
Morehead City	0	399,407	0	0	399,407
Charleston	0	0	0	833	833
Jacksonville	0	4,306	0	0	4,306
Total	81,393,417	44,441,721	12,828	14,790,499	140,638,465

[a]U.S. Department of Commerce (21).

[b]All amounts in bushels.

Table 58. Atlantic Coast ports: 1966 shipments of heavy grains[a]

Origin Port	Code	Commodity				
		Wheat	Corn	Sorghum Grains	Soybeans	Total
Portland, Maine	101	4,156,688[b]	0	0	0	4,156,688
Boston, Mass.	401	0	103,948	63,933	3,067	180,948
Gloucester	404	460	396	0	0	856
New York	1001	138,909	834,993	372,724	28,336	1,374,962
Albany	1002	12,248,863	2,501,200	0	0	14,750,063
Philadelphia	1101	14,594,284	11,817,116	39,368	1,541,013	27,991,781
Paulsboro, N.J.	1105	142,500	0	0	0	142,500
Camden, N.J.	1107	141,672	386,786	0	74,667	603,125
Baltimore	1303	46,706,443	13,225,269	206,465	2,042,665	62,180,842
Norfolk, Va.	1401	24,329,612	29,916,780	0	4,633,022	58,879,414
Charleston, S.C.	1601	1,737,589	975,937	0	6,588,743	9,302,269
Brunswick	1701	361,667	0	0	0	361,667
Jacksonville	1803	0	78,504	0	0	78,504
Miami	5201	4,050	43,218	341	0	41,111
W. Palm Beach	5204	0	0	1,393	0	1,393
Total		104,558,687	59,881,699	684,224	14,921,513	180,046,123

[a]U.S. Department of Commerce (22).

[b]All amounts in bushels.

Table 59. Gulf Coast ports: 1958 shipments of heavy grains[a]

Origin Port	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Tampa	0[b]	2,702	0	0	2,702
Pensacola	3,925	61,681	25,041	0	90,647
Mobile	7,390,518	12,339,239	1,435	8,653,285	28,384,477
New Orleans	27,574,544	43,539,849	982,524	35,414,806	107,511,723
Baton Rouge	16,214,754	20,302,819	0	12,125,880	48,643,453
Destrehan	149,230	0	0	0	149,230
Port Arthur	15,965,526	4,109,815	12,840,488	0	32,915,829
Galveston	48,011,696	9,891,227	18,973,558	0	76,876,481
Houston	42,988,172	3,110,069	20,087,819	0	66,186,060
Corpus Christi	618,050	2,357,221	18,305,926	0	21,281,197
Total	158,916,415	95,714,622	71,216,791	56,193,971	382,041,799

[a]U. S. Department of Commerce (21).

[b]All amounts in bushels.

Table 60. Gulf Coast ports: 1966 shipments of heavy grains[a]

Origin Port	Code	Commodity: Wheat (41)	Corn (44)	Sorghum Grain (46)	Soybeans (223)	Total
Mobile	1901	2,920,492[b]	18,605,243	349,719	9,643,566	31,519,020
Pascagoula	1903	4,669,406	37,168,729	237,168,729	20,540,037	86,094,336
Panama City, Fla.	1907	0	0	0	78,882	78,882
Morgan City, La.	2001	0	0	0	151,500	151,500
New Orleans	2002	56,735,424	134,572,894	1,157,087	48,480,579	240,945,984
Baton Rouge	2004	30,685,828	56,503,416	1,718,938	31,191,780	120,099,962
Port Sulphur	2005	36,706	0	0	0	36,706
Destrehan, La.	2009	27,387,273	115,703,897	3,434,618	62,117,360	208,643,148
St. Rose, La.	2013	41,520	0	0	0	41,520
Port Arthur, Tex.	2101	53,042,599	0	15,071,662	0	68,114,261
Beaumont, Tex.	2104	62,405,653	0	11,869,880	1,095,842	75,371,375
Lake Charles, La.	2105	27,440	0	0	0	27,440
Galveston	2201	57,881,138	399,608	50,727,846	43,270	109,051,862
Freeport	2204	37,045	0	150,584	0	187,629
Corpus Christi	2205	8,532,135	0	94,529,621	123,200	103,184,956
Brownsville	2301	0	0	6,467,438	0	6,467,438
Houston	5301	193,134,693	408,900	40,993,817	0	234,537,410
San Juan	4909	0	9,611	1,080	0	10,691
Total		497,537,352	363,372,298	250,188,454	173,466,016	1,284,564,120

[a]U. S. Department of Commerce (22).

[b]All amounts in bushels.

Table 61. Pacific Coast ports: 1958 shipments of heavy grains[a]

Origin Port	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Los Angeles	315,035[b]	1,000	0	0	316,035
Long Beach	308,000	0	0	0	308,000
San Francisco	313,610	752,617	200,000	0	1,266,227
Stockton	1,144,819	2,554,969	1,908,593	0	5,608,108
Oakland	447,398	120,855	226,673	0	904,926
Alameda	0	232	0	0	232
Astoria, Ore.	1,776,732	0	0	0	1,776,732
Portland	39,515,533	195,865	0	0	39,711,398
Longview, Wash.	10,909,544	417,122	0	0	11,326,666
Vancouver	11,301,913	110,236	0	0	11,412,149
Seattle	13,408,102	141	0	0	13,408,243
Tacoma	9,072,887	0	0	0	9,072,887
Total	88,623,573	4,152,764	2,335,266	0	95,111,603

[a] U. S. Department of Commerce (21).

[b] All amounts in bushels.

Table 62. Pacific Coast ports: 1966 shipments of heavy grains[a]

Origin Port	Code	Commodity				
		Wheat (41)	Corn (44)	Sorghum Grain (46)	Soybeans (223)	Total
Los Angeles	2704	50,369[b]	22,080	78,275	0	150,724
Long Beach	2709	373,038	3,586	36,176,710	0	36,553,334
San Francisco	2809	338,756	305,454	665	1,270	646,145
Stockton	2810	1,325,901	859,562	5,526,672	0	7,712,135
Oakland	2811	0	3,876	3,546	0	7,422
Alameda	2813	0	3,566	0	0	3,566
Sacramento	2816	0	0	32,000	0	32,000
Astoria, Oregon	2901	3,836,131	0	0	0	3,836,131
Coos Bay, Oregon	2903	496,035	0	0	0	496,035
Portland	2904	77,710,263	2,618	0	0	77,712,881
Longview, Wash.	2905	28,850,044	0	0	0	28,850,044
Vancouver, Wash.	2908	22,519,036	20	0	0	22,519,056
Kalma, Wash.	2909	18,710,599	20,000	0	0	18,730,599
Seattle	3001	26,574,494	82,621	0	0	26,657,115
Tacoma	3002	16,127,935	0	0	0	16,127,935
Everett	3006	548,793	0	0	0	548,793
Total		197,465,444	1,305,831	41,817,868	1,270	240,590,413

[a]U. S. Department of Commerce (22).

[b]All amounts in bushels.

Table 63. Great Lakes ports: 1958 shipments of heavy grains[a]

Origin Port	Commodity				
	Wheat	Corn	Sorghum Grain	Soybeans	Total
Duluth	0[b]	1,369,585	0	0	1,369,585
Superior	35,000	3,295,373	0	0	3,330,373
Milwaukee	0	792	0	0	792
Saginaw-Bay City	0	118,000	0	0	118,000
Ludington	0	0	0	518,328	518,328
Chicago	0	8,612,131	0	6,021,075	14,633,206
Geary	0	0	0	226,961	226,961
Toledo	0	1,810,711	0	3,433,804	5,244,515
Total	35,000	15,206,592	0	10,200,168	25,441,760

[a]U. S. Department of Commerce (21).

[b]All amounts in bushels.

Table 64. Great Lakes ports: 1966 shipments of heavy grains[a]

Origin Port	Code	Commodity: Wheat (41)	Corn (44)	Sorghum Grain (46)	Soybeans (223)	Total
Duluth	3601	5,393,629[b]	14,004,686	0	3,840,205	23,238,520
Superior	3608	36,227,870	20,545,090	0	6,780,468	63,553,428
Milwaukee	3701	295,253	12,789,816	0	959,676	14,044,745
Chicago	3901	403,396	57,118,189	253,220	19,143,370	76,918,175
Detroit	3801	0	27,843	0	0	27,843
Toledo	4105	8,004,675	24,474,225	0	27,087,770	59,566,670
Port Huron	3802	0	38,909	0	0	38,909
Saginaw-Bay City	3804	1,843,513	252,506	0	630,450	2,726,469
Total		52,168,336	129,251,264	253,220	58,441,939	240,114,759

[a]U. S. Department of Commerce (22).

[b]All amounts in bushels.

APPENDIX C. OPTIMAL SHIPPING PATTERNS FOR HEAVY GRAIN EXPORTS FROM THE UNITED STATES

Table 65. Optimal shipping pattern for wheat: model I

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0[a]	8,764,723	0	0
Western South America	0	32,222,532	0	0
Eastern South America	0	62,321,338	0	0
Northwestern & Central Europe	0	95,524,929	0	7,947,366
Northeastern & Southern Europe	0	109,311,734	0	0
Western Asia	0	27,763,465	0	0
Eastern Asia	0	71,761,635	197,465,444	0
Southern & Southeastern Asia	45,966,285	64,654,476	0	18,232,868
Australia and Oceania	0	0	0	0
Northern Africa	58,592,402	0	0	0
Western Africa	0	7,633,628	0	0
Eastern Africa	0	1,885,724	0	0
Southern Africa	0	15,693,168	0	0

[a]All amounts in bushels.

Table 66. Optimal shipping pattern for corn: model I

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0[a]	3,260,009	0	0
Western South America	0	1,949,968	0	0
Eastern South America	0	1,214,008	0	0
Northwestern & Central Europe	0	187,905,095	0	54,478,828
Northeastern & Southern Europe	0	134,785,794	0	0
Western Asia	0	10,359,226	0	0
Eastern Asia	0	9,698,351	1,305,831	0
Southern & Southeastern Asia	59,881,699	0	0	0
Australia and Oceania	0	32,482	0	0
Northern Africa	0	0	0	668,098
Western Africa	0	3,523,195	0	0
Eastern Africa	0	4,707.036	0	0
Southern Africa	0	5,936,537	0	0

[a]All amounts in bushels.

Table 67. Optimal shipping pattern for grain sorghum: model I

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0	303,976	0	0
Western South America	0	378,449	0	0
Eastern South America	0	447,862	0	0
Northwestern & Central Europe	0	98,760,043	0	0
Northeastern & Southern Europe	0	11,592,051	0	0
Western Asia	0	16,324,387	0	0
Eastern Asia	0	36,499,671	41,817,868	0
Southern & Southeastern Asia	684,224	82,646,102	0	0
Australia and Oceania	0	0	0	0
Northern Africa	0	0	0	25,138
Western Africa	0	1,778,637	0	0
Eastern Africa	0	182,631	0	0
Southern Africa	0	117,068	0	0

[a]All amounts in bushels.

Table 68. Optimal shipping pattern for soybeans: model I

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0	334	0	0
Western South America	44,351	0	0	0
Eastern South America	0	1,099,596	0	0
Northwestern & Central Europe	0	69,449,884	0	32,470,547
Northeastern & Southern Europe	0	32,018,666	0	0
Western Asia	0	10,206,789	0	0
Eastern Asia	0	695,767	1,270	0
Southern & Southeastern Europe	14,877,162	59,893,722	0	0
Australia and Oceania	0	20,016	0	0
Northern Africa	0	0	0	0
Western Africa	0	81,242	0	0
Eastern Africa	0	0	0	0
Southern Africa	0	0	0	0
Total cost of transportation of wheat, corn, grain sorghum and soybeans = $729,881,836				

[a]All amounts in bushels.

Table 69. Optimal shipping pattern for wheat: model II

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0[a]	8,764,723	0	0
Western South America	0	64,445,064	0	0
Eastern South America	0	124,642,676	0	0
Northwestern & Central Europe	0	103,472,295	0	0
Northeastern & Southern Europe	0	109,311,734	0	0
Western Asia	0	27,763,465	0	0
Eastern Asia	0	0	269,227,079	0
Southern & Southeastern Asia	0	110,620,761	0	0
Australia and Oceania	0	0	1	0
Northern Africa	104,558,687	0	0	188,403,323
Western Africa	0	38,168,140	0	0
Eastern Africa	0	1,885,724	0	0
Southern Africa	0	78,465,840	0	0

[a]All amounts in bushels.

Table 70. Optimal shipping pattern for corn: model II

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0[a]	3,260,609	0	0
Western South America	0	3,899,936	0	0
Eastern South America	0	2,428,016	0	0
Northwestern & Central Europe	0	242,383,920	0	0
Northeastern & Southern Europe	0	269,571,588	0	0
Western Asia	0	20,718,452	0	0
Eastern Asia	0	20,702,533	1,305,831	0
Southern & Southeastern Asia	59,881,699	0	0	18,232,868
Australia and Oceania	0	324,820	0	0
Northern Africa	0	0	0	6,680,980
Western Africa	0	3,523,195	0	0
Eastern Africa	0	47,070,360	0	0
Southern Africa	0	59,365,370	0	0

[a]All amounts in bushels.

Table 71. Optimal shipping pattern for grain sorghum: model II

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0	303,976	0	0
Western South America	0	756,898	0	0
Eastern South America	0	895,724	0	0
Northwestern & Central Europe	0	98,760,043	0	0
Northeastern & Southern Europe	0	11,592,051	0	0
Western Asia	0	81,621,935	0	0
Eastern Asia	0	213,679,829	334,542,944	0
Southern & Southeastern Asia	8,210,688	325,110,616	0	0
Australia and Oceania	0	1	0	0
Northern Africa	0	0	0	251,380
Western Africa	0	3,557,274	0	0
Eastern Africa	0	1,826,310	0	0
Southern Africa	0	1,170,680	0	0

[a]All amounts in bushels.

Table 72. Optimal shipping pattern for soybeans: model II

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0[a]	1,000	0	0
Western South America	88,702	0	0	0
Eastern South America	0	2,199,192	0	0
Northwestern & Central Europe	0	101,920,431	0	0
Northeastern & Southern Europe	0	64,037,332	0	0
Western Asia	0	10,206,789	0	0
Eastern Asia	0	684,337	12,700	0
Southern & Southeastern Asia	14,832,811	134,708,957	0	0
Australia and Oceania	0	200,160	0	0
Northern Africa	0	0	0	1
Western Africa	0	812,420	0	0
Eastern Africa	0	1	0	0
Southern Africa	0	1	0	0
Total cost of transportation of wheat, corn, grain sorghum and soybeans = $1,523,599,704				

[a]All amounts in bushels.

Table 73. Optimal shipping pattern for wheat: model III

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0[a]	131,470,845	0	0
Western South America	0	64,445,064	0	0
Eastern South America	0	124,642,676	0	0
Northwestern & Central Europe	0	0	0	103,472,295
Northeastern & Southern Europe	0	163,967,601	0	0
Western Asia	25,366,023	391,085,952	0	0
Eastern Asia	0	0	269,227,079	0
Southern & Southeastern Asia	40,227,333	0	125,703,808	0
Australia and Oceania	0	0	1	0
Northern Africa	38,965,331	0	0	253,996,679
Western Africa	0	38,168,140	0	0
Eastern Africa	0	2,828,586	0	0
Southern Africa	0	78,465,840	0	0

[a]All amounts in bushels.

Table 74. Optimal shipping pattern for corn: model III

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0[a]	48,909,135	0	0
Western South America	0	3,899,936	0	0
Eastern South America	0	12,140,080	0	0
Northwestern & Central Europe	0	0	0	363,575,588
Northeastern & Southern Europe	0	506,729,930	0	167,199,040
Western Asia	0	20,718,452	0	0
Eastern Asia	0	20,702,533	1,305,831	0
Southern & Southeastern Asia	59,881,699	0	0	6,680,980
Australia and Oceania	0	162,410	0	0
Northern Africa	0	0	0	0
Western Africa	0	7,046,390	0	0
Eastern Africa	0	47,070,360	0	0
Southern Africa	0	59,365,370	0	0

[a]All amounts in bushels.

Table 75. Optimal shipping pattern for grain sorghum: model III

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0[a]	4,559,640	0	0
Western South America	0	756,898	0	0
Eastern South America	0	4,478,620	0	0
Northwestern & Central Europe	0	95,723,530	0	3,036,513
Northeastern & Southern Europe	0	18,080,028	0	5,104,073
Western Asia	0	81,621,935	0	0
Eastern Asia	0	213,679,809	334,542,944	0
Southern & Southeastern Asia	8,210,688	325,110,616	0	0
Australia and Oceania	0	1	0	0
Northern Africa	0	0	0	251,380
Western Africa	0	3,557,274	0	0
Eastern Africa	0	1.826.310	0	0
Southern Africa	0	1,170,680	0	0

[a]All amounts in bushels.

Table 76. Optimal shipping pattern for soybeans: model III

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0[a]	1,000	0	0
Western South America	88,702	0	0	0
Eastern South America	0	5,497,980	0	0
Northwestern & Central Europe	0	0	0	152,880,646
Northeastern & Southern Europe	0	100,824,471	0	59,268,859
Western Asia	0	153,101,835	0	0
Eastern Asia	0	1,032,855	12,700	0
Southern & Southeastern Asia	14,832,811	172,094,399	0	0
Australia and Oceania	0	100,080	0	0
Northern Africa	0	0	0	100,000
Western Africa	0	812,420	0	0
Eastern Africa	0	100,000	0	0
Southern Africa	0	100,000	0	0
Total cost of transportation of wheat, corn, grain sorghum and soybeans = $2,257,505,597				

[a]All amounts in bushels.

Table 77. Optimal shipping pattern for wheat: model IV

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0[a]	8,764,723	0	0
Western South America	0	32,222,532	0	0
Eastern South America	0	62,321,338	0	0
Northwestern & Central Europe	70,371,156	33,101,139	0	0
Northeastern & Southern Europe	0	109,311,734	0	0
Western Asia	27,763,465	0	0	0
Eastern Asia		71,761,635	197,465,444	0
Southern & Southeastern Asia	0	110,620,761	0	0
Australia and Oceania	0	0	0	0
Northern Africa	6,424,066	0	0	52,168,336
Western Africa	0	7,633,628	0	0
Eastern Africa	0	1,885,724	0	0
Southern Africa	0	15,693,168	0	0

[a]All amounts in bushels.

Table 78. Optimal shipping pattern for corn: model IV

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0	3,260,609	0	0
Western South America	0	1,949,968	0	0
Eastern South America	0	1,214,008	0	0
Northwestern & Central Europe	0	198,264,318	0	44,119,602
Northeastern & Southern Europe	0	134,785,794	0	0
Western Asia	10,359,226	0	0	0
Eastern Asia	0	9,698,351	1,305,831	0
Southern & Southeastern Asia	0	0	0	28,592,094
Australia and Oceania	0	32,482	0	0
Northern Africa	0	0	0	668,098
Western Africa	0	3,523,195	0	0
Eastern Africa	0	4,707,036	0	0
Southern Africa	0	5,936,537	0	0

[a]All amounts in bushels.

Table 79. Optimal shipping pattern for grain sorghum: model IV

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0	303,976	0	0
Western South America	0	378,449	0	0
Eastern South America	0	447,862	0	0
Northwestern & Central Europe	0	98,760,043	0	0
Northeastern & Southern Europe	0	11,592,051	0	0
Western Asia	684,224	15,640,163	0	0
Eastern Asia	0	36,499,671	41,817,868	0
Southern & Southeastern Asia	0	83,330,326	0	0
Australia and Oceania	0	0	0	0
Northern Africa	0	0	0	25,138
Western Africa	0	1,778,637	0	0
Eastern Africa	0	182,631	0	0
Southern Africa	0	117,068	0	0

[a]All amounts in bushels.

Table 80. Optimal shipping pattern for soybeans: model IV

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	0	334	0	0
Western South America	44,351	0	0	0
Eastern South America	0	1,099,596	0	0
Northwestern & Central Europe	4,670,373	64,779,511	0	32,470,547
Northeastern & Southern Europe	0	32,018,666	0	0
Western Asia	10,206,789	0	0	0
Eastern Asia	0	695,767	1,270	0
Southern & Southeastern Asia	0	74,770,884	0	0
Australia and Oceania	0	20,016	0	0
Northern Africa	0	0	0	0
Western Africa	0	81,242	0	0
Eastern Africa	0	0	0	0
Southern Africa	0	0	0	0
Total cost of transportation of wheat, corn, grain sorghum and soybeans = $529,610,936				

[a]All amounts in bushels.

APPENDIX D. ACTUAL SHIPPING PATTERNS FOR UNITED STATES HEAVY GRAIN EXPORTS: 1966

Table 81. Actual shipping pattern for wheat: 1966[a]

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	388,400[b]	6,144,890	929,512	739,157
Western South America & Eastern South America	6,842,384	83,159,426	2,808,953	1,531,019
Northwestern & Central Europe	15,705,290	68,733,270	4,234,402	15,071,436
Northeastern & Southern Europe	5,442,768	101,339,621	0	2,532,345
Western Asia	2,199,674	20,679,220	4,251,146	614,878
Eastern Asia	51,544,627	103,938,951	86,308,930	3,256,827
Southern & Southeastern Asia	5,285,708	9,926,710	92,475,002	0
Australia and Oceania	0	0	0	0
Northern Africa	14,981,851	57,861,610	852,000	8,723,259
Western Africa	709,267	6,611,573	0	275,743
Eastern Africa	18,652	6,302,272	0	0
Southern Africa	350	15,692,818	0	0

[a]U.S. Department of Commerce (22).

[b]All amounts in bushels.

Table 82. Actual shipping pattern for corn: 1966[a]

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	325,557[b]	2,913,912	113,680	1,148
Western South America & Eastern South America	300,981	2,860,580	40	0
Northwestern & Central Europe	43,563,982	130,736,488	28,850	67,952,341
Northeastern & Southern Europe	9,387,417	123,721,232	0	1,675,924
Western Asia	71,810	9,649,157	0	197,105
Eastern Asia	1,546,155	8,694,399	0	0
Southern & Southeastern Asia	481,208	72,857,830	867,825	3,606,052
Australia and Oceania	164	28,000	4,224	0
Northern Africa	654,783	13,315	0	0
Western Africa	222,724	3,282,699	0	17,772
Eastern Africa	1,610,055	3,096,981	0	0
Southern Africa	1,169,519	4,765,422	1,596	0

[a]U.S. Department of Commerce (22).

[b]All amounts in bushels.

Table 83. Actual shipping pattern for grain sorghum: 1966[a]

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	341[b]	282,309	0	0
Western South America & Eastern South America	27,052	1,387,500	0	0
Northwestern & Central Europe	324,834	96,171,995	0	0
Northeastern & Southern Europe	0	11,584,537	0	0
Western Asia	0	16,324,386	0	0
Eastern Asia	184,809	73,683,741	0	0
Southern & Southeastern Asia	0	40,717,734	41,703,382	0
Australia and Oceania	0	0	0	0
Northern Africa	0	25,138	0	0
Western Africa	33,690	1,594,363	0	0
Eastern Africa	2,343	180,288	0	0
Southern Africa	6,461	110,607	0	0

[a]U.S. Department of Commerce (22).

[b]All amounts in bushels.

Table 84. Actual shipping pattern for soybeans: 1966[a]

To/From	Atlantic Coast	Gulf Coast	Pacific Coast	Great Lakes
Central America & the Caribbean	82[b]	252	0	0
Western South America & Eastern South America	0	555,706	0	0
Northwestern & Central Europe	9,562,819	91,710,118	0	10,392,413
Northeastern & Southern Europe	1,931,380	26,002,019	0	4,085,267
Western Asia	1,147,568	9,059,221	0	0
Eastern Asia	0	697,037	0	0
Southern & Southeastern Asia	2,294,855	54,442,212	0	17,992,865
Australia and Oceania	11,110	2,054	852	0
Northern Africa	0	0	0	0
Western Africa	0	0	0	0
Eastern Africa	0	0	0	0
Southern Africa	0	0	0	0

[a]U.S. Department of Commerce (22).

[b]All amounts in bushels.

APPENDIX E. CARGO PREFERENCE ACT

CARGO PREFERENCE ACT OF 1954

(68 Stat. 832)

Public Law 664 Chapter 936

An Act

To amend the Merchant Marine Act, 1936, to provide permanent legislation for the transportation of a substantial portion of waterborne cargoes in United States-flag vessels.

Be it enacted by the Senate and the House of Representatives of the United States of America in Congress assembled, that section 901 of the Merchant Marine Act, 1936, as amended, is hereby amended by inserting "a" after "Sec. 901." and by adding at the end of the section the following new subsection: "(b) whenever the United States shall procure, contract for, or otherwise obtain for its own account, or shall furnish to or for the account of any foreign nation without provision for reimbursement, any equipment, materials, or commodities, within or without the United States, or shall advance funds or credits or guarantee the convertibility of foreign currencies in connection with the furnishing of such equipment, materials, or commodities, the appropriate agency or agencies shall take such steps as may be necessary and practicable to assure that at least 50 per centum of the gross tonnage of such equipment, materials, or commodities (computed separately for dry bulk carriers, dry cargo liners, and tankers), which may be transported on ocean vessels shall be transported on privately owned United States-flag commercial vessels, to the extent such vessels are available at fair and reasonable rates for United States-flag commercial vessels, in such manner as will insure a fair and reasonable participation

of United States-flag commercial vessels in such cargoes by geographic areas: Provided, That the provisions of this subsection may be waived whenever the Congress by concurrent resolution or otherwise, or the President of the United States or the Secretary of Defense declares that an emergency exists justifying a temporary waiver of the provisions of section 901 (b) and so notifies the appropriate private agency or agencies: and provided further, That the provisions of this subsection shall not apply to cargoes carried in the vessels of the Panama Canal Company. Nothing herein shall repeal or otherwise modify the provisions of Public Resolution Numbered 17, Seventy-third Congress (48 Stat. 500), as amended."

Approved August 26, 1954.