ECONOMICS OF INTERNATIONAL WHEAT TRANSPORTATION SYSTEMS USING 1985 PRODUCTION AND CONSUMPTION ESTIMATES -- A LINEAR PROGRAMMING APPROACH

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APPROACH

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CHAPTER I

INTRODUCTION

World trade conditions for agriculture commodities have been favorable throughout the 1970's. From 1970 to 1979, total world trade of agriculture commodities increased from $51.6 billion to $199.3 billion as shown in Table I. During this expansionary process, the total dollar volume of United States agricultural trade rose from $6.9 billion to $31.9 billion, which constituted an increase in market share from 13.4 to 16.0 percent of total world agriculture trade. This is shown in Table II.

The important wheat exporters are the U.S., Canada, Argentina, and Australia. During the nineteen seventies, U.S. market share of world wheat exports rose from 47.98 to 52.45 percent, and averaged 52.99 percent for the ten year period. In terms of volume, the 9.3 percent increase in market share for U.S. exports from 1970 to 1979 is misleading, because the percentage increase in tonage was much greater than the percentage increase in market share. In achieving the 9.3 percent increase in market share during the expansionary period of the seventies, exports from the United States rose from 20.2 million metric tons in 1970 to 37.4 million metric tons in 1979, an 85 percent increase (Table III).

In 1970, Japan, India, the Republic of Korea, Pakistan, and the United Kingdom were the five largest importers of U.S. wheat.

TABLE I

VALUE OF TOTAL WORLD AGRICULTURE TRADE, 1970-79

Year	Billion Dollars
1979	199.3
1978	170.8
1977	151.8
1976	131.5
1975	122.5
1974	118.0
1973	95.5
1972	65.8
1971	55.3
1970	51.6

Sources: Food and Agriculture Organization of the United Nations, FAO Trade Yearbook, Vol. 29, (Rome, 1975).

Food and Agriculture Organization of the United Nations, FAO Trade Yearbook, Vol. 33, (Rome, 1979).

TABLE II

VALUE OF TOTAL U.S. AGRICULTURE EXPORTS AND WHEAT EXPORTS, 1970-79

Year	Total Agriculture Exports Mil.$	Wheat Exports Mil.$
1979	31,975	4,775
1978	27,290	4,071
1977	23,974	3,003
1976	22,760	4,740
1975	21,854	5,236
1974	21,608	4,605
1973	14,984	3,242
1972	8,242	1,124
1971	7,955	1,218
1970	6,958	997

Source: U.S. Department of Agriculture, U.S. Foreign Agricultural Trade Statistical Report, Fiscal Year 1980, ESS, (Washington, 1981).

TABLE III

THE FOUR MAJOR WHEAT EXPORTING NATIONS

Year	U.S.		Canada		Australia		Argentina		Total U.S. and Competitors Exports
	MMTs[a]	%	MMTs	%	MMTs	%	MMTs	%	MMTs
1970	20.2	47.98	11.8	28.02	9.1	21.61	1.0	2.37	42.1
1971	16.6	41.81	13.7	34.50	7.8	19.64	1.6	4.03	39.7
1972	30.9	57.11	15.7	29.02	4.3	7.94	3.2	5.91	54.1
1973	33.1	62.33	11.4	21.46	7.0	13.18	1.6	3.01	53.1
1974	27.7	56.76	10.7	21.19	8.6	17.62	1.8	3.68	48.8
1975	31.9	56.96	12.3	21.96	8.7	15.53	3.2	5.71	56.0
1976	25.9	47.34	13.4	24.49	9.5	17.36	5.9	10.78	54.7
1977	30.6	53.87	16.0	28.16	8.4	14.78	1.8	3.16	56.8
1978	32.5	53.01	13.1	21.37	11.7	19.08	4.1	6.68	61.3
1979	37.4	52.45	15.9	22.30	13.2	18.51	4.8	6.73	71.3
1970-79 Means		52.99		25.27		16.53		5.21	
1970-79 Percent Change	85.1%		34.7%		45%		380%		

[a]Million Metric Tons

Source: U.S. Department of Agriculture, Foreign Agriculture Circular, Grains, FAS, FG-25-81, (Washington, 1981).

However, during the seventies the United States experienced a change in the composition of the leading importers. The Soviet Union, Japan, Mainland China, the Republic of Korea and Brazil comprised the five leading importers of U.S. wheat by 1979. Table IV corresponds with these changes in composition. India, the United Kingdom, and West Germany ceased to be major importers of U.S. wheat by 1979.

India, the second largest importer of U.S. wheat in 1970, has become self sufficient as a wheat producer in the late seventies. The introduction of new high-yielding wheat varieties and new irrigation techniques were the primary factors surrounding India's ability to meet its own needs.

The reduction of U.S. imports by the European Community stems largely from the creation of the Common Agriculture Policy (CAP). CAP, a price setting policy, has given France a comparative advantage in exporting wheat to other European countries. However, the European Community mainly produces soft wheat which is less suitable for bread production. Webb indicates the European Community might still find it necessary to import Canadian or U.S. hard wheat.[1]

Most notably, the seventies brought forth the emergence of the centrally planned and less developed countries as prominent importers of U.S. wheat, and the decline of western Europe as a major market.

Problem Statement

In recent years the United States has experienced dramatic changes in composition of the import market participators for U.S. wheat. Through these changing times, the United States has been able to increase its market share. The comparative advantage of wheat

TABLE IV

LEADING NET IMPORTERS OF U.S. WHEAT, 1970 AND 1979

Countries*	1970 Million Metric Tons	1979 Million Metric Tons
USSR	---------	5,372,718
Japan	2,758,675	3,351,384
India	2,324,438	---------
Egypt	---------	1,938,070
Korea	1,338,225	1,678,286
China, Mainland	---------	1,603,626
Pakistan	1,151,912	409,380
United Kingdom	928,416	---------
West Germany	691,683	---------
Brazil	654,767	1,529,259
Mexico	---------	1,180,115
Netherlands[a]	---------	1,082,496
Turkey	647,764	---------
Venezuela	591,079	732,778
Taiwan	555,914	773,209
Israel	512,795	552,888
Phillippines	505,587	909,823
Poland	---------	760,454
Saudi Arabia	---------	690,011
Iran	---------	610,858
Indonesia	480,266	597,634
Morocco	436,917	---------
Columbia	315,612	504,420
Chile	---------	577,640
Switzerland	289,332	---------
Portugal	287,162	554,740
Nigeria	270,146	940,633
Tunisia	269,028	---------
South Vietnam	257,639	---------

*Contains only the top 20 importers of U.S. wheat in 1970 and 1979.

[a]Includes transhipments of wheat to other countries.

Source: U.S. Department of Agriculture, U.S. Foreign Agricultural Trade Statistical Report, Calendar Year 1971; and Calendar Year 1979, ESS, (Washington, 1972 and 1980).

producers in the North American Hemisphere as indicated by Johnson,[2] and the comparative advantage of the U.S. Gulf over other exporting ports in South America and the Great Lakes region (with the exception of ports in Eastern Canada) as reported by Binkley and Harrer are cited for the increasing market share.[3]

Binkley and Harrer indicate a negative relationship between a shipping route's grain trade volume and shipping rates. The authors indicate this is a result of the relationship between trade volume and efficient port facilities. However, backhaul opportunities and ship maintenance are certainly factors to be considered. The implications concerning shipping rates could affect the overall trends in the composition of importing countries and their relative trade volume.[4] Furthermore, in his Ph.D. dissertation, "The Impact of Projected World Wheat Production - Consumption Balances on U.S. Exports and Prices", Webb inferred India, France, Brazil, and the Peoples Republic of China could be responsible for a shrinking world wheat market.[5] The advantage given to France by the policies in the CAP agreement, domestic policies in Brazil and the Republic of China, and a combination of domestic policies and the introduction of high yielding wheat varieties in India are primary factors listed by Webb as plausible reasons for a shrinking world wheat market.

Given a projected world demand for wheat and projected wheat supplies for 1985, it is important to examine the economic efficiency of the ocean transportation system for a major wheat exporting country. Specifically, the examination of economic efficiency of ocean transportation systems should include ocean transportation rates, handling, and port facilities. The identification of optimal trade routes between major wheat export and import regions could prove valuable for directing resources for more efficient usage under current market conditions, as well as, changing market conditions. Furthermore, economic analysis is necessary to indicate needed adjustments to current and changing economic and political conditions that could affect trade volume and/or the composition of importing countries.

Specifically the objectives are:

1. To develop a model of the world wheat market which considers export load-out capacities and import load-in capacities by regions, quantity and sizes of available ships capable of hauling wheat, shipping rates by ship size, and draft requirements of ports,
2. To identify an optimal solution of the least-cost flow of wheat given values for the parameters listed in objective 1,
3. To identify the range over which an activity or ocean freight rate can change without altering the optimal solution, and
4. To develop demand curves for transportation services.

Organization of Study

The remainder of this study will be divided into seven chapters. Chapter II will be a review of literature on Location

Theory. First, the fixed market approach and then the market area approach to location will be presented.

Chapter III will contain a review of transportation theory and the effects of improvements in transportation.

The general linear programming model and the general transportation model will be presented in Chapter IV. The remaining sections of the chapter will introduce the simplex procedure, sensitivity analysis, and parametric programming.

Chapter V will contain the procedures used to analyze the problem to meet the objectives listed in Chapter I. In Chapter VI there will be a discussion of the data used in the model.

The results of a simplex procedure, sensitivity analysis, and parametric programming will be given in Chapter VII, and the conclusion and comments will follow in Chapter VIII.

FOOTNOTES

[1]Alan J. Webb, "World Trade in Major U.S. Crops, A Market Share Analysis," United States Department of Agriculture, ESS-7 (Washington, 1981), p. 22.

[2]D. Gale Johnson, "The Impact of Freer Trade on North American Agriculture," American Journal of Agricultural Economics, LV (1973), p. 294.

[3]James K. Binkley and Bruce Harrer, "Major Determinants of Ocean Freight Rates for Grains: An Economic Analysis," American Journal of Agricultural Economics, LXIII (1981) pp. 54-55.

[4]Ibid., p. 56.

[5]Alan J. Webb, "The Impact of Projected World Wheat Production and Consumption Balances on U.S. Exports and Prices" (Unpublished Ph.D. Dissertation, Oklahoma State University, 1980), p. 91.

CHAPTER II

REVIEW OF LOCATION THEORY LITERATURE

The discussion of location theory will be divided into two distinct segments, according to the two classical approaches to location theory. First, the early contributions of Johann Heinrich von Thunen and Alfred Weber concerning the "fixed market" approach to location will be reviewed. Secondly, an account of the "market area" approach to location by August Losch, Walter Isard, and Edgar Hoover will be presented.

The Fixed Market Approach

An early upbringing in an agrarian environment apparently provided direction for von Thunen's career in agriculture. In 1803, while attending the Agriculture College at Gross-Flottberg in Holstein, von Thunen wrote the Description of Agriculture in the Village of Gross-Flottberg which proved to be the seeds of The Isolated State, published in 1826. Based upon the latter, von Thunen is generally acclaimed as founder of the economic theory of location.[1]

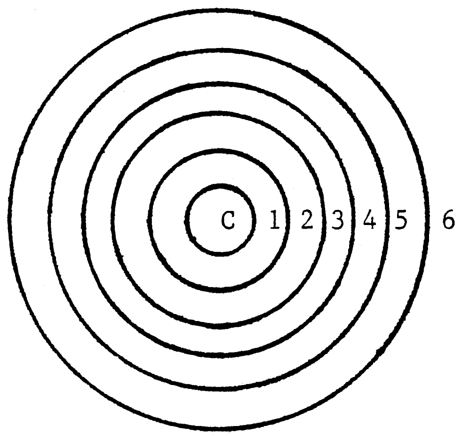
In articulating his approach, von Thunen assumed a very large town in the center of a fertile plain which has no navigable waterways crossing it, hence the "isolated state."

The soil is homogeneous with respect to fertility and cultivation. The fertile plain is isolated from the rest of the world in such a manner that communication between states is nonexistent. He also assumes only the center township exists and must provide the rural community with manufactured products, and in return the rural district will provide the town with needed provisions. Given the above stated assumptions, the problem von Thunen faced concerns the pattern of cultivation and how this pattern is affected by distance from the town.[2]

The main underlying assumptions made by von Thunen can be stated as: 1) the farmers are profit-maximizers, 2) market prices are given and are the same to all farmers for goods delivered to the city, 3) profit equals market price minus the sum of production costs and transportation costs, and 4) transportation cost varies directly with the distance from the city, using freight rates set on a straight-ton mileage basis regardless of the product hauled.[3]

The results of von Thunen's analysis indicate that highly perishable products and those products which are heavy or bulky in relation to their value will be produced in the region closest to the city. The opposite is true for those products that are less perishable and more valuable per unit of weight.[4] Thus, products are grouped into a series of zones or rings as shown in Figure 1.[5] Logically, the outermost boundary of each ring is where profits equal zero.

Marginal analysis and factor-product relationships concerning von Thunen's work implies land near the city or market can be made more profitable with intensive applications of the variable



C = city market

1 = perishables (fresh dairy products, vegetables)

2 = forest (lumber, firewood)

3 = grain (alternating with fodder)

4 = grain (alternating with fallow and pasture)

5 = grain (alternating with fallow) and pasture

6 = pasture (livestock, cheese)

Figure 1. Production Zones in von Thunen's Plain

resources, capital and labor. Extensive agricultural practices would prove more profitable as distance from the market increased. Stated more simply, earnings are maximized where cultivation is proportionate to the net price farmers receive, where the net price is the gross city price minus transportation cost.[6]

Unlike von Thunen, who addressed the location of agriculture production, Alfred Weber explored the causes by which the location was determined for factories. Weber referred to the forces which operate as economic causes, "locational factors", and the objects which the economic causes acted upon are "locational units".

Throughout Weber's analysis, one product is compared with respect to advantages in production arising from locational factors. In reality a given product may have two or more different grades of quality. To circumvent the problem associated with different grades of quality, the different grades of quality are assumed to "have been welded together into a unit by life through being treated as one by consumption."[7]

"Locational factors" are described as an advantage of producing in a given location as opposed to producing in some other location. The advantage is a savings in cost (implies a savings in cost arising from reduced transportation costs).

"Locational factors" are classified as either general or specific in nature. Factors which are considered general are transportation, capital, labor, and rent. Factors specific to a given enterprise are weather and perishability. All "locational factors" can be further categorized into two groups according to the influence they exercise: 1) regional factors and 2) agglomerative factors.

Regional factors direct industry towards specific geographic areas creating a framework of industrial location. Agglomerative factors, consisting of "agglomerative" or "deglomerative" factors, exert pressures to locate industry in such a manner that the resulting framework completely ignores any geographical considerations.

Weber defines the theoretical stages in industrial production processes and distribution of goods (location analysis) as: 1) securing the place of location and the fixed capital needed for equipment, 2) securing the materials, power, and fuel materials, 3) manufacturing process, 4) the shipping of goods. These stages of production and distribution help define "locational factors". That is, "locational factors" are "advantages in cost" which indeed have a magnetic effect on the optimum location of industries.[8]

Causal relationships of industrial location are examined under the following assumptions given by Weber: 1) availability of transport facilities for all users and straight-ton mileage rates regardless of the product, 2) equal prices of fuel and raw materials at all deposits, 3) no mobility of labor with the labor supply at a particular location being perfectly elastic, 4) the geographic nature of demand and consumption is treated as a given phenomenon.[9]

Using the above guidelines, Weber was faced with determining where the processing activities should be located with respect to minimizing total transfer costs of production materials and finished products plus labor costs associated with processing.

In the analysis, labor costs were assumed to be constant, and industries gravitated towards the point which transportation costs were minimized. This can be better illustrated by Weber's Locational Triangle, which assumes two raw materials (M_1 and M_2) are used to produce one finished product. The finished product can only be sold in one market, denoted by C, (Consumption Location). Two inherent characteristics of these raw materials are described as "gross" and "localized." A material is considered "gross" when it loses weight during processing, and "localized" pertains to a material that is found only in a given location, Figure 2.

At some point, P, straight-ton transportation costs are minimized. However, if the cost of one input (labor) is lower, an attraction towards that point tends to draw industry away from the point of minimal transportation cost. Changes in location will only take place when gains derived from a decrease in input (labor) costs compensate the increase in costs associated with transportation. An input with "weight losing" characteristics has the tendency to draw the production site towards its point of origin. The input used in the largest quantity during the production process also possesses the same magnetic effect upon the determination of the production site. However, the above criteria must be met before any move in the production site occurs (gains from the move must compensate the increased transportation cost).[10]

In Weber's paradox, two limitations existed concerning first the number of inputs used in the production process, and second the marketing process being limited to only one consumer region. However,

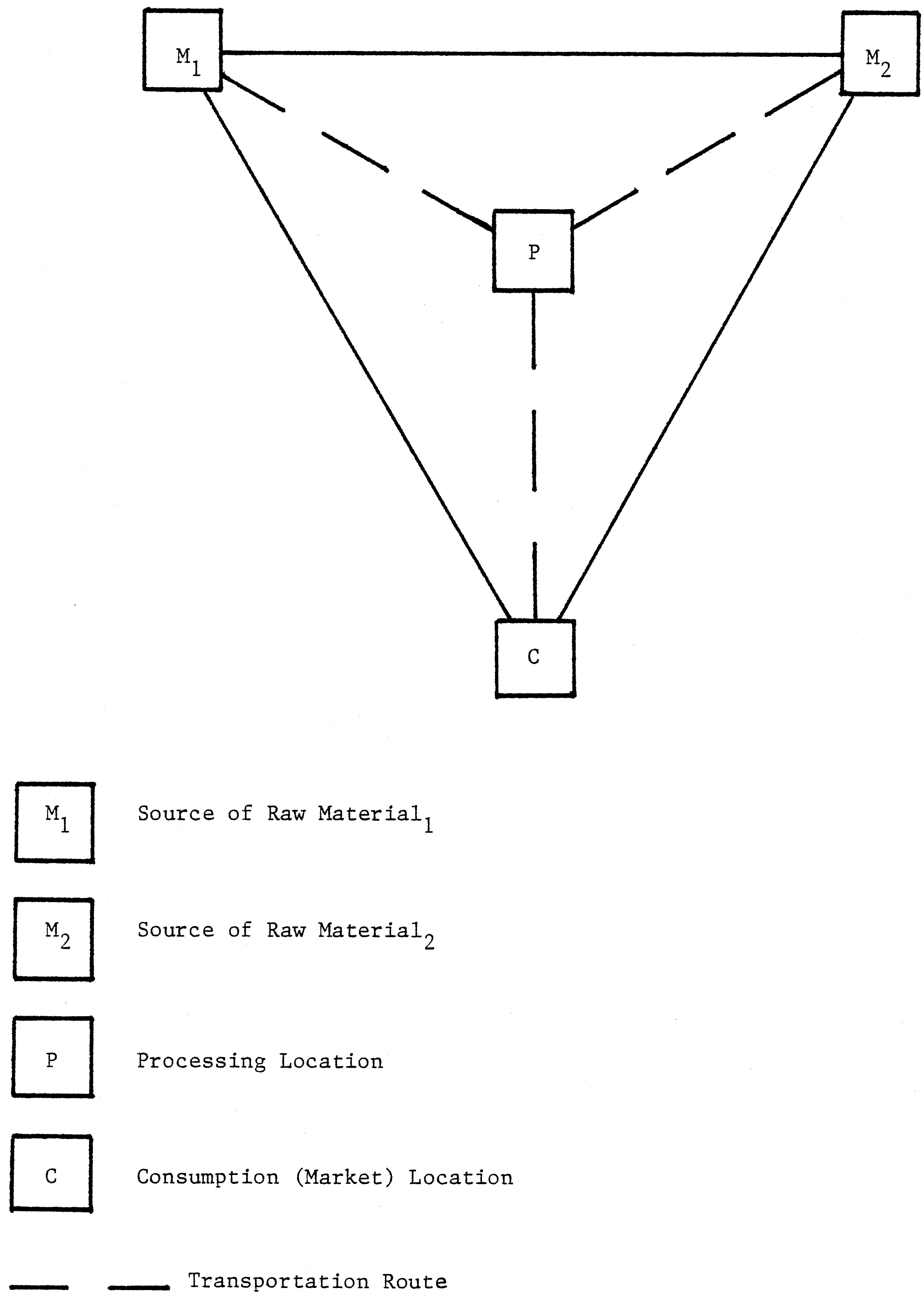


Figure 2. Weber's Locational Triangle

Weber's Locational Triangle laid the foundation upon which Location Theory could be built.

The Market Area Approach

August Losch is noted for his contribution describing the nature of economic regions. In his analysis of industrial location, Losch did not impose severe restrictions in defining the region of economic activity. He recognized the world as a complex system of interrelated services. The analysis of these services pertain to the investigation of the interrelationships of consumption and production units, and the simultaneous location of markets, producing centers, transportation systems, distribution of population and cities. Losch goes on to state, "What matters is the complicated structure, the Gestalt , not the average characteristics of an area."[11]

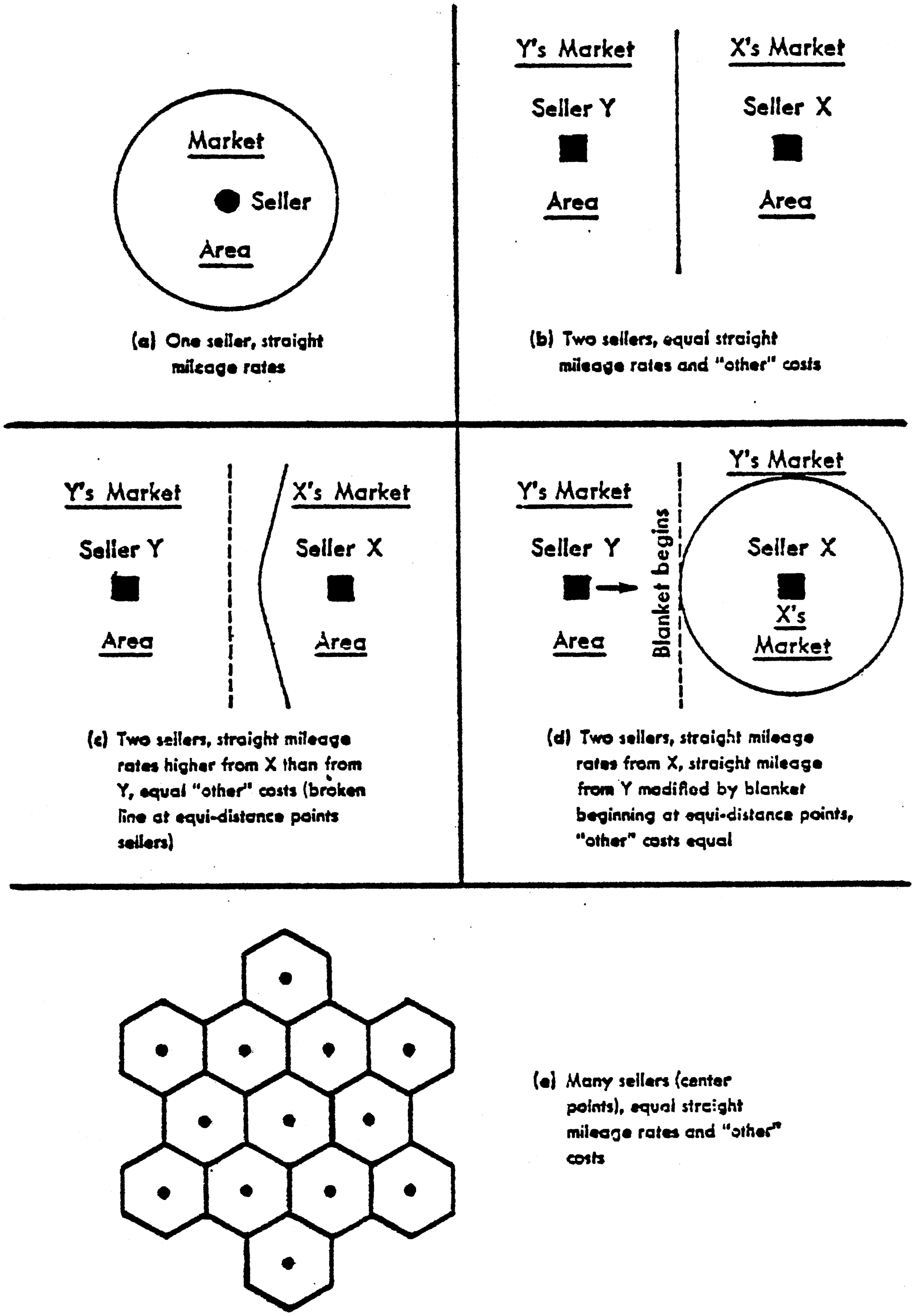
In von Thunen and Weber's analysis the optimum location of industries was determined to be the point where costs are minimized. Losch states the point of optimum industrial location is not determined by individual factor cost or gross receipts, but the difference between the two, net profit. He further criticizes Weber's analysis for treating demand and price as given phenomena, when in fact, demand varies with price (as does the location of industries).

A simple case of a linear demand curve illustrates the interrelationships between product demand, price and the location of industries. A small increase in product price would restrict the quantity purchased by consumers in the outermost regions of the product's market area, more than consumers located closer to production facilities. Producers in adjacent market areas will absorb those consumers located on the outer edge of the market area lost by the producer charging the higher price. Indicating a factory which seeks to maximize total demand is affected more by adjacent producers when prices are high than when they are low. Losch's problem was to determine the optimal, natural market area with respect to the size and shape of the market area.[12]

To assure the nonexistence of spatial differences when classifying "market areas," Losch made (by his own definition) radical assumptions. Raw materials are assumed to be evenly and adequately distributed across the production plain. Homogeneous in all respects, the production plain contains self-sufficient farms that are randomly distributed.[13] Different market area characteristics, illustrated in Figure 3, are categorized by Losch as:

1. One Seller - The only seller is located in the center of the plain with easy access to transportation facilities. The producer's total cost structure has two components: 1) production costs (assumed to be constant) and 2) transportation costs (varies directly with distance). As total cost increases, the products retail price must rise to maintain a given profit margin. Thus, the marketing area is defined as the region of equal distance from the selling point. The boundary is determined when high prices cause sales to cease, Figure 3 (a).

2. Two Sellers - In the model containing two producers the above assumptions apply. Each producer will have the advantage of selling his procuct to consumers located on their respective side of



Source: August Losch, The Economics of Location, tr. William H. Woglom and Wolfgang F. Stopler (New Haven, 1954).

Figure 3. Natural Market Area Under Various Transport Rates

an imaginary equal-cost line. The boundary would be a straight line directly in the middle of the two producers. An increase or decrease in the transportation cost will have no effect upon the boundary line if production costs remain constant, Figure 3 (b).

Next, under the exact same conditions, allow the freight rate for Seller X to increase by some percentage. The equal-cost line will shift towards Seller X as the market area for X decreases and Y's market area increases. The boundary between market areas will no longer be a straight line, but a hyperbola, Figure 3 (c).

In the final consideration of the two seller market area, both Seller X and Seller Y have straight-ton transporation rates. Seller Y's transportation costs are modified by allowing a blanket rate which begins at some point on a direct line between the two sellers, Figure 3 (d). Seller X's market area will be restricted to a circular shaped area around the production site while Seller Y will be allowed to absorb the remaining consumers if his blanket rate is lower than the mileage rate faced by Seller X.

3. Many Sellers - Imagine many sellers located throughout our plain. Each seller has equal nontransport (production) costs and straight-ton mileage as a basis for transport costs. Under these conditions the market areas cannot take the shape of circles. This would result in areas which would not be included in the market area or there would be overlapping areas. The most feasible structure of the market area would be a hexagon configuration. The hexagon structure would completely cover the plain without overlays, and meet the requirements of reducing transport costs and resulting price differentials to outlying buyers, Figure 3 (e).[14]

Walter Isard was critical of general economic theory. He felt a comprehensive theory of economics should include both time and space dimensions. General theory, as he knew it, managed the "time variable" inadequately. Isard's basic objective was to improve the spatial and regional frameworks of location economics through the development of a new general theory of location and space-economy. The evolution of his new general theory of location and space-economy, Isard admits, contributes little in handling specific problems of reality. However, Isard goes on to state, the introduction of his theory is useful in providing insights into the operation of economic process in the real world.[15]

Using Weber's doctrine as a basis, commodities have been classified according to mobility, dispensability, geographic occurrence, and weight loss. Isard condensed these categories according to substitution characteristics. They are: 1) substitution between transport inputs and between various outlays and revenues associated with the use of different commodities or combinations of commodities in the production process, 2) substitution between several sources of any one product, and 3) substitution associated with the various places to which a commodity can be transported. These categories are an integral part in the analysis of the equilibrium location of the firm.

Assumptions for the producer in the model are: 1) its productive activities do not affect the locus of consumption, transport rates, prices of raw materials, labor and other factors and products, and agglomeration economies and other locational variables, and 2) its actions do not provoke retaliatory measures by other producers.[16]

Edgar M. Hoover observed transfer costs affectd the location preference of producers, unless his suppliers and consumers could absorb transfer costs entirely. His work in location theory dealt extensively in the analysis of supply areas.

Consider one producer who interacts exclusively with one supplier and one market point. The producer's problem addresses the concern over where he will locate on a transportation line connecting the supply region to the market point. If the supplier or consumer absorbs any or all of the transportation costs, the producer's decision to locate closer to the market point or supply area will be distorted. Although, in some instances freight absorbtion by the seller is normal. For example, sellers of finished products and products which the transportation costs are a small percentge of the total price will absorb the transportation costs. For purposes concerning his analysis, the absorbtion of freight costs by the seller are treated as negligible factors.

The problem of determining the optimum location for producers is illustrated in Figure 4. The baseline measures the distance between the supply area of raw materials and the location of the market point. Gradients a and b represent the procurement cost associated with raw materials and the distribution cost of the finished products for all possible producing points along the baseline. Procurement costs display an increasing steplike characteristic as distance increases from the supply area, and distribution costs reflect similar characteristics as the production

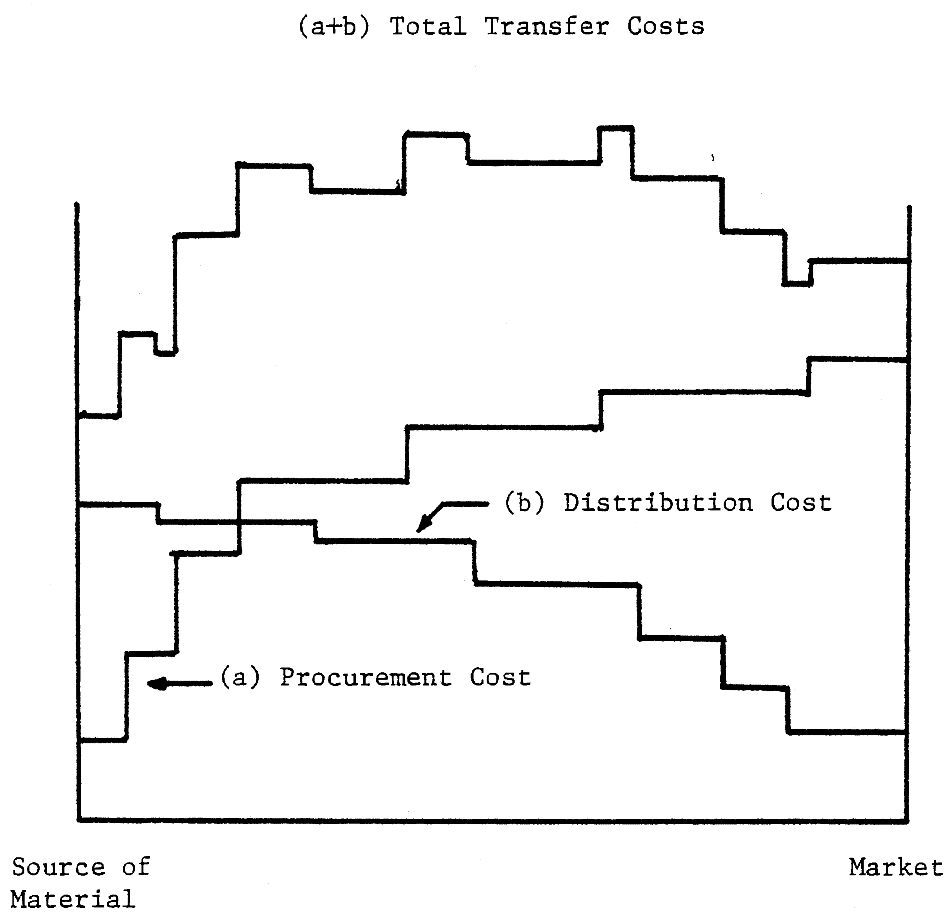


Figure 4. Gradients of Procurement Cost, Distribution Costs, and Total Transfer Costs Per Unit of Product for Processing Locations Along a Route Between a Source of Material and Market

site moves away from the market point. The top gradient is representative of total transfer costs (a plus b) for various locations along the baseline. Assuming rational producers who seek to operate at a least-cost location, the optimal production site would be located close to the raw materials market. However, the observant reader will notice the gradient of procurement costs is steeper than the gradient of distribution costs. Thus, the decision to locate closer to the source of the material. Had the distribution cost curve been drawn steeper than the procurement cost curve, then the firm would have a tendency to locate closer to the market. Hoover concludes:

> The ideal location for a production process on the basis of transfer costs from a single material's source and to a single market will generally be at either the source or the market rather than anywhere between.[17]

Referring back to Figure 4, why was the best industrial site for the producer located at the material source versus the market place? Simply stated, the producer's total transfer costs illustrate the relative quantities of raw material used to produce a unit of product. That is, suppose three tons of the raw material is needed to produce one ton of the product. Then the appropriate gradients to use for comparison are those illustrating the transporting of three tons of raw materials versus one ton of product. Assuming straight-ton mileage rates for all goods shipped, the producer would have an incentive to locate closer to the raw material source.[18]

Most earlier studies have assumed "market-oriented" production centers (producers sold to one major market). However, Hoover states the opposite situation is equally feasible. That is, sellers are small and scattered throughout, which forces the buyers to buy from many different sellers in order to achieve economies of scale to survive. For example, a grocery store which sells bread in a local neighborhood confronts a "market area" and a grain elevator operates in "supply areas." Interrelationships between "market areas" and "supply areas" become apparent as a raw material is traced through the intermediate stages of production.[19]

Through earlier analysis of the optimal location of industries, the common denominator was transporation costs. The aggregation of transportation and other input costs determine the individual firm's isocost line. The point of tangency between the producer's isoproduct and isocost curves result in a least cost combination. The firm's least cost combination of producing a product and the consumer's demand curve for the product are the determining factors of revenue. Increasing revenue, obviously, is the overall goal for free-market entrepreneurs.

FOOTNOTES

[1] J. H. von Thunen, The Isolated State, tr. Carla M. Wartenberg, ed. Peter Hall (Oxford, 1966), p. xii.

[2] Ibid., pp. 7-8.

[3] Mack Leith, "An Interregional Analysis of the United States Grain Marketing Industry" (Unpublished Ph.D. Dissertation, Oklahoma State University, 1970), p. 11.

[4] von Thunen, p. 8.

[5] Roy J. Sampson and Martin T. Farris, Domestic Transportation: Practice, Theory and Policy (Boston, 1966), p. 221.

[6] von Thunen, p. xxxi.

[7] Alfred Weber, Theory of the Location of Industries, tr. Carl J. Friedrich (Chicago, 1929), p. 19.

[8] Ibid., pp. 17-26.

[9] Ibid., pp. 37-39.

[10] Ibid., pp. 41-44, 102-107.

[11] August Losch, The Economics of Location, tr. William H. Woglom and Wolfgang F. Stolper (New Haven, 1954), p. X.

[12] Ibid., pp. 27-29.

[13] Ibid., p. 105.

[14] Sampson, pp. 227-232.

[15] Walter Isard, Location and Space Economy (New York, 1956), p. viii.

[16] Ibid., pp. 93-97.

[17] E. M. Hoover, The Location of Economic Activity (New York, 1948), pp. 27-31.

[18] Ibid.

[19] Ibid., pp. 47-50.

CHAPTER III

REVIEW OF TRANSPORTATION LITERATURE

From reviewing literature on location theory, the reader will discover transportation economics is intertwined with location economics. Of the principal factors in determining the location of industry and economic activity, transportation is generally considered to be one of the most important, while many regard transportation as the single most important factor.[1] A brief review of transportation economics is in order due to the major significance given to transportation.

Transportation and Its Implications

Transportation is the movement of persons or property from one place to another. As economists analyzing transportation, we are concerned with transporting from one point to another while minimizing the amount of time and cost expended. Distance as a factor of transportation cost is incidental, since time and cost factor are the only dimensions of transportation cost which can be improved upon.

In economics, transportation is considered part of the production process due to the fact it creates place utility. When raw materials are transported to the production center and the resulting finished products are shipped to the market place, each stage creates place utility. Time utility might be created during transit of the raw material or finished product. Overall, improvements in the transportation system are directed at the maximization of place and time utility while foregoing the least amount of time and cost.

Transportation systems have three types of mechanical elements: 1) the vehicle, 2) the mode of power, and 3) the way (route). The way could simply be a path between two points. However, modern transportation economic analysis is concerned with improved ways, i.e., railways, waterways, or airways. In recent years, most improvements in transportation have come from technological advancements. The rate of adapting these new technological advancements depends on economic, social, and political conditions in any given country.

A large concentration of producers and consumers exchanging goods compose a commercial center. A port, an example of a commercial center, is characterized by a transfer of goods from inland vehicles to ocean faring vessels, and vice versa. To realize economies of size, a commercial center must acquire large quantities of goods from distant regions. Transport vehicles used to move goods from local markets to commercial centers, by nature of the quantities shipped, are small and sometimes cruder forms of transportation. Larger bulk movement of goods occurs between two main commercial centers called primary markets. Emphasis in transportation optimization is between primary markets. Primary markets are connected to submarkets and submarkets are attached to sub-submarkets, Figure 5.

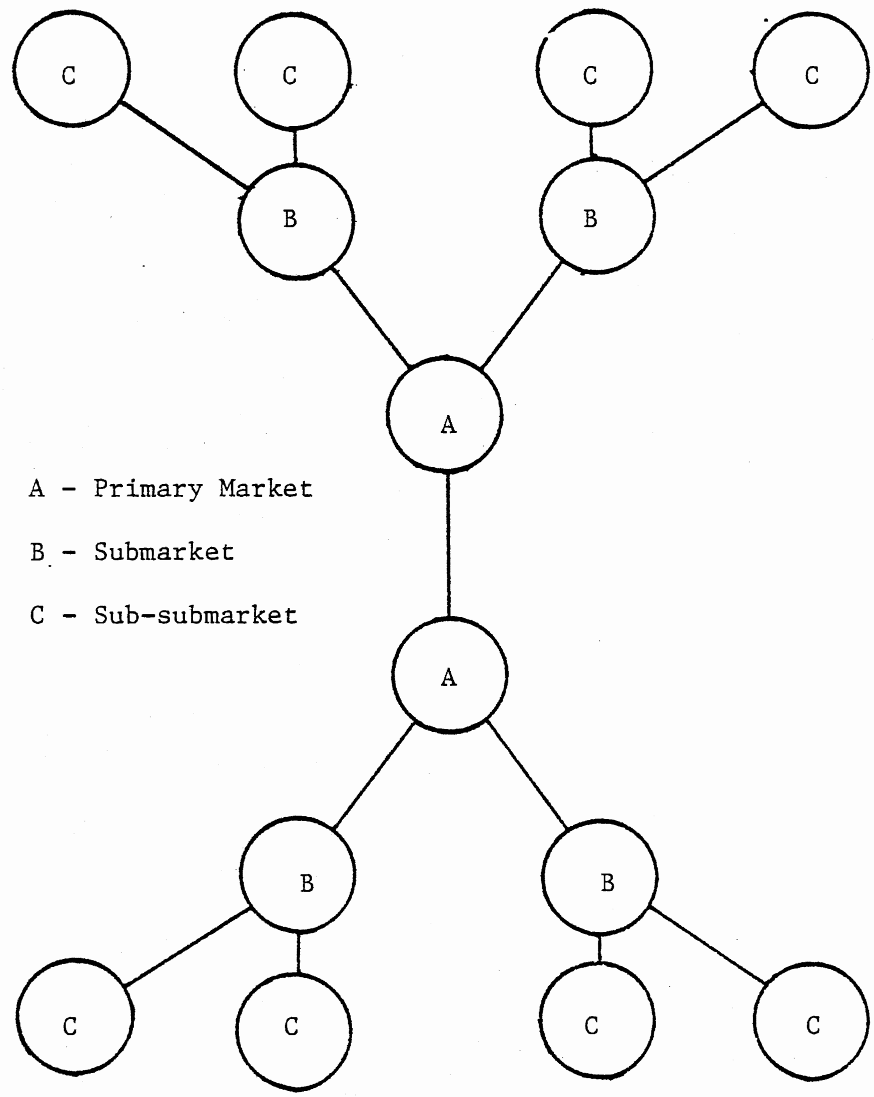


Figure 5. The Flow of Goods Over a Transportation System

Improvements in transportation increase the total region available for resource extraction, allow a more intensive application of the division of labor concept, promote large-scale production, stabilize price, and reduce total production costs. Transportation is an integral part of allocating resources and the advancement of economic efficiency.

Availability of Resources

A fundamental concept of natural resources is the distinction between their availability for economic use and their mere physical existence. Criteria for availability are: 1) there must be a knowledge of the productive capabilities of the natural resource, 2) if the resource is in some remote place or below the surface of land, or water, it must be discovered, 3) the quality of the resource must be comparable with identical resources found in other regions or to available substitutes, 4) transportation must easily be available to carry persons and goods with sufficient speed, and 5) the cost must be low enough to enable the products derived from the resources to compete in the market.

Division of Labor

Division of labor is defined as the cooperation in doing a task or parts of a task. Division of labor is classified into three categories: 1) occupational, 2) territorial, and 3) technical. The size of the community is a limiting factor on the degree of division of labor. The community can only consume a given amount of output which indirectly determines to what extent will the division of labor be profitable. However, transportation increases the market and supply areas which in turn influences the size of city and the extent of occupational division of labor.

Transportation makes feasible territorial division of labor. The United States has developed a system of production which enables resources to be used in a region where they are best suited. The Midwest's "Bread Basket" provides an excellent example where favorable climate, excellent soil, and intensive applications of capital and labor coupled with available access to transportation has resulted in a territorial division of labor. Territorial divisions of labor provide the foundation for large-scale production and technical division of labor.

Technical division of labor subdivides occupations in mechanized industries, and further enhances the economic gains derived from occupational division of labor. Economic gains include: 1) a higher level of craftsmanship, 2) time savings from eliminating changing of tasks, 3) taking advantage of specialized skills, 4) stimulating innovation and inventiveness, and 5) using lower cost and more adequate mechanical power.

Large-Scale Production and Large Markets

Large-scale production normally requires transportation of raw materials from different geographic points. Large-scale production is, more often than not, a result of an industry striving towards economies of size. Economies of size are meaningless, unless producers have a large market for their products.

Concluding, transportation facilities which foster the flow of raw materials and labor to producers and brings finished products back to consumers make possible social gains derived from large-scale production.

Equalization of Supply -- Price Stabilization and Competition

The lack of transportation in less developed countries (LDC's) has contributed to situations in which segments of the population are undernourished and quite often starving while countries not too far distant have adequate or surplus food supplies. Countries which have a developed transportation system are not necessarily bound to consume only what they produce, and it is equally true they do not have to depend on one international supplier. A developed transportation system allows a country to sell surplus production and compete in the world market for those goods which they are unable to produce for themselves.

Equalization of supply throughout a region ensures a stable price for any given commodity. If one section of an area experiences a storm or crop failure, the shortcoming of total supply will not always necessitate a price increase. For any given commodity, price is determined by the availability of alternate resources. Thus, improved transportation results in competition among sellers. Distant sellers of a commodity who have access to cheap, reliable transportation are able to compete with producers who are located closer to the market area. The related benefits summarized from an improved transportation system are: 1) greater stability of price,

2) a more adequate and reliable supply, and 3) greater competition in the sense of access to alternate supplies.

Transportation as a Cost of Production

For a rational producer to continue producing, the price received for his product must cover all costs in the long-run. One component of the total production cost is transportation. As noted earlier, transportation services increase the value of the good by place utility. It is equally true that a reduction in the transportation bill will reduce total costs of production, and the consumer will benefit from a lower price (assuming perfect competition). In modern society, most goods require some form of transportation service to the ultimate consumer, and the amount of transportation cost associated with any good depends upon the good's characteristics. If the commodity transported is not perishable, travels only a short distance, or its value is higher relative to its bulk, then transportation costs are a small portion of total production cost. Conversely, transportation is a large component of total production cost if the commodity is bulky, requires special services, or must be transported over a long route. In general, whenever transportation costs are a large component of total production cost, improvements in transportation results in social gains. That is, the price of these commodities which are sensitive to fluctuating transportation cost will decline.[2]

Theoretical Derivation of Transfer Costs. The price of a homogeneous product in two different regions will differ by an amount necessary to provide transportation services between the two regions when both regions experience perfect competition. As transportation costs decrease the price of the commodity will move towards equilibrium. Figure 6 contains a back-to-back diagram which is commonly used to illustrate transfer costs when two regions are explored through equilibrium analysis. Even after the axis is adjusted for transfer costs between Region X and Region Y, a higher price in Region X compared with Region Y, $P_x > P_y$, would prompt movement of the homogeneous product from Region Y to Region X. The intersection of the region's excess supply curves at k defines the equilibrium price of the good or commodity with trade. For region's X and Y, prices received are Og and O'g, respectfully. The quantity transferred between regions is gk, or Region Y shipped jl and Region X received st.[3]

Summarizing the economic impact of a reduction of transfer costs and increasing time utility, the following benefits are given: 1) market areas are expanded, 2) local monopolies in the sale and production of goods are dispersed, 3) possibilities for economies of scale in manufacture and distribution are enhanced, 4) remote raw material sources are made more accessible to production units, 5) territorial specialization in production of all kinds are promoted, and 6) rent value of land is increased, including the reduction or elimination of the restraints upon urban growth and land use.[4]

Transportation economics is basic to the problem of identifying and optimizing efficient international wheat trade. Increased wheat exportation by the United States has resulted, in part, from the use of territorial division of labor. Increasing world demand for wheat

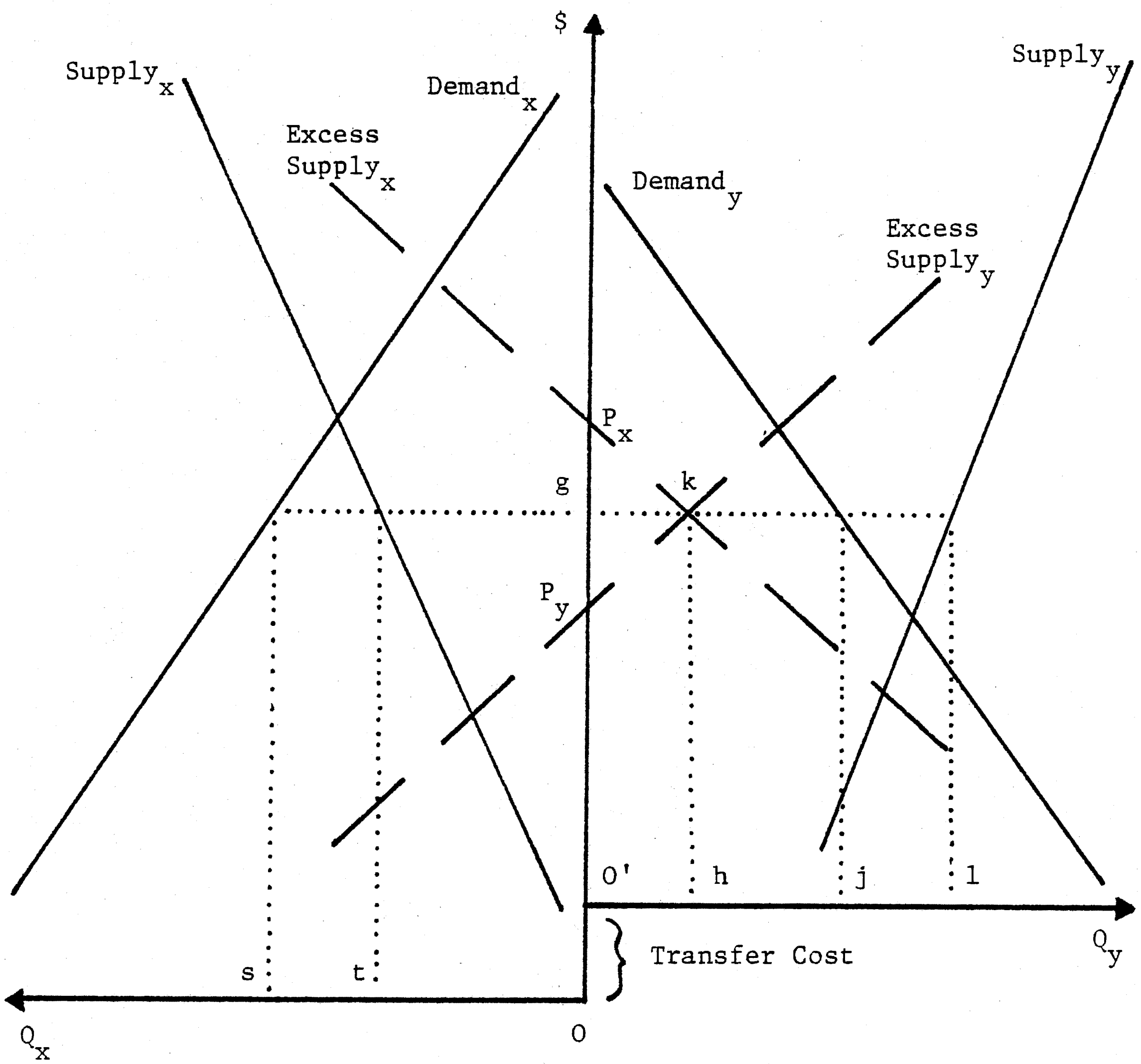


Figure 6. Effect of Transfer Costs on Trade Flow and Price

exports encourages farmers to expand into large-scale production operations which can take advantage of economies of size. As exports grow in the amount of volume shipped, it is important to know the primary markets (ports) and their transfer capabilities. Movement of commodities between primary markets is the important issue of this study. Alternate shipping routes (ways) between primary markets and various ship sizes (vehicle) will be explored also. Ocean transportation systems will be analyzed through the employment of a general linear programming model -- the simplex procedure.

FOOTNOTES

[1] Dudley F. Pegrum, Transportation Economics and Public Policy (Homewood, 1973), p. 5.

[2] Roy J. Sampson and Martin T. Farris, Domestic Transportation: Practice, Theory and Policy (Boston, 1966), pp. 228-232.

[3] Raymond G. Bressler, Jr. and Richard A. King, Market, Prices, and Interregional Trade (New York, 1970), p. 90.

[4] Marvin L. Fair and Ernest W. Williams, Economics of Transportation (New York, 1959), p. 26.

CHAPTER IV

THE MODEL

Chapter IV is divided into two parts. The first part contains a review of world grain trade models. In the second section there is a review of linear programming, culminating with a discussion of the algorithm to be employed in this study.

Review of World Grain Trade Models

There have been limited applications of different algorithms in analyzing world grain trade. Although several attempts to model the world grain trade have been pursued, the spatial equilibrium model and a model characterized by similar assumptions, the IMF model, are the basic alternatives. These approaches are discussed in the following sections.

Spatial Equilibrium Models for World Wheat Trade

Schmitz and Bawden[1] divide the world into 15 regions in their 1973 study. The United States, Canada, Australia, Japan, United Kingdom, Germany, France, Italy, Netherlands, and Belgium-Luxembourg are regions of the world defined as endogenous to the model. The rest of the world is categorized into the regions Other America, Other Europe, Other Asia, and Africa. These regions are exogenous to the world trade model.

Supply and demand equations are estimated for each of the endogenous regions. Within each endogenous region, a production and consumption center are specified and the costs of transportation are computed between these centers.

Schmitz and Bawden's model forecasts the value or flow of endogenous parameters for 1980, once the exogenous variables (i.e., per capita income or Japan's net imports) are projected for 1980. Supply is identified for countries that have 36 percent of world production, and demand is identified for countries with 22 percent of world consumption. The effects of changing weather and tariffs along with the Green Revolution are considered in the model by changing the values of the exogenous variables.

Grennes et al.[2] suggest that Schmitz and Bawden could have improved their study by comparing the minimum transport cost trade matrix which the model generated for the 1960's with the observed trading patterns for that period. They conclude by stating their skepticism of the reliability for 1980 projections in Schmitz and Bawden's study.

A 1971 USDA study by Rojko et al.[3] divided the world into 22 regions to project a world grain trade for 1980 with the use of the spatial equilibrium model. The primary emphasis of this study is to analyze policy decisions of developing countries on world grain trade for 1980. The study examines the trade of wheat, coarse grains, and rice. A key component of the study is the various rates of growth within developing countries' agriculture sectors which were implemented into the model. In general, most policy considerations resulted in a world surplus. The results were similar to a more recent study by Blakeslee, Heady, and Framingham.[4]

The model used by Rojko et al. was similar in nature to the Schmitz-Bawden model. The differences lie in the direct constraints placed upon the trade flows. For example, the model required 20 percent of Japanese wheat imports to come from Australia.

IMF Models

The models reported by Armington[5] and by Artus and Rhomberg[6] and Rhomberg[7] in the IMF Staff Papers are classified in this manner because of an assumption common to each model. Both models assume 1) the marginal rate of substitution between two products of one kind are independent of products of another kind.

Armington further assumes: 2) the elasticity of substitution between like products is constant, and 3) the elasticity of substitution between any two products of the same nature competing in a market is equal to the elasticity of substitution for any other two products of the same kind competing for the same market. These additional two assumptions allow for the percentage change in quantity demanded of a product to be expressed as an additive function of percent changes in expenditures on the good and percent changes in relevant prices. This implies an exporting country with no change in price will simply maintain its market share for that good.

The model of Artus and Rhomberg substitutes the following two assumptions for assumptions 2 and 3 of Armington's model: 4) the ratios of elasticities of substitution remain constant, and 5) the elasticity of substitution between two like products in import markets is equal for all import markets, while the elasticity of substitution between the two like products can be different abroad and in the domestic market.

One major advantage of these two models is the allowance for preferential treatment of wheat from one region over wheat produced in a different region. There are two reasons behind the allowance for preferential treatment. The first reason has two components: 1) the IMF models distinguish goods by place of production, and 2) the trade flows in the IMF models are based on actual past data collected from historic trade flows instead of optimizing some objective function. Second, the IMF models do not restrict quantity of multilateral trade flows as does the spatial equilibrium model.

More recently, Grennes et al.[8] analyzed the world wheat market with a model similar to the IMF models. The 1978 study aggregates the world into six endogenous regions and an exogenous region called the Rest of the World. The six major endogenous regions include the four major exporters, i.e., United States, Canada, Australia and Argentine, and two major import regions, Japan and the European Economic Community.

Grennes et al. chose the IMF approach in modeling the world because the IMF model allows for differentiating between wheat origins. They cite several reasons why differentiation is important. These are: 1) the good might be "intrinsically heterogeneous," i.e., the difference in quality might only be observed across producers, or data for the good might be reported as an aggregate of different varieties; 2) even if a good is intrinsically homogeneous, products may be viewed with apprehension from some countries due to "national factors"; 3) time aggregation in reporting data becomes a problem when there are different production cycles throughout the world; and 4) monopolistic competition can be extended to include any degree of imperfect competition where the supplier's market share can vary.

For purposes of this study neither the spatial equilibrium nor IMF model was used. The spatial equilibrium model identifies supplies, demands, and the prices required to clear the market given projections for key parameters (i.e., per capita income). This study does not intend to identify supply and demand for regions, since these values have been determined in a prior study. The present purpose is to identify an optimal flow route considering transportation costs, and handling capacities of both importers and exporters with regard to both loading and unloading rates and ship handling capability. Supply and demand are assumed given for each region.

Studies using the IMF model do not aggregate the world in an ideal fashion. Emphasis has been placed on historically significant importers. Most notably, Grennes et al. only identify two major import regions, the EEC and Japan. Since composition of major importers is changing, as reported in Chapter I, it becomes important to include these new prominent market areas. Again, the same is true for the IMF models; supply and demand do not need to be identified. For these reasons, a linear programming model is used in this study.

Linear Programming

General Linear Programming Model

Linear programming is a computational method used to determine the best plan or course of action where 1) a specific or numerical objective condition exists; 2) there are many alternatives for the plan, and 3) the means or available resources are limited. Since linear programming's (also called LP) inception during World War II, LP has been used to solve a wide range of problems of both macro and micro nature. Linear programming is a normative tool, although it can incorporate positive tools.

The principle components of LP are the objective function, activities, and restrictions. Some of the typical types of objective functions are: 1) maximize profit over some time period, 2) minimize cost of producing products, 3) minimize cost (time) of services, 4) maximize capital build-up, and 5) maximize jobs. Real, intermediate, disposal or slack, and artificial are the four types of activities. The restrictions placed on LP are categorized as: 1) physical, 2) institutional, 3) subjective, and 4) sign.

Linear programming works within the guidelines of seven assumptions. These assumptions are: 1) additivity of resources and activities, 2) linearity of the objective function, 3)non-negativity of decision variables, 4) divisibility of activities and resources, 5) finiteness, 6) proportionality of activity levels to resources, and 7) single value expectations.

Adhering to the assumptions, the general notation for the objective function, activities, and restrictions in the general linear programming model can be stated as:

$$\text{Maximize:} \quad Z = C_1X_1 + C_2X_2 + \dots + C_nX_n \qquad (4.1)$$

$$\text{Subject to:} \quad a_{11}X_1 + a_{12}X_2 + \dots + a_{1n}X_n \leq b_1$$

$$a_{21}X_1 + a_{22}X_2 + \dots + a_{2n}X_n \leq b_2$$

$$\vdots$$

$$a_{m1}X_1 + a_{m2}X_2 + \dots + a_{mn}X_n \leq b_m$$

where, $X_1, X_2, \dots, X_n \geq 0$

and, b_i = amount of i^{th} resource available,

X_j = level of j^{th} activity,

a_{ij} = amount of i^{th} resource required per unit of j^{th} activity, and

C_j = return per unit of X_j to unpaid resource.

The general notation can be condensed even further to:

$$\text{Maximize:} \quad Z = \sum_{j=1}^{n} C_jX_j \qquad (4.2)$$

$$\text{Subject to:} \quad \sum_{j=1}^{n} a_{ij}X_j \leq b_i$$

where, $X_j \geq 0$.

In matrix notation the general linear programming problem is defined as:

$$\text{Maximize:} \quad Z = C'X \qquad (4.3)$$

$$\text{Subject to:} \quad AX \leq B$$

where, $X \geq 0$

and, A = m X n matrix of technical coefficients,

C = n X 1 vector of returns, prices, or other weights for the objective function,

X = n X 1 vector of activities, and

B = m X 1 vector of resource restrictions or other restraints.

A basic solution is found when the number of nonzero valued variables equals the number of constraints, and for a solution to be feasible, the solution must meet all of the resource restrictions and all the activities are non-negative. A feasible solution becomes optimal when the solution maximizes (minimizes) the objective function.[9]

General Transportation Model

Solving transportation problems has long been a primary use for LP. Many publications concerning LP as a tool for solving transportation problems have been written over the past few decades. Early authors addressing the issue were Hitchcock,[10] Dantzig,[11] and Koopmans,[12] while Heady and Candler,[13] Hillier and Liekerman,[14] and Gass[15] wrote on the subject in later years. The list could go on and on.

The general transportation model is a linear programming model with modifications in the assumptions. There are five assumptions for the general transportation model. Assumptions 3, 4, and 5 are similar or analogous to the assumptions presented in the general linear programming model section. The assumptions for the transportation model are: 1) resources and products each are homogeneous, 2) demands at the various destinations and the supplier of the resource or product at the origins are known, and total demand equals total supply, 3) the cost (or profit) of (or from) transforming resources to products or transporting the commodity from origin to destination is known and is independent of the quantity converted or shipped, 4) the objective function is given and is maximized or minimized, and 5) the transformation from resources to products or the transportation of a product from an origin to a destination can only be performed at non-negative levels.

In algebraic notation, the general transportation model is stated as:

Minimize: $$Z = \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} X_{ij} \quad (4.4)$$

$i = 1, 2, \ldots, m$

$j = 1, 2, \ldots, n$

Subject to: $$\sum_{i=1}^{m} X_{ij} = Y_j \quad (4.5)$$

and, $$\sum_{j=1}^{n} X_{ij} = b_i \quad (4.6)$$

and, $$\sum_{j=1}^{n} Y_i = \sum_{i=1}^{m} b_i \quad (4.7)$$

and, $$X_{ij} \geq 0 \quad (4.8)$$

where, Z = the cost of the operation,

C_{ij} = the cost of transporting a unit of product from origin i to destination j,

X_{ij} = the amount of product transported from origin i to destination j,

Y_j = the amount required by the j^{th} destination,

b_i = the supply available at the i^{th} origin,

m = the number of supply points, and

n = the number of demand points.

The basic assumptions of a general transportation model can be identified in the algebraic notation. In fact, identification of the assumptions would prove valuable as an explanatory tool. Equation (4.4) identifies the objective function as a minimization problem concerned with minimizing total transfer costs. That is, to minimize the total sum transportation costs of products derived when multiplying the cost of transporting a unit of X from origin i to destination j by the amount of X transported from i to j. Equation (4.5) states the sum quantity of X flowing from all regions to the j^{th} destination point, must equal the total demand, Y_j, at the j^{th} destination point. Likewise, Equation (4.6) states the sum quantity of all X moving out of origin i to all regions must be equal to the quantity of X available at origin i, b_i. Equation (4.7) simply states the total quantity demanded (the sum requirements of all destinations) must equal the total quantity supplied (the sum of all origins available supply). The specification which stipulates that flows cannot be permitted at negative levels is the non-negativity condition, Equation (4.8).

Two important concepts should be brought to attention. First, the lack of weighting factors on Equation (4.5) and (4.6) indicates a unit of X from any m origins would satisfy the demand for a unit of X at any of the n destination points. Since there are no weighting factors involved, the implication is that the commodity, X, is homogeneous between origins and destinations. Next, the non-negative condition is included because the cost of transporting a commodity from region 1 to region 4 is not the negative of the cost of transporting a commodity from region 4 to region 1. The flow direction becomes the important factor to keep clear.[16]

The general transportation tableau representing equations (4.5), (4.6), and (4.7) is in Figure 7. The cost of shipping X_{ij} is C_{ij}.

Solving the General Transportation Model

The first step in solving the general transportation problem to identify an initial feasible plan. The northwest corner rule, Vogel's approximation method, and Russell's approximation method are three different methods used to identify the initial plan. The most common method used is the northwest corner rule.

Once the initial feasible plan is identified, the next step is to optimize the objective function, i.e., minimize transportation costs. However, if degeneracy exists in the matrix then the simplex procedure cannot procede. Degeneracy occurs when an inactive cell blocks the construction of a stepping stone path. With an M x N matrix, any plan is degenerate when the plan has less than M + N - 1 active cells. Thus, a feasible plan can be found when an M x N

		DESTINATIONS						
	i \ j	1	2	...	(j)	...	(n)	
ORIGINS	1	X_{11}	X_{12}	...	X_{1j}	...	X_{1n}	A_1
	2	X_{21}	X_{22}	...	X_{2j}	...	X_{2n}	A_2
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	(i)	X_{i1}	X_{i2}	...	X_{ij}	...	X_{in}	A_i
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	(m)	X_{m1}	X_{m2}	...	X_{mj}	...	X_{mn}	A_m
		b_1	b_2	...	b_j	...	b_n	

Figure 7. The General Transportation Tableau

matrix has at least M + N - 1 active cells or an M x N matrix with M + N - 1 active cells and no self-contained paths is non-degenerate. This type of plan is called a basic feasible plan.[17]

Several methods are available for improving the basic feasible plan in order to achieve optimality. These are the stepping stone, MODI (Method of Distribution Inland), first inspection, row inspection, and column inspection. The first two, stepping stone and MODI, are the most popular and widely used methods. Refer to Heady[18] and Hillier[19] for a complete discussion of the optimizing techniques.

Converting the General Transportion Model to Simplex

The simplex procedure is an algorithm used in solving many types of linear programming problems, including the general transportation model. The steps in the simplex procedure are outlined as: 1) inequalities are transformed into equalities by using slack variables, 2) the initial solution is defined, 3) from the initial solution the procedure will select another feaasible solution having a comparative advantage in an iterative sequence, and 4) finally the algorithm will stop at the solution meeting the criterion for optimality.[20]

In the general transportation tableau, there are m origins and n destinations. Each cell is a possible shipment from an origin to a destination, and is called an activity. However, in a simplex tableau, activities are represented only in the columns, while the rows contain restraints placed on these activities. There are m X n columns and m + n rows in a simplex tableau. Refer to Goss[21] for a formal explanation.

The Criterion Equation

The simplex algorithm determines then to move from one feasible solution to another feasible solution by the criterion equation. The criterion equation can be derived from equation (4.1) for a two output case. The profit equation and acivity restrictions are shown in equations (4.9) and (4.10).

$$Z = C_1X_1 + C_2X_2 \tag{4.9}$$

$$a_{11}X_1 + A_{12}X_2 \leq b_1 \tag{4.10}$$

$$a_{21}X_1 + a_2X_2 \leq b_2$$

The following relationships hold true for a_{11} and a_{12}.

$$a_{11} = \frac{1}{MPP_{b_1X_1}} \tag{4.11}$$

$$MPP_{b_1X_1} = \frac{\Delta X_1}{\Delta b_1} \tag{4.12}$$

$$a_{12} = \frac{1}{MPP_{b_1X_2}} \tag{4.13}$$

$$MPP_{b_1X_2} = \frac{\Delta X_2}{\Delta b_1} \tag{4.14}$$

From equation (4.10), X_2 is expressed in terms of X_1.

$$X_2 = \frac{b_1}{a_{12}} - \frac{a_{11}}{a_{12}} X_1 \tag{4.15a}$$

Substitute into equations (4.15a) equations (4.11) and (4.13) and simplify.

$$X_2 = \frac{b_1}{a_{12}} - \frac{\frac{1}{MPP_{b_1X_1}}}{\frac{1}{MPP_{b_1X_2}}} X_1 \tag{4.15b}$$

$$X_2 = \frac{b_1}{a_{12}} - \frac{MPP_{b_1X_2}}{MPP_{b_1X_1}} X_1 \tag{4.15c}$$

Next, insert into equation (4.15c) equations (4.12) and (4.14) and simplify.

$$X_2 = \frac{b_1}{a_{12}} - \frac{\frac{\Delta X_2}{\Delta b_1}}{\frac{\Delta X_1}{\Delta b_1}} X_1 \qquad (4.15d)$$

$$X_2 = \frac{b_i}{a_{12}} - \frac{\Delta X_2}{\Delta X_1} X_1 \qquad (4.15e)$$

Equation (4.15e) is inserted into the profit equation.

$$Z = C_1X_1 + Cl_2 \left(\frac{b_i}{a_{12}} - \frac{\Delta X_2}{\Delta X_1} X_1 \right) \qquad (4.16)$$

Next rearrange equation (4.7) to:

$$Z = C_1X_1 + \frac{b_1}{a_{12}}(C_2 - C_2 \frac{\Delta X_2}{\Delta X_1} X_1) \qquad (4.17)$$

and then to:

$$Z = \frac{b_1}{a_{12}} C_2 + (C_1 - \frac{\Delta X_2}{\Delta X_1} C_2)X_1 \qquad (4.18)$$

The criterion equation is:

$$C_1 - \frac{\Delta X_2}{\Delta X_1} C_2 \qquad (4.19)$$

and if:

$$C_1 > \frac{\Delta X_2}{\Delta X_1} C_2$$

then it is profitable to give up a unit of X_2 for a unit of X_1. Once the profit equation is maximized, an optimal solution is found. The reverse is true for a minimization problem.

Sensitivity Analysis

One optimal solution results when the simplex procedure is applied to the linear programming model. Since the value of the parameters are averages or estimates of future expectations, the cautious interpreter should be skeptical of the optimal solution. A parameter can also assume a value determined by a policy decision.

For these reasons, it is important to determine the effect on the optimal solution if a parameter assumes a different value.

Some parameters can be assigned a new value, within reasonable limits, and have no affect on the optimal solution. For other parameters, a small change might result in a new optimal solution. Sensitivity analysis becomes an important tool in identifying those parameters which are sensitive to change. Once the parameters are identified, special care can be given in estimating the sensitive parameters.

In the simplex procedure there is a simple procedure for testing whether the solution remains optimal after one of the values assigned to a parameter is changed. Readers seeking further explanation of sensitivity analysis are referred to Hillier[22] or Heady.[23]

Parametric Programming. Parametric programming is a tool used in sensitivity analysis. In parametric programming, one parameter is varied over some interval to determine when the optimal solution changes. That is, instead of examining a specific change from $b_1 = 12$ to $b_2 = 24$, parametric programming allows the examination of:

$$b_2 = 12 + k$$

where k is varied continuously from 0 to 12 by some specified quantity (i.e., by one).

An advantage of parametric programming is price mapping. Price mapping obtained from a series of computer printouts of optimal solutions each of which are developed from a new price. Each solution provides a point on a demand curve. Only one price can be varied at a time. Again, for an illustration of the mechanics of parametric programming refer to Hillier[24] or Goss.[25]

United States participation in the international wheat market may be analyzed through implementing a linear programming transportation model. In this model, exporting ports of the five major exporters are classified into regions of notable concentration after giving consideration to geographic factors. For the United States, the regional port classes are the U.S. Gulf of Mexico, U.S. East Coast, U.S. Pacific, and U.S. Great Lakes. Canada is subdivided into the four groups listed as the West Coast, Great Lakes Region, East Coast and St. Lawrence Seaway area. Australia and France are not subdivided and Argentina's ports are listed as a single group, the River Plate. The receiving or destination ports are categorized as Western Europe, Egypt, Rest of Africa, India, Japan, Rest of Asia, Brazil, Rest of Latin America and the Caribbean, Soviet Union, People's Republic of China, and Eastern Europe. The linear programming transportation model is used to determine the optimal flow of wheat between ports of origin and destination ports given a set of restraints. The algorithm's adaptability to physical constraints and limiting factors is also a criteria in the model selection process. Implementing sensitivity analysis and parametric programming will give added confidence in the reliability of the parameters and will indicate how sensitive the optimal solution is to changes in parameter values.

FOOTNOTES

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[20]Forrest Stegelin, "Methodological Analysis of the Export Transportation Network Flows: Hard Red Winter Wheat" (Unpublished Ph.D. Dissertation, Oklahoma State University, 1979), p. 34.

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[22]Hillier, pp. 182-193.

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CHAPTER V

PROCEDURES AND AN ANALYTICAL FRAMEWORK FOR DEVELOPMENT OF A SIMPLE WORLD WHEAT MARKET

Analysis of an "Optimal Trade Flow" within the framework of Linear Programming requires several pieces of information before any computations can be made. Identification of an "Optimal Trade Flow" is responsive to regions selected for analysis. Once the regions are determined, estimates of the available supply and demand between regions are prime components of the model. As noted earlier, supply and demand must equate or one of the basic assumptions of the transportation model is violated.

The validity or reasonableness of the estimated supply or demand for any given region should be investigated by comparing the estimated supply or demand position of a region to the respective regions calculated import/export capacity. This measure provides a safeguard on shipping a quantity of wheat to or from a region which has no historic record or estimated capacity to handle such a magnitude of wheat.

Shipping rates from Region A to Region B are identified and discussed as an integral component in the optimal flow decision making process.

Procedures for Disaggregating the World Into Descriptive Supply and Demand Units

The world is a dynamic assembly of different cultures. Inherent to each culture is a system of religous, social, economic and political values. We might suspect cultural differences have contributed to regional differences with regard to wheat import demand and the intensity of adapting to new grain loading/discharging technology. The ability to generate outside revenue for trade or utilize world lending institutions such as the International Monetary Fund and the World Bank could also influence the ability of a country or region to participate in the world wheat market. Since the objective is to represent the world through a simple transportation network for one commodity, it is not necessary to dwell upon the world as a complex system of interregional interaction. However, the complexity of the world is important enough to warrant mention.

In deciding how to model the world's different regions for examining economic efficiency of ocean transportation systems for major wheat exporting countries in an optimal flow situation, two issues should be addressd immediately. First, will the aggregation of countries into large regions be too constricting for proper identification of regional trade flows? Second, in striving for realism it is possible to be overly concerned that the model behave as an exact representation of the world wheat market. An immense amount of data on port facilities, intermodal transportation systems, financing capacity, and domestic use is required for an exact representation of the complete wheat logistics for a country. Thus, if the world were disaggregated into single country units, would the results merit the time and costs?

After considering these two issues and performing an extensive review of literature, a regional aggregation was selected, as shown in Table V. Selecting these geographic aggregations conforms with the regions used to estimate the supply and demand for wheat in the world for 1985. However, any import/export scenario for the world using those geographic regions listed in Table V that are inserted into the model once a transportation algorithm is completed and an "Optimal Trade Flow" adhering to the new import/export scenario is determined. Next, supply and demand estimates for wheat are discussed since the regions selected rely on the supply and demand estimates and vice versa.

World Production - Consumption Balances for 1985 With Regards to Export/Import Position

In general, the volume of grain entering international markets, as a proportion of total production and consumption of grain, has risen over the past decade. The upward trend can be accounted for by the increased grain imports of the centrally planned economies and some LDC's.

Observing changing world trade patterns, McCalla offers the following conclusions: 1) a few concentrated exporters continue to control the export market, and the importance of the United States in the export market is rising; 2) LDC's are emerging as dominant importers of wheat while the importance of developed countries has declined; 3) the centrally planned economies have entered the wheat

TABLE V

GEOGRAPHIC AGGREGATIONS USED IN MODEL ESTIMATIONS

Western Europe

Germany, Italy, Netherlands, France, United Kingdom
Rest of Western Europe

Africa

Egypt
Rest of Africa

Asia (Excluding People's Republic of China)

India, Japan
Rest of Asia

Latin America and the Caribbean

Argentin, Brazil
Rest of Latin America and the Caribbean

Communist Countries

Soviet Union, People's Republic of Chine, Eastern Europe

North America

Canada

Oceania

Australia
Rest of Oceania

and feed grains market as major importers; 4) the USSR has basically switched from a net exporter to a net importer but her activity in the world grain market has been erratic, resulting in significant destabilizing effects; 5) the EC-9 has switched to a net exporter of wheat but continues to be a steady importer of coarse grains; 6) the most rapid and substained increases in demand for wheat and feed grains are coming from OPEC nations and middle income LDC's with an adequate foreign exchange; 7) overall volume of trade is increasing, the rate of increase in coarse grains is larger than increases in wheat, and 8) the proportion of wheat production traded has remained constant at 21 percent while the proportion of coarse grain production traded has doubled to about 13-16 percent.[2]

Changing world trade patterns and trends have directly altered the tendency of major exporters to overproduce wheat. Throughout the sixties and early seventies, the United States diverted land from grain production to combat a chronic excess supply. However, presently U.S. grain stocks are below previous levels of the sixties and early seventies without land set aside programs.[3] Estimates of relative import/export positions should reflect changing world trade patterns as offered by McCalla.

The procedure chosen to forecast a region or an individual country's relative position as a net importer or net exporter is the balance sheet approach. Webb's supply and demand estimates for wheat were chosen because the estimates are results of some of the most recent research.[4] Variables of the balance sheet identity for wheat are:

Production + Carry-In Stock + Imports = Food Use + Feed Use + Seed Use + Other Uses + Carry-Out Stocks + Exports (5.1)

Since Webb's objective is to project future levels of export supply (import demand), the identity is rearranged and solved for exports. He assumes "Other Uses" are relatively insignificant, therefore, the variable "Other Uses" is omitted. Excluding major exporters, Inventory Stocks primarily represent pipeline stocks with only small differences between Carry-In and Carry-Out Stocks. Thus, the balance sheet identity is reduced to:

Production - Food Use - Feed Use - Seed Use = Net Exports (5.2)

Estimates of Production, Food Use, Feed Use, and Seed Use provide a simple approach to outline changes in the world wheat supply and demand for importing and exporting countries.

Excluding the Soviet Union, the People's Republic of China, and the regional aggregations noted as "Rest of...", a balance sheet analysis is performed for each country in Table V. Limitations in data availability require production and domestic utilization trend equations for the two communist countries and region aggregations. Individual countries are selected for balance sheet analysis on the basis of a five percent share of the world wheat import or export market. One exception, the Netherlands, is included because of its significant contribution as a marketing center.

The United State's participation in the world wheat market is examined by Webb under two market conditions. In the first market condition, the United States participates as a residual supplier for the other three major exporters of wheat (Argentina, Australia, Canada, and the United States). In the second market condition, the United States maintains its market share in 1985. The market share for the United States and the three combined exporters is based on 1974-1976 average shares, resulting in a 54.65 percent market share for the United States and 45.35 percent for the remaining three combined exporting countries.

Import/Export Capacity Restriction for Regions and Selected Countries

Import/Export capacity restrictions serve as a safety check value against shipping to or from a region some capacity in excess of probable or actual grain handling capability. Two methods are employed to determine the capacity restriction. One method uses an engineering approach and the other method is based on past participation of the country and/or regions in the world wheat market. Finally, the size of vessel a port can handle is discussed as a subcomponent of Import/Export Capacity.

An Engineering Approach to Estimate Wheat Handling Capacity

Bulk wheat handling capacity for the exporting countries United States, Canada, Australia, and Argentina is estimated by the engineering approach. France's exporting capacity is examined under the historic participation approach. The engineering approach utilizes the loading/discharging per hour rate for each grain elevator in a port as the basis for the procedure. Two steps are used in this study for examining wheat handling capacity based on the loading/discharging rate per hour. First, the yearly grain handling capacity for a port with one grain elevator installation can be defined as:

Loading/Discharging Per Hour Rate X Number of Working Hours in a Day X Five Day Workweek X 52 Weeks in a Year = Yearly Engineering Grain Handling Capacity. (5.3)

Second, the yearly engineering grain handling capacity is examined under different work week alternatives. Each work week alternative attempts to account for some percentage of actual working time to total available working time. Four percentages of working time utilized by an export elevator are defined as 50 percent, 55 percent, 60 percent, and 65 percent.

For a port with several grain elevators, a yearly engineering grain handling capacity for each facility is computed and summed. The summation of the grain handling capacity for each facility is representative of the port. The procedure is applicable for determining each major exporting country's grain handling capacity as a nation or by geographic regions. That is, the summation of each port's grain handling capacity within a region or country is representative of the each region's or country's grain handling capacity.

Grain handling capacity includes the movement of all grains. Thus, annual grain handling capacity is further specified to include only bulk handling capacity for wheat. An average percentage of wheat exports to total grain marketed by each country between 1976-1980 is used as an adjustment variable to calculate wheat handling capacity. The engineering grain handling capacity multiplied by the adjustment variable estimates the specific yearly wheat handling capacity for major exporting countries. The United States and Canada are subdivided into regions while Australia and Argentina's wheat handling capacity is estimated as an aggregate. A simple illustration of a projected U.S. wheat supply allocated by regions with given port capacities is provided to clarify the procedure for the reader (Note: The numbers used are fictitious).

The principal wheat export regions, the Great Lakes, Atlantic Coast, Gulf Coast, and Pacific Coast are allocated wheat exports by a five-year-average percentage of wheat shipments through each region (1976-1980) or export share. A flow diagram outlining the procedures is shown in Figure 8. Figure 9 contains a flow diagram of actual exports in 1977. An export share for the Gulf Coast of 50 percent of a projected 1.5 billion bushels of export wheat for 1985, results in the allocation of 0.75 billion bushels of wheat for export through the Gulf Coast. Once the quantity of wheat is assigned to a region, an upper restriction for wheat is calculated for the region. From equation 5.3, six billion bushels is calculated as the annual grain handling capacity for the Gulf Coast. The reduction variable, a five-year-average percentage of wheat to total grains exported through a region, is estimated at 20 percent for the Gulf Coast. The reduction variable multiplied by the total grain handling capacity implies the wheat handling capacity for the Gulf Coast is 1.2 billion bushels per year. Thus, the upper limit restriction for annual wheat movements through the Gulf Coast is 1.2 billion bushels. The procedure is then repeated for each of the remaining regions.

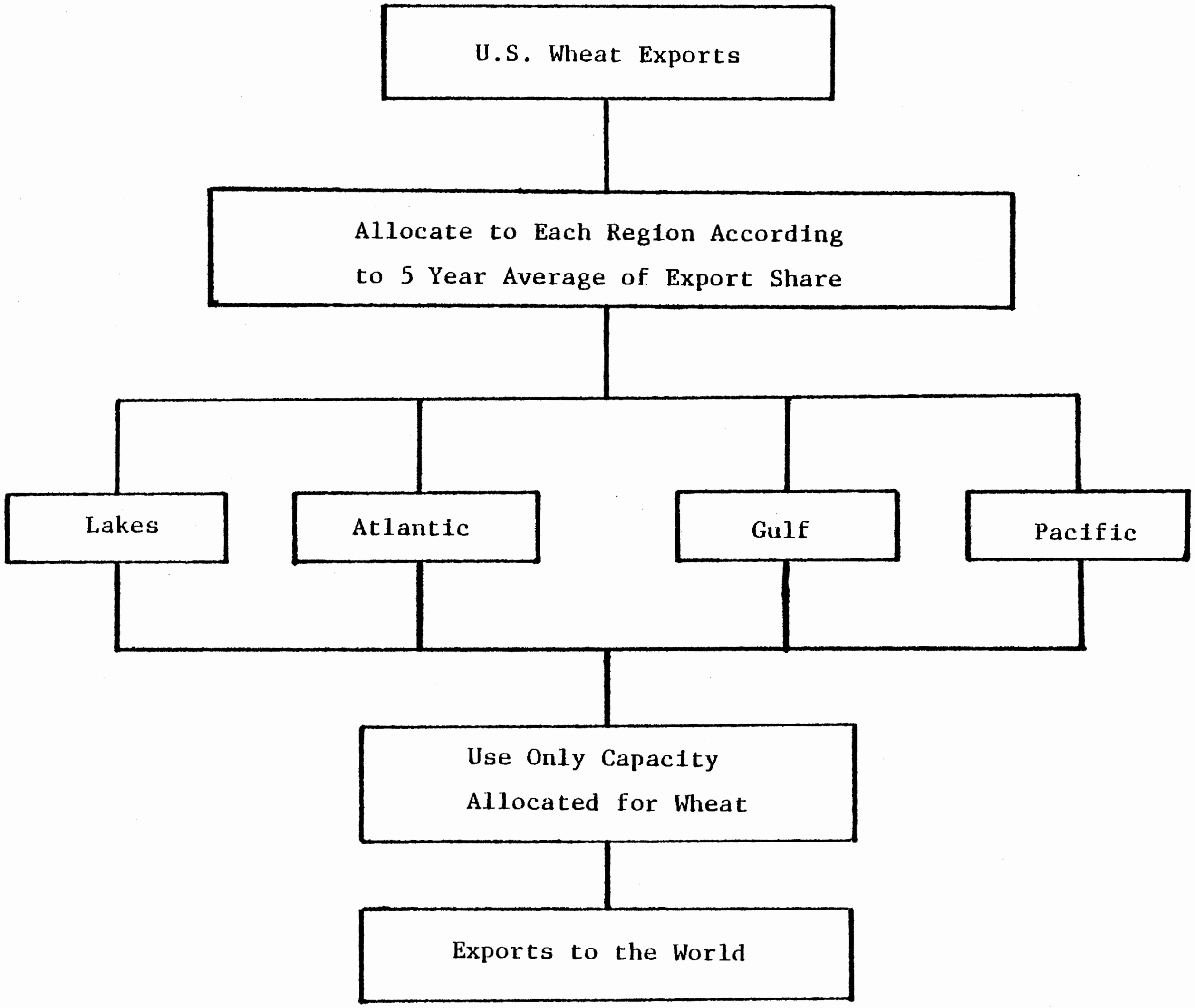
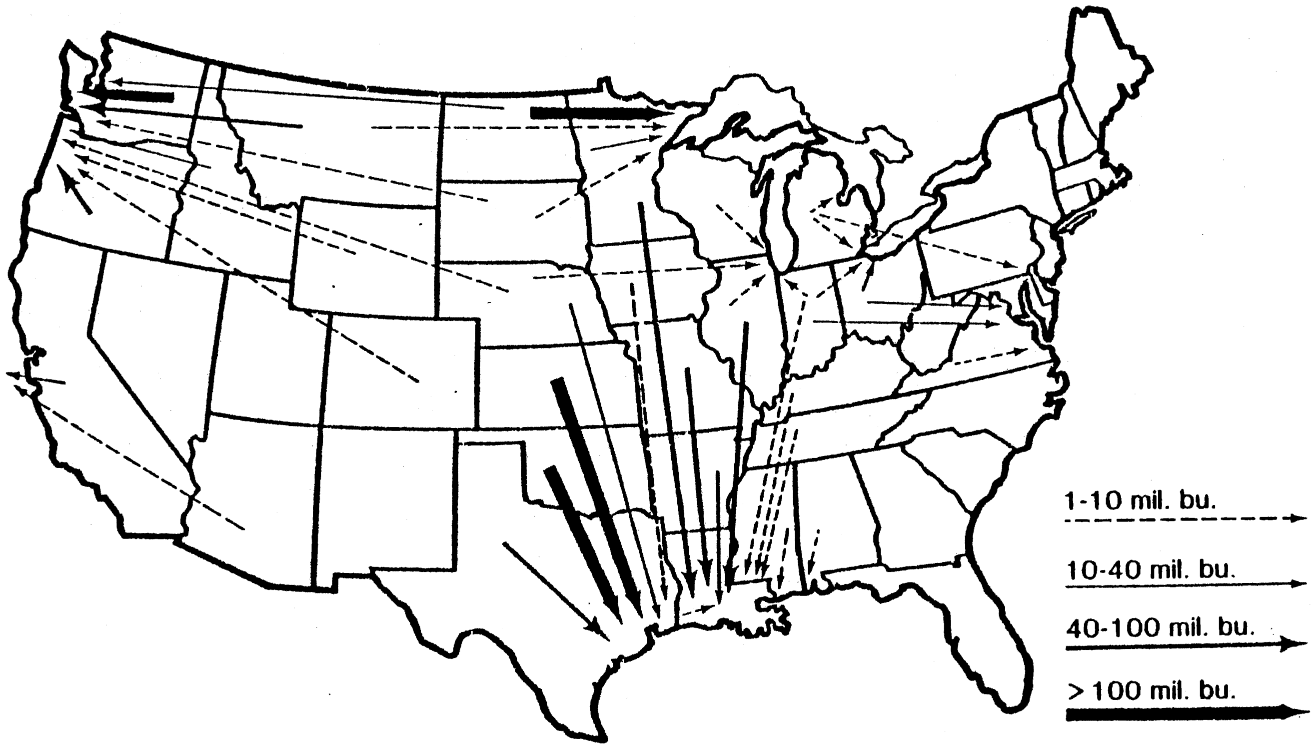


Figure 8. Projected U.S. Export Wheat Flow Diagram



Source: Wheat Movements in the United States, Mack Leath, Lowell Hill, and Stephen Fuller, North Central Regional Research Publication No. 274, Southern Cooperative Series Bulletin 252, Illinois Bulletin 767, University of Illinois at Urbana-Champaign, January, 1981.

Figure 9. Patterns of Wheat Flows to U.S. Port Areas in 1977

A Historical Participation Approach to Estimate Wheat Handling Capacity

Obviously, in some regions of the world sufficient data are not available for the engineering approach to be applicable. In many Less Developed Countries grain elevators do not exist, although in many cases the LDC's receive wheat in bulk quantities. Often the bulk wheat is first discharged to lighters outside the port in deeper water or the wheat is bagged on ship and removed by cranes. Lighters are used to lighten the load of a vessel reducing the draft required by the vessel.

A historical participation approach to estimate annual wheat handling capacity is employed for all other regions in the world where data for the engineering approach are not available. The largest yearly quantity of wheat imported into a region from 1970 to 1979 is the basis used in the historical participation approach. An unused capacity is added to the basis (i.e. 10 or 20 pecent) to give a realistic import capacity.

Vessel Restrictions as a Component of Port Capacity

Nonindustrialized nations are often subject to physical restrictions pretaining to the vessel size their ports can facilitate. The draft requirements of the vessel and the berth length are the most limiting factors with respect to vessel size.

Ship sizes are divided into six categories according to grain shipment size. The categories, in thousands of tons, are: 1) less than 10, 2) 10-19, 3) 20-29, 4) 30-39, 5) 40-49, 6) 50-59, 7) 60-69, and 8) 70 or more. The number of vessels in each category entering into any region is restricted according to 1981 vessel size characteristics. The purpose of the vessel size restriction is to prevent the model from shipping wheat on a vessel capable of 70,000 plus tons into a region without port facilities large enough to handle the vessel.

Ocean Transportation Rates for Bulk Grains

Ocean transportation rates for bulk grains are assumed to be homogeneous for all grains, including wheat. The daily newspaper journal, The Journal of Commerce, contains daily ocean freight rate quotes for various commodities. Ocean freight rate quotes from The Journal of Commerce from January 1, 1981 to December 31, 1981 serve as the source for charter rates. The daily freight rate quotes do not include all charter freight rate quotes for grain movements, but the rates are representative of shipping costs associated with grain movements from one region to another.

Charter freight rate quotes for grain shipments are first grouped in broad geographic areas according to point of origins and destinations found in Table VI. Within each destination area there may be one or more subgroupings which further adheres to geographic criteria. The ocean bulk grain freight rate from the U.S. Gulf Coast to the Antwerp-Hamburg Range is an example of a quote group from an origin to a subregion. Charter quotes for transportation rates to geographic areas within a grouping are subdivided into ship sizes listed previously.

TABLE VI

ORIGINS AND DESTINATIONS FOR OCEAN FREIGHT RATE DETERMINATION

Origins	Destinations (Region/Subregion)
US Gulf Coast	Africa
US Atlantic Coast	North Africa
US Great Lakes	West Africa
US Pacific Coast	East Africa
Canada, Pacific Coast	Asia
Canada, Great Lakes	Middle East
Canada, Atlantic Coast	Far East
Canada, St. Lawrence Seaway	Latin America
Australia	Mexico, Central America, and Caribbean
Argentina	South America-Atlantic Coast
France	South America-Pacific Coast
	Eastern Europe
	Baltic Sea
	Black Sea
	Western Europe
	Antwerp-Hamburg Range
	United Kingdom
	Scandanavia
	Spain to Portugal
	Baltic Region
	Spain to Italy
	Adreatic Sea
	Aegean Sea
	Japan
	USSR
	Black Sea
	Baltic Sea
	Egypt
	China

Consideration is given in this study to differences in shipping rates between countries and/or subregions. Identifying differences in shipping rates between adjacent countries and/or subregions provides clarity in understanding shipping flows with regard to major trade routes. Obviously, some countries and/or subregions will display no significant difference in shipping rates. An analysis of varience (AOV) procedure is used to determine if any two or more adjacent subregions can be combined for estimating shipping rates. That is, the variation in shipping rates is tested to determine if variation is due to the size of vessel or the combination of two or more regions. If the combination of subregions does not explain a significant portion of the variation in shipping rates, then it is concluded the two subregions can be combined.

Upon completing the subregion groupings, a general linear regression technique is applied to estimate shipping rates by size. The general model is:

$$Y = B_o + B_1 X + e \qquad (5.4)$$

where, Y = shipping rate

X = the size of vessel employed, and

e = error term

Two important aspects of estimating an equation representative of shipping rates between an origin and destination should be presented at this time. First, the daily freight rate quotes reported in the Journal of Commerce are grouped by month of occurance and deflated by the respective months grain freight index.

$$\frac{\text{Shipping quote in month A}}{\text{Grain Freight Index for month A}} = \text{Deflated Shipping Rate} \qquad (5.5)$$

Grain freight rates have been declining sharply over the time interval, January to December. Figure 10 contains the grain freight index. Deflating the shipping rate by Equation (5.5) eliminates some distortion occuring in the shipping rate along a shipping route where an identical shipment in January is dramatically different from a shipment in December due to inflationary pressures or exchange rates.

Second, the midpoint of a ship size classification (i.e. 15 thousand M.T. for the 10-19 thousand metric tons size interval) is used to estimate the predicted shipping rate for that particular ship classification.

Selected Scenarios for Analysis

This study examines an "Optimal Trade Flow" in four export scenarios. The United States is assigned a high level of wheat exports in scenarios 1 and 2 and a low level of wheat exports in scenarios 3 and 4. Thus, the world wheat exporting countries would export wheat at low levels in scenarios 1 and 2 and high levels in scenarios 3 and 4. Scenarios 1 and 3 are restricted by 1981 vessel size flow patterns and scenarios 2 and 4 are without vessel size flow pattern restrictions.

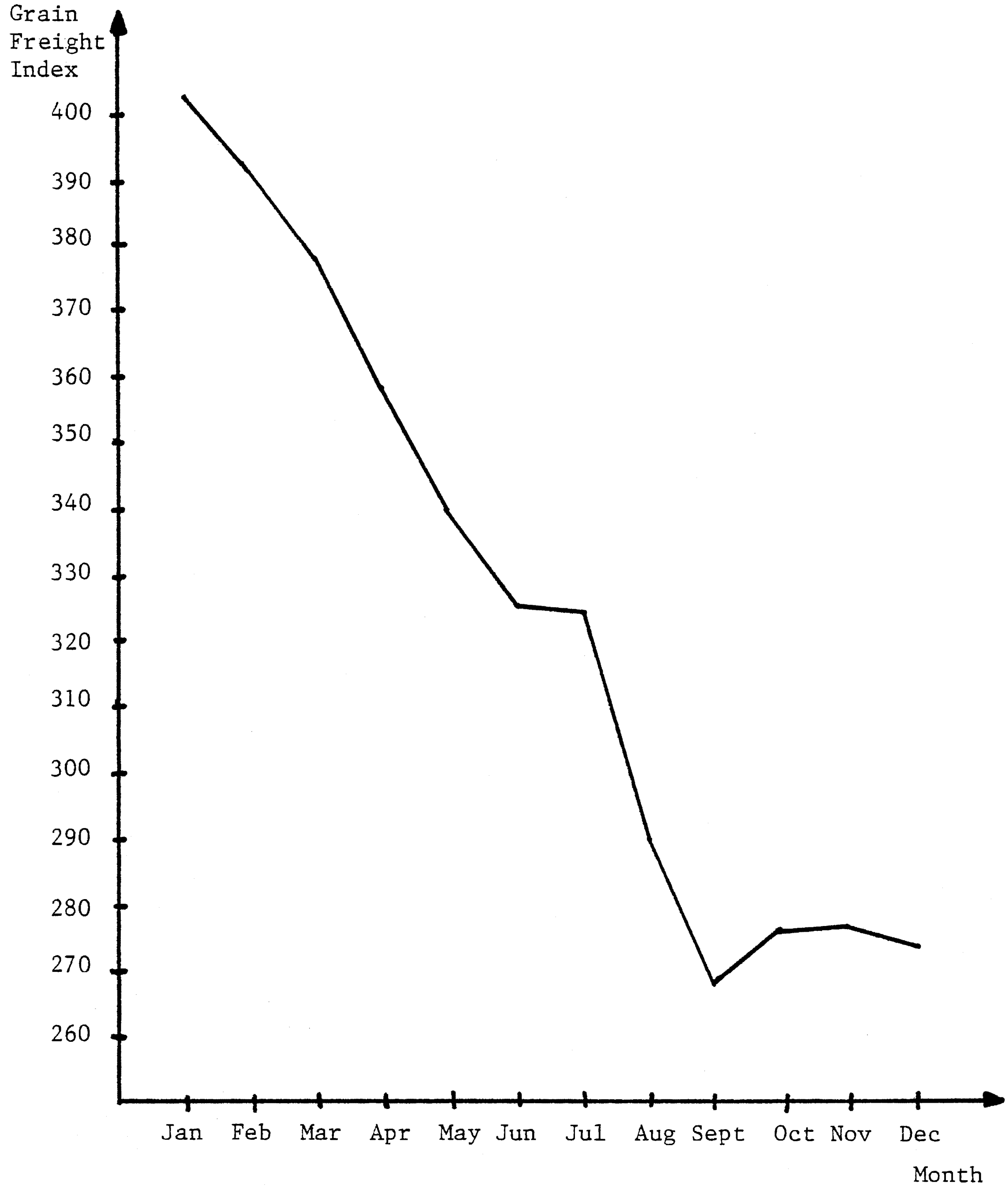


Figure 10. Monthly Grain Freight Index for 1981

FOOTNOTES

[1]Robert Bain, "Changes in the International Grain Trade in the 1980's," USDA, Economic Research Service, Foreign Agricultural Economic Report Number 167 (Washington, 1981), p. 3.

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CHAPTER VI

FORMULATION OF DATA USED IN THE LINEAR PROGRAMMING MODEL

Several specific techniques are utilized in generating data used in the LP model. Data sources and procedures for using the balance sheet approach to world wheat demands, identifying port capacities and shipping characteristics, and generating shipping rates are discussed in detail in the folloiwng sections and related appendices.

Balance Sheet Approach to World Wheat Demands in 1985

Webb's balance sheet approach consists of annual data from 1960-1976. The data were collected from four primary sources: 1) the International Wheat Council (IWC), 2) the Food and Agricultural Organization of the United Nations (FAO), 3) the United States' Foreign Agricultural Services (FAS), and 4) the Organization for Economic Cooperation and Development (OECD). The names and definitions of variables used in the balance sheet equations are given in Appendix A. Webb's Ph.D. dissertation should be consulted for the actual data contained in the balance sheet for each country and region.

Each balance sheet contains an error term. The error term is the amount necessary to equate total supply to total demand. Two explanations are given for the gap between total supply and total demand. First, the data used by Webb are from a combination of two or three of the four listed sources. Not every source of yearly data used the same collecting and accounting techniques which resulted in a discrepency when the figures were summed. Second, the balance sheet data and prices were adjusted to a July/June crop year. The method used to adjust components in the balance sheet identity often resulted in an inequality, i.e. total supply not equal to total demand. Third, total demand includes some utilization under "other uses".[1]

1985 Balance Sheet Projections

Demand Areas

A surplus or deficit position was calculated for each country and/or region. The Baseline Approach used the Balance Sheet estimates as the basis for calculating import positions. The major difference between the Baseline and the Balance Sheet Approach is that the Baseline excludes India, China, France and Brazil from being considered as potential importers in 1985. Table VII contains the results of the Balance Sheet calculations. The calculated import demand for the world is 29.9 million metric tons (MT). Webb asserts that world import demand is underestimated by 12 million MT, due to underreporting in the regions, "Rest of Africa, Asia, Latin America, and Oceania".

Each "Rest of ..." region, (except Rest of Western Europe) is assigned a percentage share of the 12 million MT. The total

TABLE VII

1985 BALANCE SHEET PROJECTIONS

	Area Harvested	Yield	Production	Food Use	Feed Use	Seed Use	Dom. Util.	Supply-Demand Balance	Adjusted Supply-Demand Balance
	mha	mt/ha	mmt	mmt	mmt	mmt	mmt	mmt	mmt
Western Europe Total			64.2				58.2	6.0	6.0
Germany	--	--	8.7[d]	3.9	3.3	.3	7.5	1.2	1.2
Italy	--	--	8.9[d]	10.2	.8	.6	11.6	- 2.7	- 2.7
Netherlands	.1	6.2	.5	1.0	.6	.1	1.7	- 1.2	- 1.2
France	4.0	4.8	19.4	4.5	3.1	.6	8.2	11.2	11.2
United Kingdom	1.4	4.1	5.8	5.2	2.3	.3	7.9	- 2.0	- 2.0
Rest of West Europe	--	--	20.9[d]	--	--	--	21.4[d]	- .5	- .5
Africa Total			13.2				25.3	-12.1	-15.0868
Egypt	.6	4.6	2.6	8.4	--	.1	8.5	- 5.9	- 5.9
Rest of Africa	--	--	10.6[d]	--	--	--	16.8[d]	- 6.2	- 9.1868
Asia Total			90.8				101.7	-10.9	-16.5856
India	--	--	45.9[d]	36.0	.5	2.9	39.4	6.5	6.5
Japan	--	--	.2[d]	5.2	.6	--	5.8	- 5.6	- 5.6
Rest of Asia[a]	--	--	44.7[d]	--	--	--	6.5[d]	-11.8	-17.4856
Latin America Total			12.9				17.1	- 4.2	- 7.5252
Brazil	5.7	1.5	8.4	4.5	.8	.4	5.7	2.7	2.7
Rest of Latin America[b]	--	--	4.5[d]	--	--	--	11.4[d]	- 6.9	-10.2252
Rest of Oceania	--	--	.3[d]	--	--	--	.4[d]	- .1	- .1024

TABLE VII (Continued)

	Area Harvested	Yield	Pro duction	Food Use	Feed Use	Seed Use	Dom. Util.	Supply-Demand Balance	Adjusted Supply-Demand Balance
	mha	mt/ha	mmt	mmt	mmt	mmt	mmt	mmt	mmt
Communist Total			205.7				214.3	- 8.6	- 8.6
Eastern Europe	--	--	37.5[d]	--	--	--	39.8[d]	- 2.3	- 2.3
USSR	--	--	114.4[d]	--	--	--	124.1[d]	- 9.7	- 9.7
PRC	--	--	53.8[d]	--	--	--	50.4[d]	3.4	3.4
Subtotal[c]			387.1				417.0[d]	- 29.9	-41.9
Subtotal[e]							--	--	-65.7
Argentina	--	--	8.7[d]	4.4	.3	.7	5.4	3.3	
Australia	8.5	1.2	10.5	1.4	.7	.6	2.7	7.8	
Canada	9.7	2.2	21.7	2.1	2.5	.9	5.5	16.2	
3 Exporters' Total			40.9				13.6	27.33	

[a]Excludes People's Republic of China.

[b]Excludes Argentina.

[c]World total less four major exporters.

[d]Estimated as an aggregate.

[e]World total less four major exporters, Brazil, China, India, and France

calculated import demand for the "Rest of ..." regions is 24.9 million MT. Rest of Africa accounts for 24.89 percent of the 24.9 million MT. Thus, Rest of Africa is allocated 24.89 percent of the 12 million MT, or 2.9868 million MT. Rest of Asia, Rest of Latin America, and Rest of Oceania are allotted 5.6856, 3.3252, and 0.0024 MT, respectively.

Adjusting original balance sheet projections by the additional 12 million MT increases the total projected imports to 41.9 million MT. The Baseline Approach implies world import demand to be 65.6 million MT.

Excluding Western Europe, each continent has a deficit position. Most notably, each region defined as "Rest of ..." typically possesses a large deficit relative to its respective continent's surplus/deficit position. Since these geographic aggregations (Rest of ...) may be too large to identify shipping rates and economically efficient shipping routes, each region defined as "Rest of ..." is divided into subregions (Table VIII). Also, some changes are implemented in defining Western Europe.

Wheat imports to each subregion is allocated on a percentage basis out of total wheat imports to the region. The percentage of wheat imports to each subregion from the total wheat imports of the region is allocated to each subregion. Thus, if the subregion North Africa typically imports 64.4 percent of all wheat shipments to Webb's regional aggregation "Rest of Africa" then North Africa is assigned 5.916 million MT of the adjusted 9.1868 million MT.

The percentage used to allocate wheat to subregions is based on a five-year-average percentage. The percentage allocated and the ultimate quantity of wheat allocated to each subregion is found in Table VIII.

The method used to calculate the surplus/deficit position of subregions in the Western Europe region deserves explanation. Referring to the five-year-average percentage corresponding with the subregions, the countries estimated originally by Webb are entered at a 100 percent level. For the countries contained in the subregion grouping that were originally contained in Webb's regional aggregation, "Rest of Western Europe", the quantity assigned to each country is based on the five-year-average percentage of that country's participation in wheat imports to Western Europe's total wheat imports.

Thus, in the subregion Antwerp to Hamburg Range, Belgium/Luxembourg accounts for 8.129 percent of Western Europe's wheat imports. Belgium/Luxembourg is assigned 8.129 percent of the quantity estimated by Webb for Rest of Western Europe or 406,450 MT of wheat. The procedure is reapplied to each subregion within the regional category, Western Europe.

The adjusted surplus/deficit position of each subregion in Table VIII represents the subregion in the linear programming model. The countries contained in each subregion which are instrumental in allocating subregions a surplus/deficit position are located in Appendix A.

Supply Areas

United States and Canadian ports are divided into regions according to a natural geographic breakdown. Australia and Argentina

TABLE VIII

REGION AND SUBREGION CLASSIFICATION (EXCLUDING MAJOR SUPPLIERS)

Region/Subregion	Five Year Average Percentage	Unadjusted Surplus/ Deficit Position	Total Unadjusted Subregion Surplus/ Deficit Position	Total Unadjusted Region Surplus/ Deficit Position	Adjusted Surplus/ Deficit Position	Total Adjusted Subregion Surplus/ Deficit Position	Total Adjusted Region Surplus/ Deficit Position
Western Europe				5.9943			5.9943
Western Europe-Atlantic				8.709426			8.709426
Antwerp-Hamburg Range			- 0.40645			- 0.40645	
Germany	100.00	1.2					
Netherlands	100.00	- 1.2					
Belgium/Luxembourg	8.13	- 0.40645					
United Kingdom			- 2.006602			- 2.006602	
United Kingdom	100.00	- 2.0					
Ireland	1.32	- 0.006602				-	
Scandanavia	3.738	- 0.01869	- 0.01869			- 0.01869	
Baltic Region	0.13675	- 0.006837	- 0.006837			- 0.006837	
France			11.18379			11.18379	
France	100.00	11.2					
Switzerland	3.242	- 0.91621					
Spain-Portugal	7.118	- 0.03559	- 0.03559			- 0.03559	
Western Europe-Mediteranean				-2.71507			-2.71507
Spain to Italy	NA	NA	NA				
Adreatic			- 2.71278			- 2.71278	
Italy	100.00	- 2.7					
Austria/Yugoslavia	2.56	- 0.01278					
Aegean	0.458	- 0.00229	- 0.00229			- 0.00229	

TABLE VIII (Continued)

Region/Subregion	Five Year Average Percentage	Unadjusted Surplus/ Deficit Position	Total Unadjusted Subregion Surplus/ Deficit Position	Total Unadjusted Region Surplus/ Deficit Position	Adjusted Surplus/ Deficit Position	Total Adjusted Subregion Surplus/ Deficit Position	Total Adjusted Region Surplus/ Deficit Position
Egypt				- 5.9			- 5.9
Africa				- 6.2			- 9.1868
North Africa	64.40	- 3.9928	- 3.9928		- 5.9160	- 5.9160	
West Africa	25.50	- 1.581	- 1.581		- 2.3430	- 2.3430	
East Africa	10.10	- 0.6262	- 0.6262		- 0.9278	- 0.9278	
Japan				- 5.6			- 5.6
India				6.5			6.5
Asia				-11.8			- 17.4856
Middle East	33.27	- 3.92586	- 3.92586		- 5.81746	- 5.81746	
Far East	66.73	- 7.87414	- 7.87414		-11.66814	-11.66814	
Latin America			- 6.9				- 10.2252
Mexico, Central America, and Caribbean	33.06	- 2.48814	- 2.48814		- 3.6872	- 3.6872	
South America-Atlantic	24.94	- 1.7224	- 1.7224		- 2.5502	- 2.5502	
South America-Pacific	38.98	- 2.68962	- 2.68962		- 3.9878	- 3.9878	
Brazil				2.7			2.7
Oceania				- 0.1			- 0.1024
Communist				- 8.6			- 8.6
Soviet Union				- 9.7			- 9.7
People's Republic of China				3.4			3.4
Eastern Europe				- 2.3			- 2.3
Eastern Europe Baltic Sea	88.0	- 2.024	- 2.024				
Eastern Europe Black Sea	12.0	- 0.276	- 0.276				

are not subdivided into regions. The United States is divided into four regions (Gulf Coast, Pacific Coast, Atlantic Coast, and Great Lakes) as shown in Table IX. Canadian ports are grouped into two regions (Great Lakes/St. Lawrence/Atlantic Coast, and Pacific Coast).

Predicted quantities of wheat available for export are assigned to each region according to a five-year-average percentage of wheat movement through each region. The percentage of wheat exports alloted to the U.S. Gulf, U.S. Pacific, U.S. Atlantic and U.S. Great Lakes are 52.89, 35.25, 4.61, and 7.25 percent, respectively. The Canadian subregions, Great Lakes/St. Lawrence/Atlantic and Pacific are allocated 61.32 and 38.68 percent, respectively, of Canadian exports. These are shown in Table X.

In this analysis, leading exporters are assigned an export quantity according to each country's volume share from 1975-1979. Table XI contains the volume shares of leading exporters.

For the United States, 40.9 percent of 65.6 million MT or 28.8259 million MT of world import demand is met by the United States. Canada, Australia, France, and Argentina account for 11.6748, 8.1986, 7.1492, and 3.2138 million MT respectively, of world import demand. The remaining 13 percent or 9.5265 million MT is allowed, in the first and second scenarios to be furnished by the United States and in the third, and fourth scenarios to be furnished by the other major wheat exporters. Thus, in the first and second scenarios, the United States has a high level of exports. The maximum quantity of wheat exported from the U.S. is 35.3525 million M.T.,or 53.9 percent of total wheat exports.

TABLE IX

U.S. REGIONAL WHEAT ALLOCATION

Region	5 Year Average Percent
Gulf	52.89
Pacific	35.25
Atlantic	4.61
Great Lakes	7.25
Total	100.00

Source: U.S. Department of Agriculture, _Foreign Agriculture Circular, Grains_, Foreign Agriculture Service, (Washington, various issues).

TABLE X

CANADIAN REGIONAL WHEAT ALLOCATION

Region	5 Year Average Percent
Great Lakes/St. Lawrence/Atlantic	61.32
Pacific	38.68
Total	100.00

Source: International Wheat Council, _World Wheat Statistics_, (London, various issues).

TABLE XI

WORLD WHEAT EXPORTS: VOLUME SHARES OF LEADING EXPORTERS

Year Ending: June 30	United States	Canada	Australia	France	Argentina
			Percent		
1960	41.7	21.6	11.6	3.6	4.5
1961	40.7	20.6	12.9	3.8	4.9
1962	38.9	20.3	10.8	6.7	4.1
1963	40.2	26.2	13.5	4.7	4.9
1964	36.8	22.6	12.3	8.7	8.1
1965	36.9	23.5	8.9	7.5	12.4
1966	34.8	25.8	12.0	5.3	5.4
1967	37.7	16.7	13.1	7.9	2.6
1968	29.8	17.7	10.9	12.3	5.6
1969	30.2	16.5	13.5	11.2	3.8
1970	34.7	20.1	16.6	5.7	2.8
1971	29.9	24.2	15.3	9.9	2.4
1972	43.4	21.3	7.7	11.1	4.0
1973	44.9	16.8	7.8	12.7	1.6
1974	41.0	16.2	12.0	11.7	3.1
1975	43.3	16.6	10.8	12.5	4.4
1976	38.1	18.8	12.4	9.9	8.2
1977	39.6	19.9	13.9	9.4	3.3
1978	41.9	17.4	8.7	11.9	4.3
1979 1/	41.9	16.1	16.3	10.4	5.2
1975-79 Average	40.9	17.8	12.5	10.9	4.9

[1]Preliminary.

Source: U.S. Department of Agriculture, Foreign Agriculture Circular, Grains, Foreign Agriculture Service, (Washington, various issues).

The projected quantity demanded does not take into account intra-European Economic Community trade. Intra-member wheat trade is an integral component of the Common Agriculture Policy agreement. To circumvent the proposed problem, deficit positions of member nations were reduced by a factor representative of the quantity normally suppled by France. France accounted for 50.68 percent of EEC iomports from 1976 to 1980. Under the scenario, where the United States high level of exports, available exports from France were reduced from 9,165,276 metric tons to 7,975,305 metric tons. The 1,189,992 metric tons of wheat are assigned to intra-EEC trade. The procedure is applied in each export scenario.

Shipping Characteristics

Harbours throughout the world vary in available draft and berth length. Each vessel size category requires certain draft and berth lengths in order to be unloaded properly. Originally, each port with a grain facility is located, and draft and berth lengths identified. Restrictions are placed on any given port to assure that vessels entering into the port are not larger than the port facility can handle. There are 130 ports located around the world that are classified as Primary ports, Minor ports, or Alternative ports.

Primary ports are a principal port where bulk grain is handled for export or import. Primary ports usually have a storage capacity of 20,000 metric tons and a loading/discharging rate of 400 metric tons per hour. Minor ports have bulk grain handling facilities, however, actual silo capacities and loading/discharging rates are often unknown. In regions where ports with grain facilities are not indicated, a large port is chosen as an Alternative port.

Shipment activities accounting for the slightly more than one hundred thirty ports (United States ports have not been included) with draft restrictions, berth length restrictions, and annual loading/discharging rates would introduce needless cumbersomeness into a model. By accounting for these restrictions and the supply ports, there would be approximately 50 thousand columns in a linear programming model. The problem with large shipping vessels entering into small harbours is circumvented when each region is assigned to handle a share representative of vessel sizes into the regions. The representative share is based on 1981 shipping flows with respect to vessel size. For example, Western Europe-Atlantic region is assigned the following vessel size pattern:

0-09 thousand metric tons	1.41 percent
10-19 thousand metric tons	21.49 percent
20-29 thousand metric tons	15.06 percent
30-39 thousand metric tons	11.04 percent
40-49 thousand metric tons	5.42 percent
50-59 thousand metric tons	18.07 percent
60-69 thousand metric tons	9.64 percent
70 plus thousand metric tons	17.87 percent
	100.00 percent

The assigned vessel size patterns for other regions will be discussed under their respective subsection in the section World Demand Areas.

Many subregions of the world do not have shipments reported in the Journal of Commerce for all vessel sizes. The largest vessel size reported for a subregion is assumed to be indicative of the size of vessel which that subregion can handle with respect to draft and berth requirements. Vessel sizes larger than the largest reported size are not included in the model as a possible activity for shipping wheat into any region. Exclusion of activites for larger vessel sizes are an implicit method used to regulate and protect a subregion from being assigned large vessels which cannot be unloaded at their ports.

Two subregions are allowed to receive wheat shipments at two ports. Spain can either receive wheat shipments at Atlantic coast ports or Mediterranean Sea ports. The Soviet Union has import capacity at both Baltic Sea and Black Sea regions. For both Spain and the Soviet Union, the LP model has the option to supply wheat into the receiving port area which represents the least cost.

Port Capacity

A historic approach or an engineering approach to estimate port handling capacity for wheat import/export are two methods employed to identify possible bottlenecks. The Port Capacity section is divided into two subsections, world demand areas and world supply areas.

World Demand Areas

Lack of data on port loading rates in many regions of the world and inconsistency of the available data necessitate the employment of the historic approach to wheat handling capacity. Table XII contains

TABLE XII

DEFICIT REGION AND SUBREGION HISTORIC IMPORT CAPACITY

Region/Subregion	Original Projected Deficit Position	Adjusted Projected Deficit Position	High Export Level (1969-1978)	Low Export Level (1969-1978)
	mmt	mmt	mmt	
Western Europe - Atlantic				
Antwerp-Hamburg Range	0.40645	0.40645	6.125	1.518
United Kingdom	2.00660	2.00660	5.386	1.495
Scandanavia	0.01869	0.01869	0.549	0.272
Baltic Region	0.00683	0.00683	0.028	0.003
Spain to Portugal	0.03559	0.03559	1.108	0.178
Spain	0.00767	0.00767	0.221	0.001
Portugal	0.02792	0.02792	0.898	0.172
Western Europe - Med.				
Spain to Italy	N/A	N/A	N/A	N/A
Adreatic	2.71507	2.71507	4.404	1.162
Aegean	0.00229	0.00229	0.457	0.031
Egypt	5.90000	5.90000	3.988	1.560
Africa				
North Africa	3.99280	5.91600	3.836	0.953
West Africa	1.58100	2.34300	1.664	0.568
East Africa	0.62620	0.92780	0.572	0.230
Japan	5.60000	5.60000	5.923	4.425
Asia				
Middle East	3.92586	5.81746	4.936	1.862
Far East	7.87414	11.66814	9.567	4.891
Latin America				
Mexico, Central America, and Caribbean	2.48814	3.68720	2.315	0.959
S. America - Atlantic	1.72240	2.55020	1.512	0.946
S. America - Pacific	2.68962	3.98788	2.109	0.923
Soviet Union	9.70000	9.70000	15.000	0.147
Eastern Europe				
E. Europe - Baltic Sea	2.02400	2.02400	5.901	3.592
E. Europe - Black Sea	0.27600	0.27600	1.121	0.092
Total	53.59168	65.58912		

the information needed to examine import capabilities on a historic basis.

Western Europe-Atlantic. Each subregions original and adjusted deficit positions are identical since no adjustment was performed on Western Europe. The resulting deficit positions are well below the largest quantity of wheat imported into each subregion. In fact, three out of five subregion's deficit positions are below the smallest quantities imported into the subregions.

There is no evidence of a possible bottleneck into any subregion in the Western Europe-Atlantic region. Excess import capacity for Western Europe-Atlantic is expected under a declining wheat demand scenario. The vessel size flow pattern was presented earlier.

Western Europe-Mediterranean. The conclusions derived after examining the Western Europe-Mediterranean region are identical to the conclusions for Western Europe-Atlantic. The deficit position of each subregion is below the largest quantity of imports. Again, a declining demand for wheat contributes to excess import capacity.

Western Europe-Mediterranean is restricted to the following vessel size flow pattern:

0-09 thousand metric tons	3.40 percent
10-19 thousand metric tons	34.01 percent
20-29 thousand metric tons	40.83 percent
30-39 thousand metric tons	8.84 percent
40-49 thousand metric tons	3.40 percent
50-59 thousand metric tons	7.48 percent

60-69 thousand metric tons	2.04 percent
	100.00 percent

Egypt. Egypt's predicted demand in 1985 is 5.9 million metric tons of wheat. From 1969-1978 the largest quantity of wheat imported into Egypt was 3.988 million metric tons. Egypt faces the possibility of bottlenecks at each wheat receiving port. An unused yearly load-in capacity of 47.9 percent would allow Egypt to handle the predicted wheat imports without experiencing bottlenecks.

The 1981 vessel size flow pattern restriction for Egypt is:

0-09 thousand metric tons	1.89 percent
10-19 thousand metric tons	5.66 percent
20-29 thousand metric tons	85.53 percent
30-39 thousand metric tons	2.52 percent
40-49 thousand metric tons	0.63 percent
50-59 thosuand metric tons	3.77 percent
	100.00 percent

Africa. North and East Africa's original projected deficit position are above the highest level of wheat imports into each subregion. An additional 10 percent load-in capacity in North and East Africa would facilitate the original projected import demand. West Africa's original projected deficit position is below West Africa's historic maximum level of imports.

However, after adjusting each subregions deficit position the 10 percent unused capacity is no longer adequate. North, West and East Africa must possess an unused yearly load-in capacity of 54.1, 40.8, and 62.2 percent, respectively. Each subregion in Africa represents a potential bottleneck in the future.

The 1981 vessel size flow pattern for Africa is:

0-09 thousand metric tons	8.86 percent
10-19 thousand metric tons	53.87 percent
20-29 thousand metric tons	33.21 percent
30-39 thousand metric tons	1.85 percent
40-49 thousand metric tons	1.48 percent
50-59 thousand metric tons	0.37 percent
60-69 thousand metric tons	0.37 percent
	100.00 percent

Japan. Japan's projected import demand for 1985 is adequately within the region's historic limits. Japan does not represent a potential bottleneck in the future according to its historic participation in the world wheat market.

The 1981 vessel size flow pattern assigned to Japan is:

10-19 thousand metric tons	7.25 percent
20-29 thousand metric tons	22.90 percent
30-39 thousand metric tons	28.90 percent
40-49 thousand metric tons	7.25 percent
50-59 thosuand metric tons	33.70 percent
	100.00 percent

Asia. The original projected deficit position for Middle and Far East Asia satisfies the maximum level criteria set by the historic import level. Once the deficit position has been adjusted, the maximum level criteria ceases to be satisfied for both subregions. Middle East and Far East Asia require 17.8 and 21.9 yearly percent unused load-in capacity, respectively, to adequately meet the import capacity requirement.

Far East and Middle East Asia's ability to maintain their demand for wheat does not appear to be hampered by potential bottlenecks. A 17.8 and 21.9 yearly percent unused load-in capacity average is a plausible level of utilization for the respective subregions.

Asia is assigned the following 1981 vessel size flow pattern restriction:

0-09 thousand metric tons	1.05 percent
10-19 thousand metric tons	14.90 percent
20-29 thousand metric tons	64.11 percent
30-39 thousand metric tons	10.45 percent
40-49 thousand metric tons	2.44 percent
50-59 thousand metric tons	5.23 percent
60-69 thousand metric tons	0.70 percent
70 + thousand metric tons	1.04 percent
	100.00 percent

Latin America. Each Latin American subregion's original projected deficit position is greater than the largest yearly quantity imported from 1969-78. The subregion, Mexico, Central America, and Caribbean would be able to maintain the original import demand if the subregion had a yearly excess load-in capacity of 10 percent. South America-Atlantic Coast and South America-Pacific

Coast subregions could maintain import demand with yearly excess load-in capacities of 15 and 30 percent, respectively.

To achieve the adjusted import demand, yearly excess capacity of 59.2 percent is required for Mexico, Central America, and Caribbean subregion. An excess capacity of 68.6 percent for the South America-Atlantic Coast and 89 percent for the South America-Pacific Coast is required. Potential bottlenecks might arise when achieving the adjusted import demand.

Latin American is assigned the following 1981 vessel size flow pattern restriction:

0-09 thousand metric tons	21.64 percent
10-19 thousand metric tons	32.90 percent
20-29 thousand metric tons	49.15 percent
30-39 thousand metric tons	1.12 percent
	100.00 percent

Soviet Union. The deficit position of the Soviet Union adheres to the import criterion. Soviet Union's import demand estimate for 1985 of 9.7 million metric tons is below the country's largest yearly participation of 15 million metric tons. There is no evidence of potential bottlenecks for wheat shipments into the Soviet Union.

The Soviet Union and Eastern Europe are assigned the follwoing 1981 vessel size flow patterns:

10-19 thousand metric tons	11.83 percent
20-29 thousand metric tons	30.10 percent
30-39 thousand metric tons	46.24 percent

40-49 thousand metric tons	8.60 percent
50-59 thousand metric tons	3.23 percent
	100.00 percent

Eastern Europe. The deficit positions for Eastern Europe subregions are below the maximum quantity of wheat imported into each subregion. At this particular time, concern is merited for future bottlenecks into Eastern Europe at the predicted import level for 1985.

Oceania. The model does not incorporate any shipment activities into the Oceania subregion. During 1981, there ws one observed grain shipment into Oceania. The shipment originated from the Gulf Coast on a 10-19 thousand metric ton vessel at a cost of 34 dollars per MT. Therefore, Oceania is assumed to be supplied by the U.S. Gulf on 10-19 thousand metric ton ships for a total cost of 3.479 million dollars.

Concluding Remarks on Import Capacity. Wheat import capacity for Egypt, Africa, and Latin America should be addressed with concern regarding the projected wheat import demand for 1985. Each region has the potential for future bottlenecks if ports in the region cannot meet the unused load-in capacity requirements stated earier while maintaining other grain import levels. The historic approach to import capacity relies on information concerning only wheat shipments. A region may opt to shift some import capacity of other grains to the handling requirements of wheat as an alternative to increase wheat handling capacity.

The utility gained from increasing wheat shipments by one unit must be greater than the utility forgone by giving up one unit of other grains. Each region faces a decision to improve it's harbour facilities if the region is not willing to give up other grains for wheat. Thus, if unused yearly load-in capacity is below the requirement needed to fulfill wheat imports and maintain other grain import requirements, the region can either substitute other grains for wheat or improve existing harbour facilities.

World Supply Areas

Of the major exporters, the United States, Canada, Australia, and Argentina have the necessary data available to estimate a yearly wheat handling capacity using the engineering approach. France's export capacity is examined under the historic approach for export capacity identification. Capacities of the U.S., Canada, Australia and Argentina are discussed first, and France's capacity is discussed last.

Each exporter is assumed to participate in the world market at its market share as shown in Table XIII. The market participation of the United States with a comparative advantage and the world possessing the comparative advantage is shown in Table XIII.

United States

The United States world wheat market share can range from 26.8259 to 35.3525 million metric tons. Wheat flow assignments to regions in the United States are based on volume share percentage and

TABLE XIII

ADJUSTED PROJECTED WORLD WHEAT SUPPLY FOR 1985
BY EXPORT COUNTRIES

Country	Market Share Percent	Projected Exports	High Level of Wheat Exports Assigned to: US	World
		mmt	mmt	mmt
United States	40.9	26.825954	35.352541	26.825954
Canada	17.8	11.674865	11.674865	14.967125
Australia	12.5	8.198641	8.198641	10.510617
France	10.9	7.149215	7.149215	9.165276
Argentina	4.9	3.213867	3.213867	4.120157
Undetermined	13.0	8.526587		

are shown in Table IX. High and low level estimates for wheat export movement through each region are found in Table XIV.

One of the objections of this study is to determine if the United States has the export capacity to handle high level of exports. The engineering approach is used to answer this export capacity question. The engineering approach to export capacity utilizes the load-out rate of each port. There are two steps to calculate an engineering export capacity. The first step relies on Formula 5.3 and the second step applies a percentage utilization of operating time concept.

Engineering Capacity -- A Structured Formula Approach. The structured formula has several areas where misidentification of a variable's value could distort the port's yearly load-out capacity. The number of working hours in a day, working days in a week, and working weeks in a year are necessary data needed to determine yearly load-out capacity. An attempt was made to identify these data.

To identify such data, two prominent export elevators in the Houston/Galveston port area were interviewed in order to achieve insight on the above mentioned parameters. The two elevators are named Elevator A and Elevator B.

Elevator A indicated a typical work week of 20 hours a day and 7 days a week or a total of 140 work hours in a week. Elevator B's typical work week was only 6 days but operated for 24 hours a day or 144 work hours in a week. Grain Elevator B's terminal manager offered two additional work week alternatives as representative of a typical elevator: 1) 6-day work week at 18 hours per day (108 work

TABLE XIV

UNITED STATES WHEAT EXPORTS BY REGION

Region	Percent Market Share	Projected Low Level	Projected High Level
		mmt	mmt
Gulf	52.89	14.188247	18.697959
Pacific	35.25	9.456149	12.461771
Atlantic	4.61	1.236677	1.629752
Great Lakes	7.25	1.944881	2.563059
Total	100.00	26.825954	35.352541

hours per week), and 2) 5-day work week at 18 hours per day (90 work hours per week).

The complexity of identifying typical work week alternatives leads to the imposition of severe doubts toward any figure for export capacity generated through this approach. The problem is compounded when the load-out rate is used at an optimal level to calculate export capacity (the level the load-out is reported). The utilization of operating time concept is employed to circumvent problems associated with a structured formula approach.

Engineering Capacity -- Utilization of Operating Time Approach. Total yearly utilization time for the suggested work week alternatives:

(1) 20 hours, 7 days a week or 7,280 hours per year,

(2) 24 hours, 6 days a week or 7,488 hours per year,

(3) 18 hours, 6 days a week or 5,616 hours per year, and

(4) 18 hours, 5 days a week or 4,680 hours per year

are:

(1) 83.1 percent work hour utilization,

(2) 85.5 percent work hour utilization,

(3) 64.1 percent work hour utilization, and

(4) 53.4 percent work hour utilization.

The author is inclined to believe all U.S. export ports would not operate at levels consistent to work week alternatives 1 and 2 for an entire marketing year. A port that operates at 85 to 90 percent of capacity must be synchrinized perfectly with an adequate intermodel transportation system (i.e. railroads, grain trucks) and that intermodal transportation system must not experience excessive breakdowns or bottlenecks. The probability of an intermodal transportation system operating this efficient to all grain export terminals is relatively small. Work week alternatives 3 and 4 intuitively could be representative of exporting ports, but what level of utilization should be employed?

Since exact levels of utilization are difficult to determine, four different utiliztion levels within the range of work week alternatives 3 and 4 are used for this analysis. These utilization levels are 50 percent, 55 percent, 60 percent and 65 percent. Ports located in each region of the United States are grouped together, and an export capacity for all grains under the different utilization levels are estimated for each region. Total grain capacities are multiplied, by the percentage of wheat exports to total grain exports in each region in order to determine the available capacity for wheat exports assuming there are no changes in other grain exports within each region. Table XV contains total grain export capacity and wheat export capacity by region under four different utilization scenarios. Export terminals and load-out rates are in Appendix B.

Gulf Coast and Great Lakes regions would not experience difficulties in handling the low level or high level of exports while operating at 50 percent capacity for wheat. The projected low level of wheat exports for the Pacific Coast region can be adequately handled at 55 percent of capacity for wheat. At 78 percent of capacity for wheat the projected high level of exports can be exported through the Pacific Coast. The Atlantic Coast region can handle the projected low level exports volume at a 75 percent level

TABLE XV

UNITED STATES WHEAT EXPORTS BY REGIONS
AND ENGINEERING EXPORT CAPACITY

Region	Projected Exports		Percent Terminal Operating Time							
			For All Grains				For Wheat			
	Low Level	High Level	50	55	60	65	50	55	60	65
	mmt	mmt	mmt	mmt	mmt	mmt	mmt	mmt	mmt	mmt
Gulf	14.1882	18.6979	229.08	252.00	274.92	297.80	32.57	35.82	39.08	42.33
Pacific	9.4561	12.4617	93.29	102.63	111.96	121.29	8.80	9.68	10.61	11.44
Atlantic	1.2366	1.6297	59.70	65.67	71.65	77.65	0.73	0.81	0.88	0.95
Great Lakes	1.9448	2.5630	150.16	165.19	180.21	195.23	2.97	3.27	3.56	3.86
Total	26.8259	35.3525	532.23	585.49	638.74	691.94	45.07	49.58	54.13	58.58

of utilization. The projected high level of exports can not be handled by the Atlantic ports. The quantity of wheat not able to go through the Atlantic Coast region would be absorbed by another region. This simplistic approach to analyze the United States wheat export capacity provides no indication of potential bottlenecks in the forseeable future, that is, if the volume share of other grains remain constant, ceteris paribus.

Canada

The market share participation for Canada is either 11.6748 or 14.9671 million MT. The problems associated with identifying key parameters in a structured formula are identical for Canadian ports as they are for U.S. ports. In fact, engineering capacity data for Canadian, Australian, and Argintine ports will not be identified by the structured formula. However, the structured formula approach is useful when determining the range used in the time utilization approach to export capacity.

Engineering Capacity -- Utilization of Operating Time Approach. The author does not have a good indication of the hours typically worked per work day at Canadian ports. Each country has port working habits which may or may not be representative of all exporting countries. Since Canadian ports are located in close proximity to U.S. ports, Canada's engineering capacity is examinded under the same 50, 55, 60, and 65 percent of terminal utilization yearly work week alternatives as the United States is examined.

Table XVI contains the engineering export capacity data by region for Canada. The utilization of operating time for all grains is reduced by the five-year-average percentage of wheat exports to total grain exports (75.42 percent), and the product is assigned to represent the wheat export capacity for Canada's two regions. The lowest operating level examined, 50 percent, is extremely high for each region compared to the projected low level of exports and projected high level of exports. The results indicate that Canadian ports have excess capacity, or the percentage working hours is much less in Canada than in the United States, or both.

From 1976-1980, Canada's largest exported quantity of wheat is 15.759 million metric tons. The total projected export quantity for Canada under the high level of exports scenario of 14.9671 million metric tons is less than the largest quantity of wheat exported. Based upon this examination, Canada does not have conditions which could lead to bottlenecks in 1985. The examination process assumes other grain exports remain constant. The export terminals and load-out rates are found in Appendix B.

Australia

Australia has 18 export terminals located in the provinces of Queensland, New South Wales, Victoria, South Australia and Western Australia. These ports are responsible for handling the predicted wheat exports for 1985 which range from 8.1986 to 10.5106 million MT. Figure 11 shows Australia's ports.

TABLE XVI

CANADIAN WHEAT EXPORTS BY REGIONS
AND ENGINEERING EXPORT CAPACITY

Region	Projected Exports		Percent Terminal Operating Time							
			For All Grains				For Wheat			
	Low Level	High Level	50	55	60	65	50	55	60	65
	mmt	mmt	mmt	mmt	mmt	mmt	mmt	mmt	mmt	mmt
Great Lakes/ St. Law./ Atlantic	7.1590	9.1778	202.99	223.29	243.59	263.89	153.11	168.42	183.73	199.05
Pacific	4.5158	5.7892	55.43	60.97	66.51	72.06	41.81	45.99	50.17	54.35
Total	11.6748	14.9671	258.42	284.26	301.10	335.95	194.92	214.41	233.90	253.40

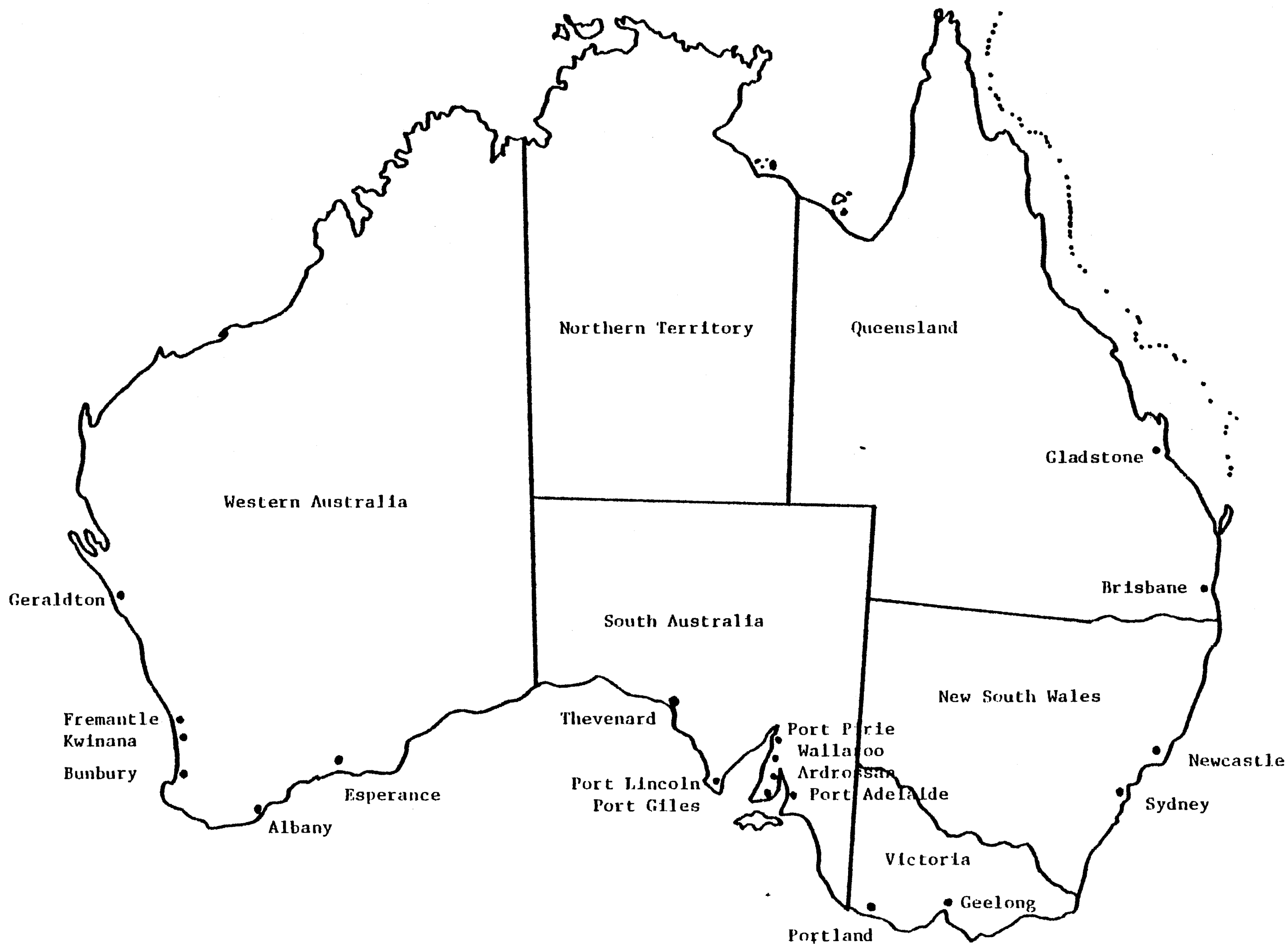


Figure 11. Main Grain Ports of Australia

Engineering Capacity -- Utilization of Operating Time Approach. Infomation on the length of operating time for export terminals has not been attainable. Although in a recent fact finding mission to Australia, concerning port capacities with regard to wheat, Rosson, reports Australian harbours conduct business during the following hours:

Monday - Friday	730-2400 (midnight)
Saturday	800-1200
Sunday	730-2400

or a total work week consisting of 91 hours.[2] Australian ports are open for business 54 percent of the available annual time. No indication is given on the time interval which the harbour is open for business that is utilized by export terminals. The export capacity for Australia was determined using the four work week alternatives of 50, 55, 60, and 65 percent. After determining the yearly export capacity for all grains, the gross export capacity is multiplied by a five-year-average percentage of wheat exports to total grain exports (79.48 percent). Four different work week alternatives for all grains and wheat are found in Table XVII.

Australian ports operating at 50 percent of available yearly capacity would have approximately 8 times the capacity needed to handle projected wheat exports for 1985. Rosson concludes the actual export capacity is lower than 87,208 million MT, but closer to 18.0 million MT per year or 1.5 million metric tons per month. The more conservative figure of Rosson accounts, at least in part, for the intermodal transportation system.[3] The historic peak quantity for wheat exports from 1976-1980 is 14.876 million metric tons.

TABLE XVII

AUSTRALIAN WHEAT EXPORTS AND ENGINEERING EXPORT CAPACITY

Region	Projected Exports		Percent Terminal Operating Time							
	Low Level	High Level	For All Grains				For Wheat			
			50	55	60	65	50	55	60	65
	mmt	mmt	mmt	mmt	mmt	mmt	mmt	mmt	mmt	mmt
New South Wales			21.02	23.12	25.22	27.33	16.71	18.38	20.05	21.72
Queensland			8.76	9.63	10.51	11.38	6.96	7.65	8.35	9.05
South Australia			32.63	35.89	39.15	42.42	25.93	28.52	31.12	33.71
Victoria			10.51	11.56	12.61	13.66	8.35	9.19	10.02	10.86
Western Australia			36.79	40.47	44.15	47.83	29.24	32.16	35.09	38.07
Total	8.1986	10.5106	109.71	120.69	131.66	142.63	87.20	95.93	104.65	113.37

In each instance, the projected high level of exports by Australia is lower than the engineering export capacity at a 50 percent utilization level (87.208), Rosson's reported annual export capacity level of 18.0 million metric tons and the previous export high. There is no indication that Australia would experience any bottlenecks given the largest possible projected export level used in this study (10.5106 million MT). Australian ports are listed in Table XVIII, Appendix B.

Argentina

Predicted wheat exports for Argentina in 1985 range from a minimum level of 3.2138 million MT to a maximum level of 4.1201 million MT. Figure 12 shows the major Argentine ports with grain export terminals.

Engineering Capacity -- Utilization of Operating Time Approach. Argentine export terminals in 1979 typically operate during an 87 hour work week with the exception of Rosario and Villa Constitucion which operated for 107 hours per week as reported by Shasi Wilson.[4] Wilson also states the Argentine government currently has plans to implement a longer work week. Export terminals which operate 87 hours a week have an annual utilization time of 51.6 percent, while export terminals that increase operating time to 107 hours per week have a 63.5 percent annual utilization time.

Annual engineering export capacities are examined under the four previous stated work week alternatives. The results are

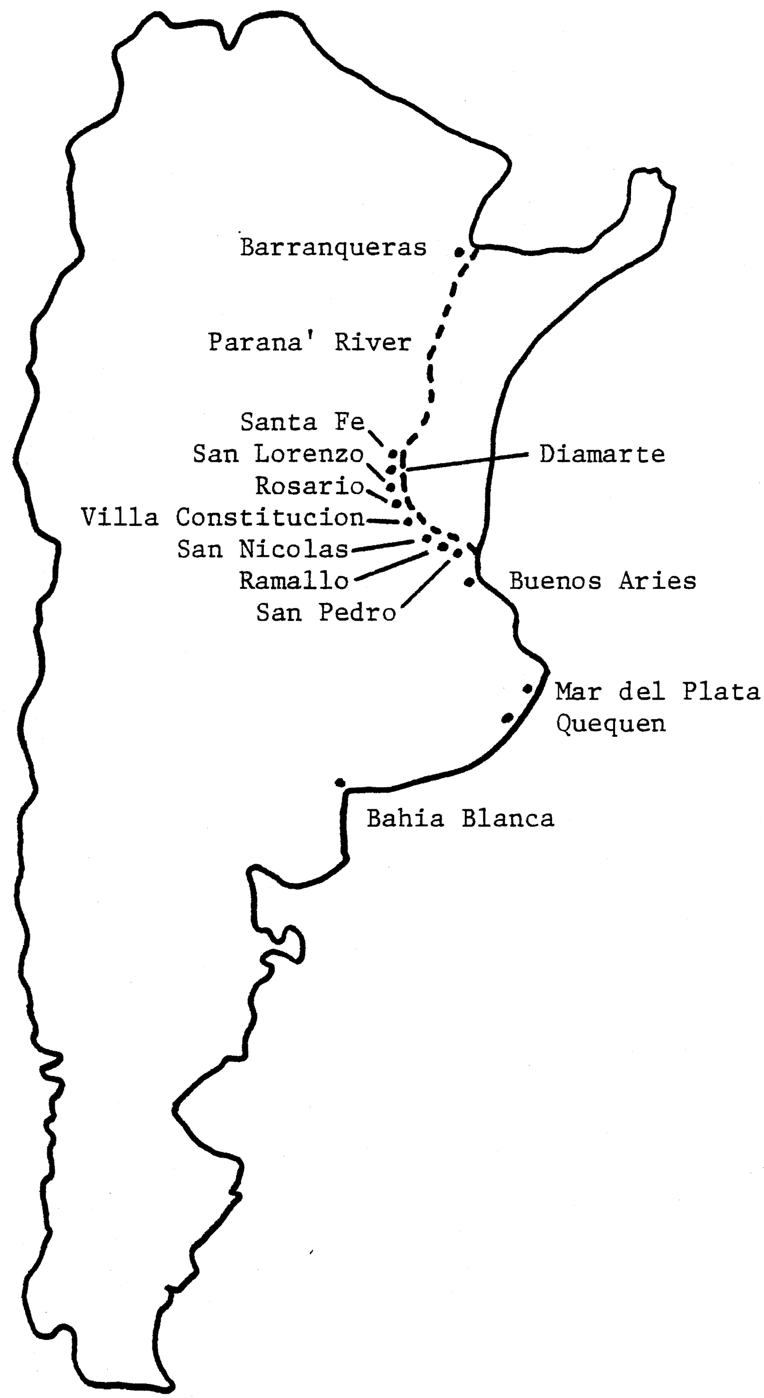


Figure 12. Main Grain Ports of Argentina

reported in Table XIX. Again, the reduction factor (five-year-average percentage of wheat exports to total grain exports) is used to calculate wheat export capacity. The reduction factor used to calculate the export capacities for wheat is 37.38 percent.

Projected low level of wheat exports and projected high level wheat exports from Argentine can be adequately facilitated on an annual basis at the 50 percent of plant operations level. The 50 percent terminal operating level for wheat is uncharacteristically high when compared with the projected wheat exports at a high level.

A review of Argentine's historic peak export year also provides insight on their wheat export capacity. From 1976-1980, Argentine's single year export high for wheat is 5.634 million MT. If 33 percent (1.866 million MT) of export capacity is unused during the peak exporting time period of the year Argentina would adequately handle the projected high level of wheat exports. For examining world wheat flows in this study, Argentina is assumed to be capable of exporting the quantity assigned for 1985 exports, and no bottlenecks occur on an annual capacity basis. Argentine ports are listed in Table XX, Appendix B.

France

Wheat exports from France in 1985 range from 7.1492 to 9.1652 million MT. Considering a low level of wheat exports, France's exports are 7.1492 million MT, while a high level of wheat exports increases French wheat exports to 9.1652 million MT. In 1980, France exported an annual high quantity of 9.888 million MT of wheat.

TABLE XIX

ARGENTINE WHEAT EXPORTS AND ENGINEERING
EXPORT CAPACITY

Region	Projected Exports		Percent Terminal Operating Time							
			For All Grains				For Wheat			
	Low Level	High Level	50	55	60	65	50	55	60	65
	mmt	mmt	mmt	mmt	mmt	mmt	mmt	mmt	mmt	mmt
Argentina	3.2138	4.1201	143.57	157.93	172.29	186.89	53.67	59.04	64.41	69.42

France is not expected to experience any bottlenecks on an annual basis for the 1985 predictions of wheat exports.

Concluding Remarks on Wheat Exporting Capacities

Although each method that was employed to identify the wheat export capacity is not suitable for every export country examined, the combined procedures have provided insight on the various operating levels and past export performance. The examination of export capacity lends credibility to the statement, there is no evidence of potential annual bottlenecks given projected export levels for major suppliers in 1985.

Shipping Rates

Estimating shipping rates along an origin/destination route involves two steps. First, analysis of variance procedures are applied to two or more combined subregions (Table VI) to identify variation in shipping rates due to vessel size and variation due to the combinations of the subregions. When variation in shipping rates due to subregion combinations is not statistically significant at the 80 percent confidence level, the null hypothesis is concluded to be zero and the subregional grouping is combined to create a new subregion for estimating shipping rates.

Once the level of aggregation is determined, a general linear regression technique is applied to estimate shipping rates. Dummy variables are introduced into the linear regression equation where there are combinations of subregions from each region. Dummy variables are useful in estimating shipping rates into a region where each subregion has a limited number of observations. Shipping rates for the various inter-regional shipping routes are estimated and reported in Appendix C. Ocean freignt rates to Western Europe from the Gulf Coast are discussed in depth in the next section. Ocean freight rates to the other regions from all destinations are discussed in Appendix D.

United States Gulf Coast to Western Europe

Following Webb's analysis, Western Europe is divided into two geographic areas called Western Europe-Atlantic Region, and Western Europe-Mediterranean Region (Table VI). Western Europe-Atlantic Region has six subregions and Western Europe-Mediterranean Region has three subregions. Analysis of variance (hereafter noted AOV) was applied to different combinations of subregions within each of the two major Western Europe regions and shipping rates were estimated.

Western Europe-Atlantic Region. There are freight rate quote observations for five of the six subregions. The Baltic region does not have any observed freight rate quotes from the U.S. Gulf Coast. The Antwerp-Hamburg Range, United Kingdom, and Scandanavian subregions are inserted into a linear regression equation and an AOV performed on the equation. The general model used in all AOV analyses is:

$$\text{Rates} = f(\text{Size and Subregion}) \tag{6.1}$$

where,

Rates = the daily reported ocean freight rate quotes after deflation by the grain shipping rate index,

Size = the size of vessel associated with the shipping rate,

Subregion = the subregion of destination for the freight rate quote.

The vessel size variable is grouped as follows:

$0 > S < 09$

$10 > T < 19$

$20 > U < 29$

$30 > V < 39$

$40 > W < 49$

$50 > X < 59$

$60 > Y < 69$

$70 \geq Z$.

The results prompted the rejection of the null hypothesis (Ho = 0) for both size and subregion variables at the 95 percent confidence level. Both variables account for a statistically significant portion of the variation in shipping rates. Thus, the subregions Antwerp-Hampurg Range, United Kingdom and Scandanavia are not combined into a new subregion grouping for estimating rates.

Next, the subregions France and Spain to Portugal were tested with the AOV procedure. The null hypothesis for both size and subregion was not rejected at the 80 percent confidence level. Hence, the results imply the true parameter for each size and subregion is actually zero.

Analysis of variance on the combination of all subregions contained in Western Europe-Atlantic Region provides for rejection of the null hypothesis for size at the 99 percent confidence level and rejection of the null hypothesis for subregion at the 90 percent confidence level.

Given the AOV results for all subregions, let's examine the suitability of the following was examined:

$$Rate = \alpha + \beta_1 SIZE + \beta_2 Z1 + \beta_3 Z2 + \beta_4 Z3 + \beta_5 Z4 \quad (6.2)$$

where,

Z1 = dummy variable for the United Kingdom subregion,

Z2 = dummy variable for the Scandanavian subregion,

Z3 = dummy variale for the France subregion, and

Z4 = dummy variable for the Spain to Portugal subregion.

The t-values for all variables, excluding Z3, are statistically significant at the 95 percent confidence level. For Z3, the null hypothesis is rejected at the 80 percent confidence level and the true parameter of Z3 is concluded to not be different from zero. Antwerp-Hamburg Range is represented by the intercept term. Equation 6.2 is re-estimated after dropping the variable Z3.

The parameters for Size, Z1, Z2, and Z4 are significant at the 95 percent confidence level. The overall equation is significnt at the 99 percent confidence level and the R-square value is .3678. This equation is used to estimate shipping rates for each vessel size according to the subregion destination. Midpoints for size categories are used to estimate ocean freight rates for grains. Appendix C contains estimated grain freight rates by size and subregions from the U.S. Gulf Coast to Western Europe and the 95 percent confidence interval for the rates. Rates for the Baltic region are assumed to be homogeneous to rates into the Antwerp-Hamburg Range.

<u>Western Europe-Mediterranean Region</u>. Subregions contained in Western Europe-Mediterranean Region are Spain to Italy, Adreatic, and Aegean. The subregion variable in the linear regression equation 6.1 represents each of the three subregions. After applying the AOV technique, the null hypothesis is rejected for both size and subregion at the 99 percent confidence level. Thus, the subregions within Western Europe-Mediterranean Region are not aggregated.

Equation 6.3 is used to estimate ocean grain freight rates for Western Europe-Mediterranean Region. Equation 6.3 is:

$$\text{Rate} = \alpha + \beta_1 \text{SIZE} + \beta_2 \text{Z5} + \beta_3 \text{Z6} \qquad (6.3)$$

where,

Z5 = dummy variable for Adreatic subregion,

Z6 = dummy variable for Aegean subregion,

and the intercept represents the Spain to Italy subregion.

The parameters for each variable in Equation 6.3 is significant at the 95 percent confidence level. For the full model, the null hypothesis is rejected at the 99 percent confidence level and the R-square value is .7458. The midpoints of the vessel size categories are used in equation 6.3 conjunction to determine grain shipping rates from the U.S. Gulf Coast to Western Europe-Mediterranean Region. The ocean freight rates for all orgin/destination combinations are contained in Appendix C.

FOOTNOTES

[1]Alan J. Webb, "The Impact of Projected World Wheat Production and Consuption Balances on U.S. Exports and Prices" (Unpublished Ph.D. Dissertation, Oklahoma State University, 1980), p. 32.

[2]C. Parr Rosson, III, personal letter, Texas A & M University, January 13, 1982.

[3]Michael L. Cook and C. Parr Rosson, III, "Methodological Issues in Examining Export Market Performance: The Australian Case," Staff Paper Series, DIR 80-1, SP-5 (Department of Agricultural Economics, Texas A & M University, September 1980), p. 11.

[4]Shasi Wilson and Michael L. Cook, "Methodological Issues in Examining Export Market Performance: The Argentine Case," Staff Paper Series, DIR 80-1, SP-7 (Department of Agricultural Economics, Texas A & M Univeristy, October 1980).

CHAPTER VII

ANALYSIS OF WORLD TRADE FLOWS AND RESULTS

Once world wheat supply and demands, alternative shipping routes and ocean freight rates associated with each shipping route are identified, a linear programming model is implemented to determine the least cost method of allocating wheat supplies to wheat demand areas.

Results

Four different scenarios are examined in this study. The first scenario consists of the United States having a high level of wheat exports, and the model is restricted to supply deficit regions in shipments according to vessel size patterns which adhere to 1981 shipping characteristics. In the second scenario the United States is assumed to have the same high level of wheat exports, but the vessel size restriction is relaxed. In the third scenario other major exporting countries are assumed to have the high level of wheat exports, but the 1981 vessel size shipping pattern is maintained. In the fourth scenario the vessel size restrictions are removed from the third scenario.

U.S. High Level of Exports with Vessel Size Restrictions

Given that the U.S. has the high level of wheat exports and the 1981 vessel size shipping pattern is maintained, the least cost ocean transportation amounts to 1,068,500,000 dollars. The average cost of transporting a metric ton of wheat is 16.59 dollars. Table XXI contains the level at which these acivities are the optimal solution and range over which these activities can vary without altering the optimal mix of transportation activities.

Argentina. Argentina supplies two subregions, the Baltic Region and USSR (Baltic Sea), on two different vessel sizes. The shipment activity on a 20-29 thousand metric ton vessel to both the Baltic Region and USSR (Baltic Sea) subregions cannot be increased without altering the optimal mix of activities, because the level of these activities in the optimal solution are at their upper levels. Increasing shipments to the USSR (Baltic Sea) on a 30-39 thousand metric ton vessel is possible without altering the mix of activities.

Each additional metric ton of wheat shipped from Argentina which is forced into solution, within the range of 3,213,867 to 4,527,291 MT would increase the total transportation bill 4.38 dollars per MT. Argentine wheat flows are found in Figure 13.

Australia. Australia should supply both Far East Asia and Egypt (Figure 13). Historically Japan has imported large quantities of wheat from Australia. Shipping rates must be reduced by 4.03 dollars per MT, 4.74 dollars per MT, 5.50 per MT for 30-39, 40-49,

TABLE XXI

WHEAT FLOWS WHICH MINIMIZE TRANSPORTATION COST, SCENARIO ONE

Supply (Demand)	Vessel Size	Quantity	Activity Ranges Lower Level	Upper Level
	tmts			
Argentina				
Baltic Region	20-29	6,837	0.0	6,837
USSR (Baltic Sea)	20-29	1,607,246	1,331,246	1,607,246
USSR (Baltic Sea)	30-39	1,599,784	1,599,784	1,875,784
Australia				
Far East Asia	20-29	6,304,986	6,179,802	6,694,180
Egypt	20-29	1,893,655	1,504,461	2,008,177
U.S. Gulf				
North Africa	20-29	153,121	0.0	542,315
East Africa	40-49	135,965	0.0	135,965
East Africa	50-59	33,991	0.0	33,991
Easr Africa	60-69	33,073	33,073	33,073
Middle East Asia	30-39	1,369,123	979,929	1,494,307
Middle East Asia	40-49	426,649	0.0	426,649
Middle East Asia	50-59	914,497	456,375	914,497
Middle East Asia	60-69	122,399	0.0	122,399
Middle East Asia	70 +	181,850	181,850	181,850
South America - Atlantic	20-29	2,550,200	0.0	2,550,200
South America - Pacific	20-29	1,660,545	1,271,351	1,775,067
Eastern Europe - Baltic Sea	30-39	787,520	0.0	1,063,520
Eastern Europe - Baltic Sea	40-49	197,800	0.0	197,800
Eastern Europe - Baltic Sea	50-59	74,060	74,060	74,060
Eastern Europe - Baltic Sea	30-39	276,000	0.0	276,000
Spain - Atlantic Coast	50-59	7,669	0.0	7,669
Adreatic	0- 9	92,100	92,100	92,390
Adreatic	10-19	924,174	921,884	926,782
Adreatic	20-29	1,106,936	717,714	1,109,226
Adreatic	30-39	240,215	237,925	240,215
Adreatic	40-49	92,390	84,981	92,390
Adreatic	50-59	203,259	196,163	203,259
Adreatic	60-69	55,706	55,706	55,706
Antwerp-Hamburg Range	70 +	206,010	0.0	206,010
United Kingdom	10-19	275,970	268,301	275,970
United Kingdom	20-29	186,559	178,890	193,396
United Kingdom	30-39	123,082	115,413	123,082
United Kingdom	40-49	59,788	52,119	69,602
United Kingdom	50-59	224,381	224,381	232,050
United Kingdom	60-69	147,266	147,266	147,266
Scandanavia	30-39	18,690	582	18,690
Portugal	0- 9	18,107	10,438	18,107
Portugal	40-49	9,813	0.0	17,482
USSR (Baltic Sea)	30-39	2,885,496	2,609,495	2,885,495
USSR (Baltic Sea)	40-49	834,200	0.0	843,200
USSR (Baltic Sea)	50-59	312,340	312,340	312,340
Egypt	20-29	125,184	0.0	817,714
Egypt	30-39	148,680	0.0	148,680
Egypt	40-49	37,170	0.0	37,170
Egypt	50-59	222,430	0.0	222,430

TABLE XXI (Continued)

Supply (Demand)	Vessel Size	Quantity	Activity Ranges Lower Level	Upper Level
	tmts			
U.S. Pacific				
Far East Asia	20-29	389,194	0.0	847,316
Far East Asia	30-39	458,122	0.0	847,316
Mexico, Central America, and Caribbean	10-19	3,076,763	2,687,569	3,076,763
Mexico, Central America, and Caribbean	20-29	610,437	0.0	999,631
South America - Pacific	0- 9	2,212,733	2,212,733	2,212,733
South America - Pacific	30-39	114,522	0.0	114,522
Japan	10-19	406,000	0.0	406,000
Japan	20-29	1,286,880	0.0	1,286,880
Japan	30-39	1,618,400	0.0	1,618,400
Japan	40-49	406,000	0.0	406,000
Japan	50-59	1,882,720	0.0	1,882,720
U.S. Atlantic				
East Africa	20-29	169,956	0.0	169,956
Middle East Asia	10-19	1,348,286	1,164,687	1,518,242
Egypt	0- 9	111,510	0.0	111,510
U.S. Great Lakes - Topoff				
East Africa	20-29	554,815	0.0	554,815
Eastern Europe (Baltic Sea)	20-29	692,530	416,530	692,530
Aegean	20-29	2,290	0.0	2,290
USSR (Baltic Sea)	20-29	1,313,424	1,306,587	1,589,424
Canada Pacific				
Far East Asia	20-29	4,515,838	4,057,716	4,515,838
Canada Atlantic				
West Africa	20-29	2,343,000	994,714	2,343,000
Middle East Asia	0- 9	183,599	0.0	183,599
Middle East Asia	10-19	1,271,057	1,101,101	1,454,656
Canada St. Lawrence Seaway				
Egypt	10-19	333,940	0.0	333,940
Egypt	20-29	3,027,431	2,334,901	3,152,615
France				
North Africa	0- 9	813,950	0.0	813,950
North Africa	10-19	4,948,929	3,997,763	4,948,929
USSR (Baltic Sea)	10-19	196,344	0.0	1,010,294
Transhipment Activity				
U.S. Gulf to France	50-59	1,223,256	0.0	1,376,377
France to Eastern Europe (Baltic Sea)	10-19	272,090	75,746	272,090
France to USSR (Baltic Sea)	10-19	951,166	137,216	1,147,510

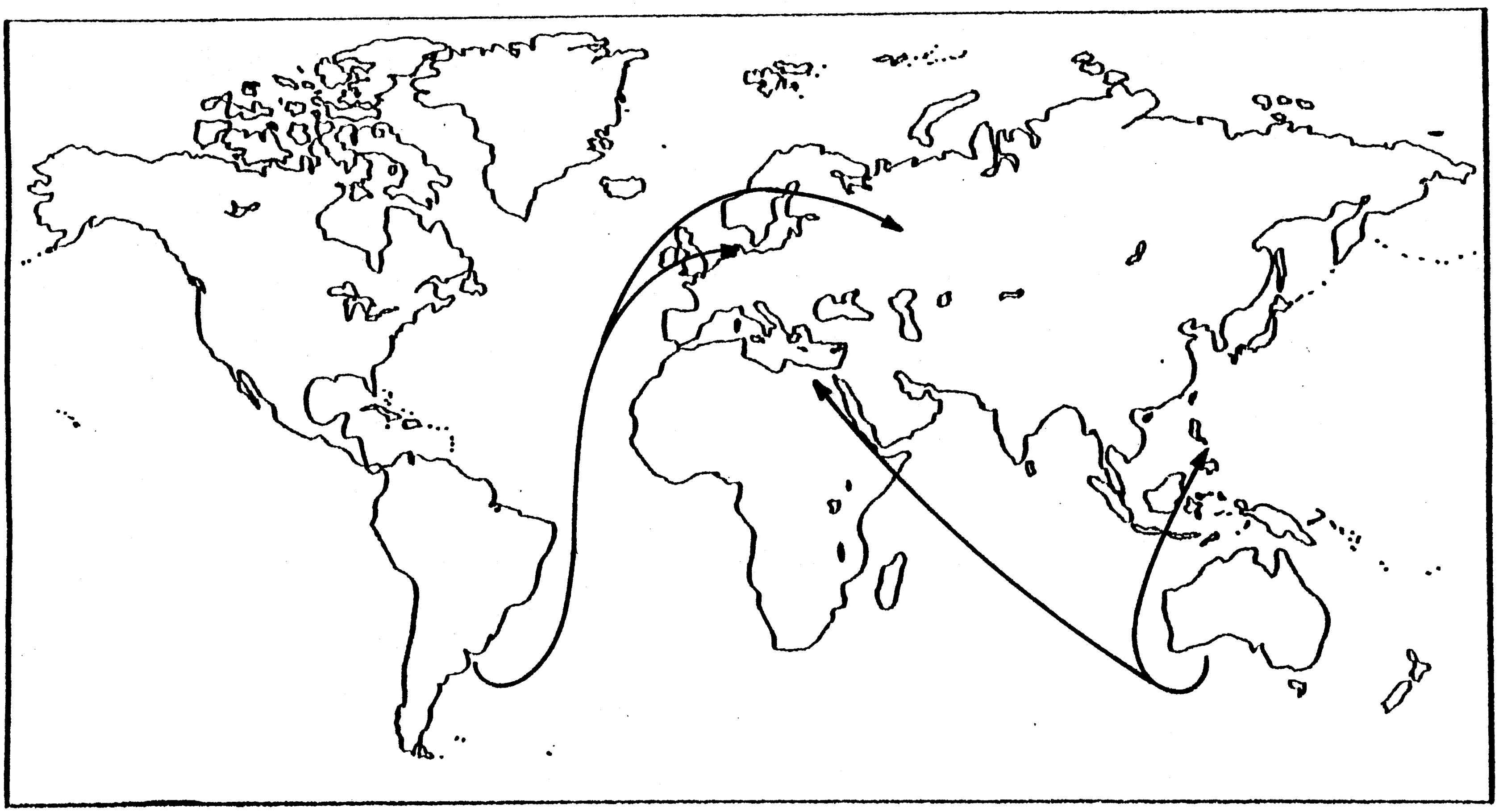


Figure 13. Argentine and Australian Wheat Flows

and 50-59 thousand metric ton vessels, respectively, before Australian wheat can be shipped to Japan. One metric ton forced from Australia would increase the total transportation bill 5.17 dollars per MT.

U.S. Gulf. Figure 14 illustrates the U.S. Gulf supplying all of Western Europe (except the Baltic Region, 6,837 MT and the Aegean, 2,290 MT). Shipments from the U.S. Gulf Coast area also arrive at ports in South American Pacific and Atlantic coast areas, Africa and Middle East Asia. The U.S. Gulf coast region can increase exports by 1,599,784 MT at a cost of 5.40 dollars per MT before any changes would result in the optimal set of activities. A one unit increase in exports past the upper limit (Table XXI) would force out of solution one unit from Argentina to the Soviet Union on a 30-39 thousand metric ton vessel size activity.

Of those activities in solution, U.S. Gulf to Middle East Asia, 30-39 thousand metric ton vessel; United Kingdom, 20-29, 30-39, 40-49, and 50-59 thousand metric ton vessels; Egypt, 20-29 thousand metric ton vessel; and the Soviet Union (Baltic Sea), 30-39 thousand metric ton vessel are sensitive to changes in ocean freight rates.

Although historically Japan and Far East Asia have received wheat shipments from the U.S. Gulf Coast, they are not included in the optimal solution. Rates from the U.S. Gulf coast to Japan would have to decrease by an average of 7.47 dollars per MT in order for the activity to enter the solution.

Shipments to Far East Asia from the U.S. Gulf (20-29 thousand metric ton vessel) would require ocean freight rates to decrease 5.45

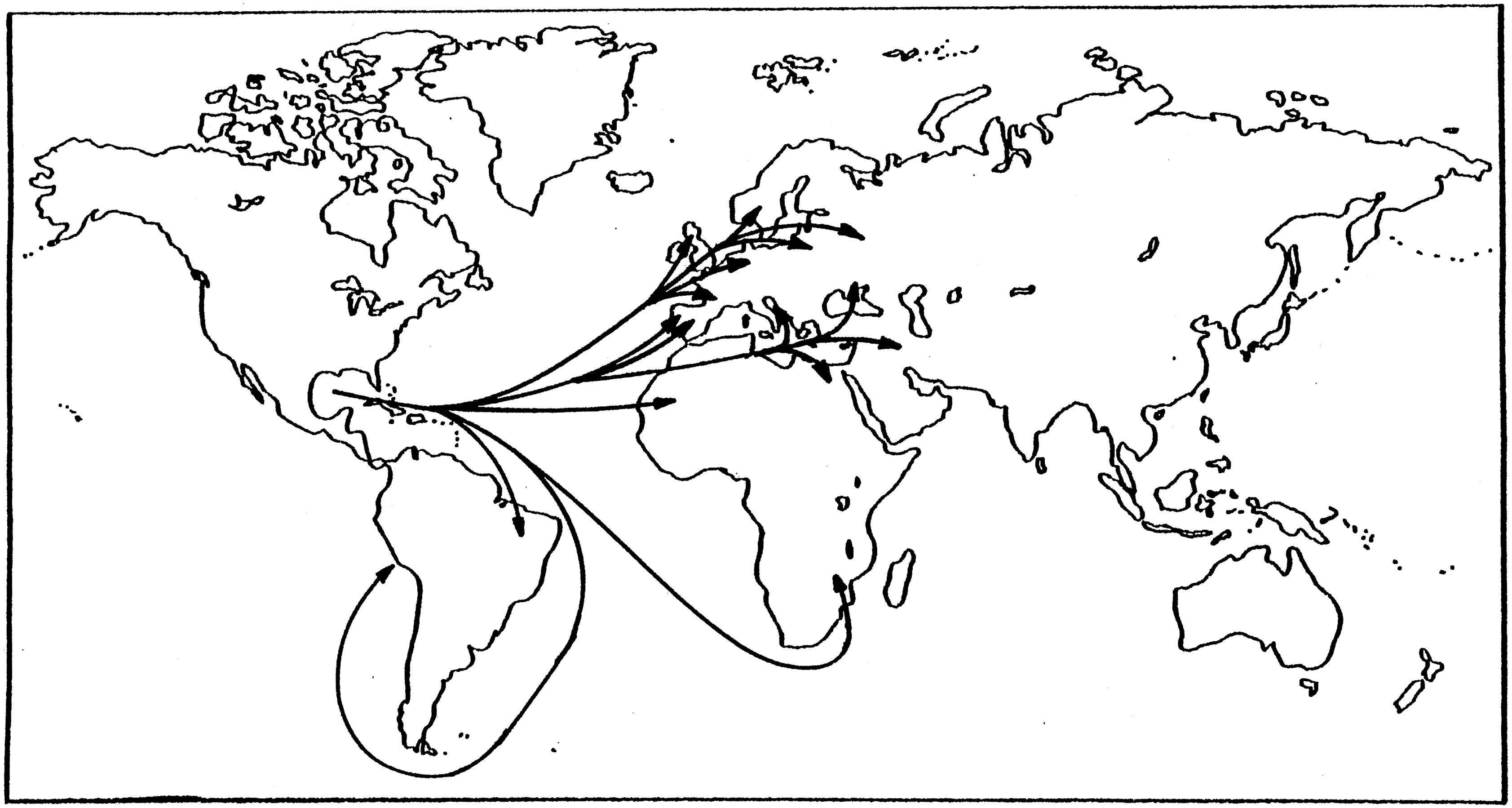


Figure 14. U.S. Gulf Wheat Flows

dollars per MT. The activity would come into solution at 125,184 MT.

U.S. Pacific. The U.S. Pacific is the sole supplier to Japan, and the Mexico, Central America, and Carabbean subregion. The U.S. Pacific also supplies the Pacific Coast side of South America and Far East Asia. Since the model is designed to minimize transportation costs, shipments originating from the U.S. Pacific have the tendency to stay in the Pacific Ocean area. Wheat shipments into Far East Asia are sensitive to changing ocean grain freight rates.

An increase in shipping rates on vessel sizes 10-19, 20-29 thousand metric tons from the U.S. Pacific to Japan would force grain shipment activities from Australia into the solution.

Wheat export flows from the U.S. Pacific to Far East Asia and Japan are examined closer in the following paragraphs. The C_j value corresponds with ocean freight rates from the port of origin to port of desination. Historically, composition of Far East Asia and Japanese wheat imports is dominated mainly by hard red winter wheat. Thus meeting Far East Asia and Japan's import requirements, the cost of transporting wheat from the Midwest to the U.S. Pacific Coast and ocean freight rates to Japan and Far East Asia must be less than the corresponding cost of transporting wheat to the U.S. Gulf Coast plus the Asian ocean freight rate.

The ocean freight rate from U.S. Pacific to Japan is 14.13 dollars per MT (20-29 thousand ton vessel) and the rail rate per metric ton from Enid, Oklahoma to the U.S. Pacific Coast as reported on May 25, 1982 is 56.22 dollars per MT. The total transportation

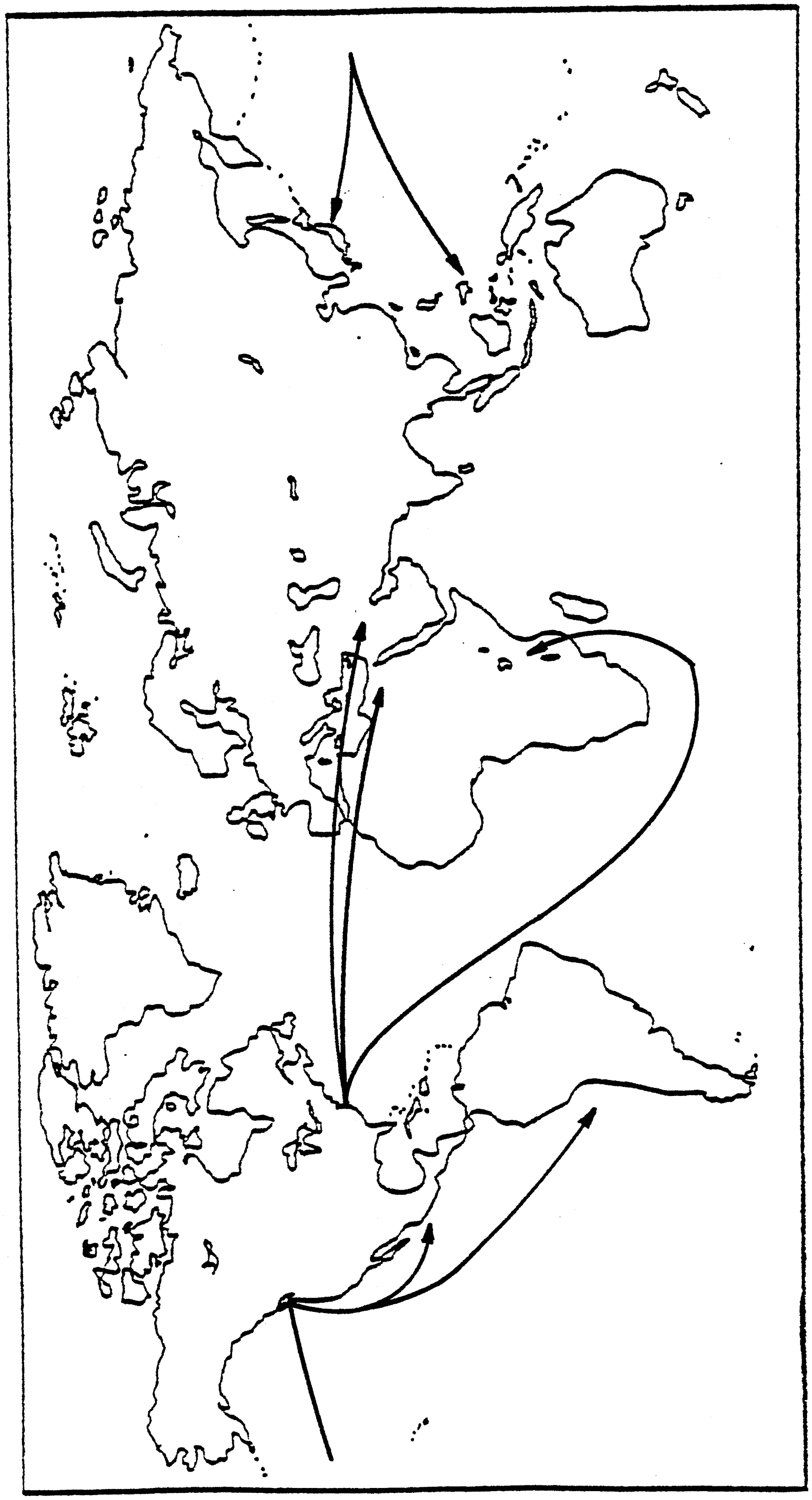


Figure 15. U.S. Pacific and Atlantic Coast Wheat Flows

cost to Japan for one metric ton of hard red winter wheat from Oklahoma (excluding ocean freight insurance and destination handling costs) is 70.35 dollars per MT. Total cost of a metric ton of hard red winter wheat from the U.S. Gulf on the same vessel size is 40.06 dollars per MT. Nineteen dollars and eighty cents accounts for railroad hauling cost from Enid, Oklahoma to the U.S. Gulf coast and 20.26 dollars per MT accounts for the ocean freight rate. It is clearly cost efficient for Japan to import hard red winter wheat from U.S. Gulf ports with respect to transportation costs.

Likewise, on a 20-29 thousand ton vessel the total transportation cost for a metric ton of hard red winter wheat to Far East Asia from the U.S. Pacific coast is 77.29 dollars per MT (railrate equals 56.22 dollars per MT and ocean freight rate equals 21.07 dollars per MT) and from the U.S. Gulf the corresponding transportation rate is 43.12 dollars per MT (19.80 dollars per MT is due to rail and 23.32 dollars per MT for ocean transportation).[2] The conclusion for Far East Asia is identical to the Japanese import conclusion concerning total transportation cost, that is, importing hard red winter wheat from the U.S. Gulf requires less expenditure than does importing from the U.S. Pacific.

U.S. Atlantic. Middle East Asia is the principle demand area served by the U.S. Atlantic coast. The activity accounts for 84 percent of all wheat shipments out of Atlantic ports. An additional unit shipped from the Atlantic coast seaboard between 1,629,752 metric tons and 1,754,936 metric tons would increase the transportation bill 12.56 dollars per MT for each additional metric ton. If exports rose one metric ton above 1,754,936 MT the Argentina row would go out of solution by one metric ton.

U.S. Great Lakes Top-Off. U.S. Great Lakes Top-Off is an activity associated with loading wheat initially at an interior lake port and topping-off the vessel at the St. Lawrence Seaway. Again, an East Coast export facility services subregions located geographically close (Figure 16).

Shipping rates associated with the shipping activity to the Soviet Union are the most sensitive. In fact, a 1.75 dollars per MT increase in the ocean freight rate forces U.S. Gulf to Eastern Europe (Baltic Sea) subregion (ship size 20-29 thousand metric tons) and U.S. Great Lakes top-off to Baltic Region (ship size 20-29 thousand metric tons) activities into solution. Each metric ton increase or decrease between 2,556,222 and 2,563,059 MT would change the optimal solution by 2.87 dollars per MT.

Canadian Pacific, Atlantic and St. Lawrence Seaway Shipment Only. The Canadian Pacific port area exports all available supply to Far East Asia. For each metric ton of wheat forced out of the Canadian Pacific within the range of 4,515,838 to 4,641,022 MT would increase the transportation bill 4.41 dollars per MT. Wheat shipments exceeding the upper limit will force Argentine wheat exports out of solution.

Wheat exports through Canadian Atlantic ports supply wheat to West Africa, and Middle East Asia. The Canadian Atlantic export region is the sole supplier to West Africa. A rise in rates from Canadian Atlantic to West Africa will force the activity out of

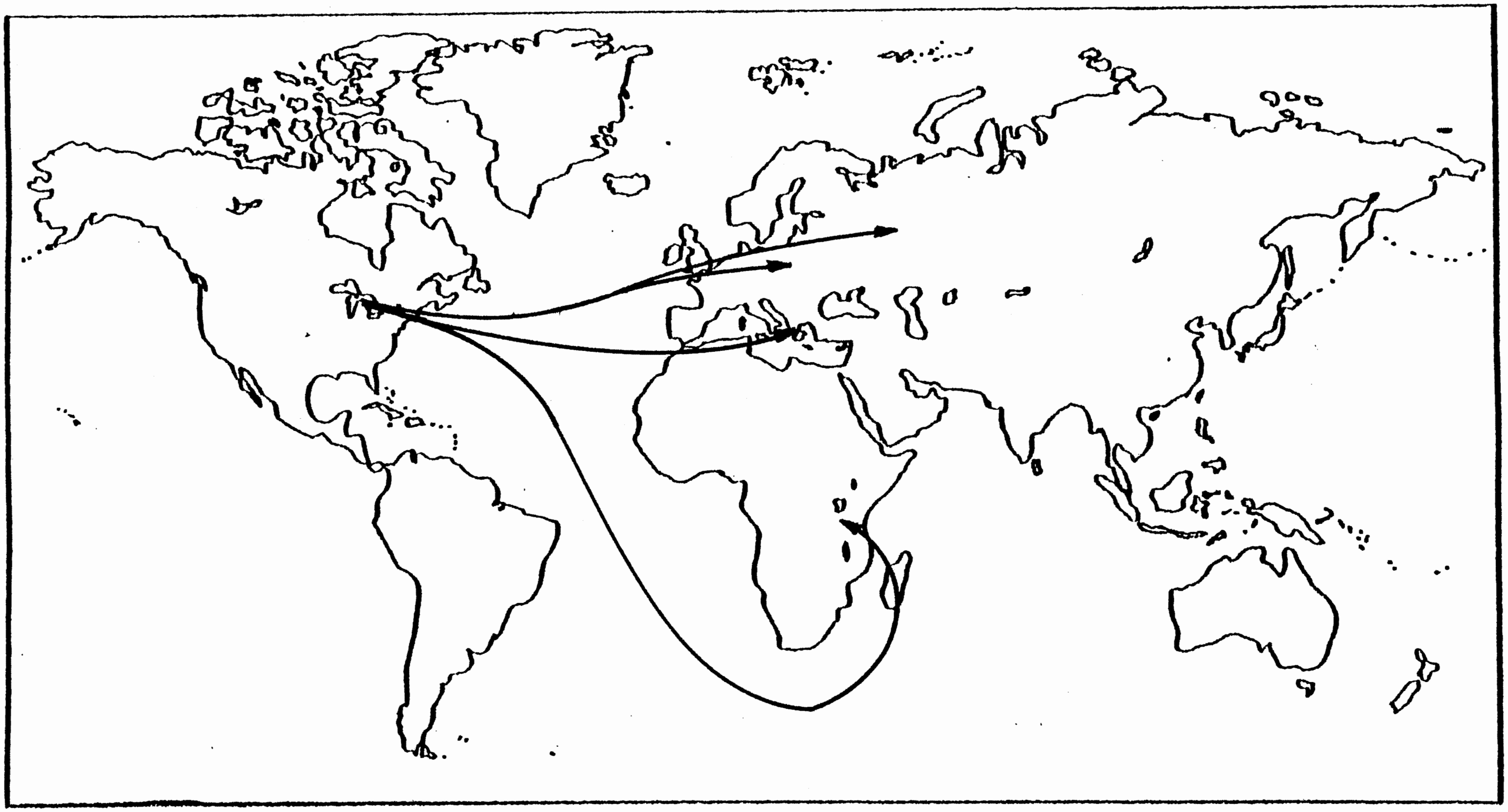


Figure 16. U.S. Great Lakes Wheat Flows

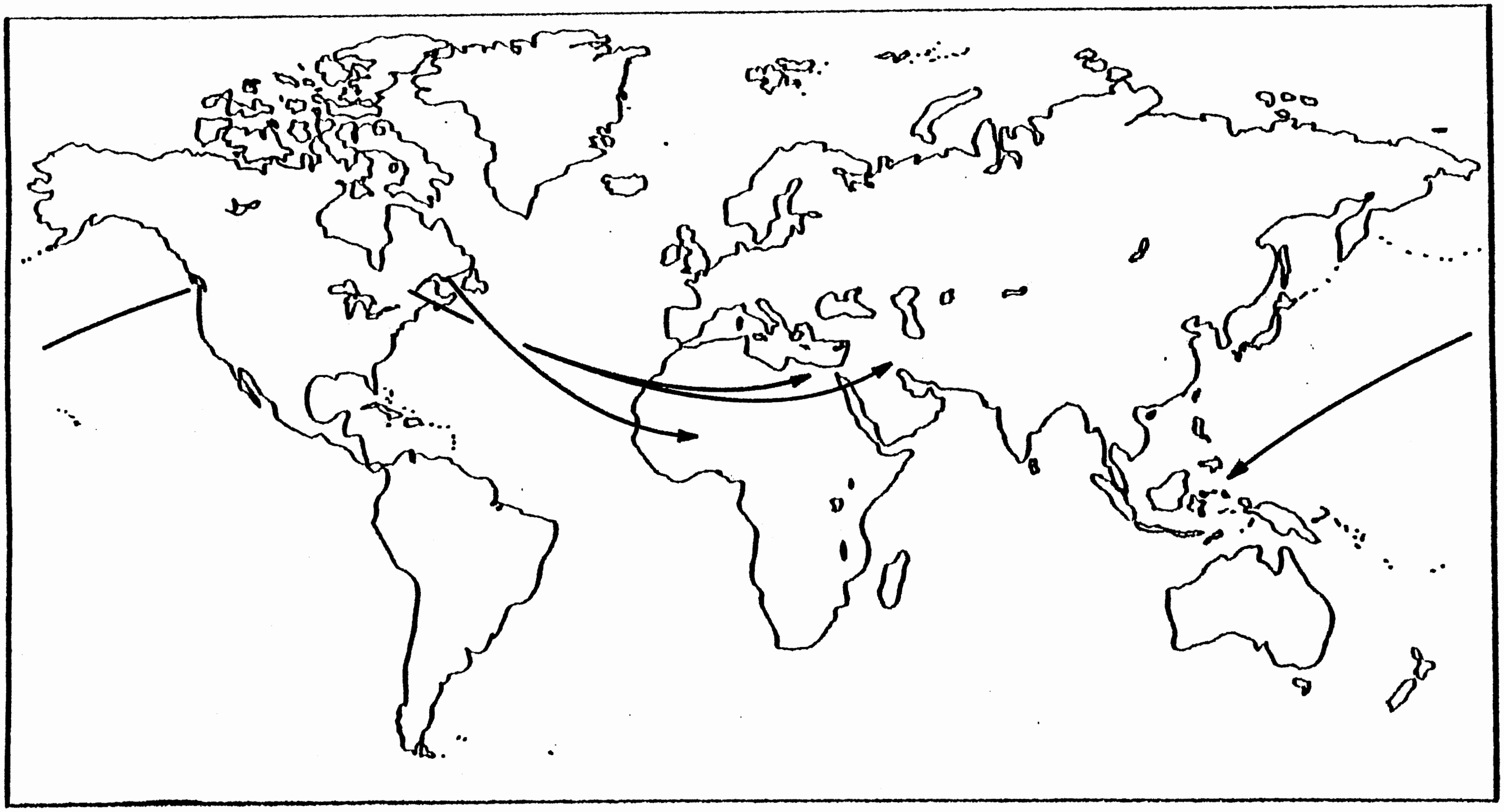


Figure 17. Canadian Pacific, Atlantic and St. Lawrence Seaway Wheat Flows

solution and force into solution grain shipments from the U.S. Atlantic Coast to West Africa.

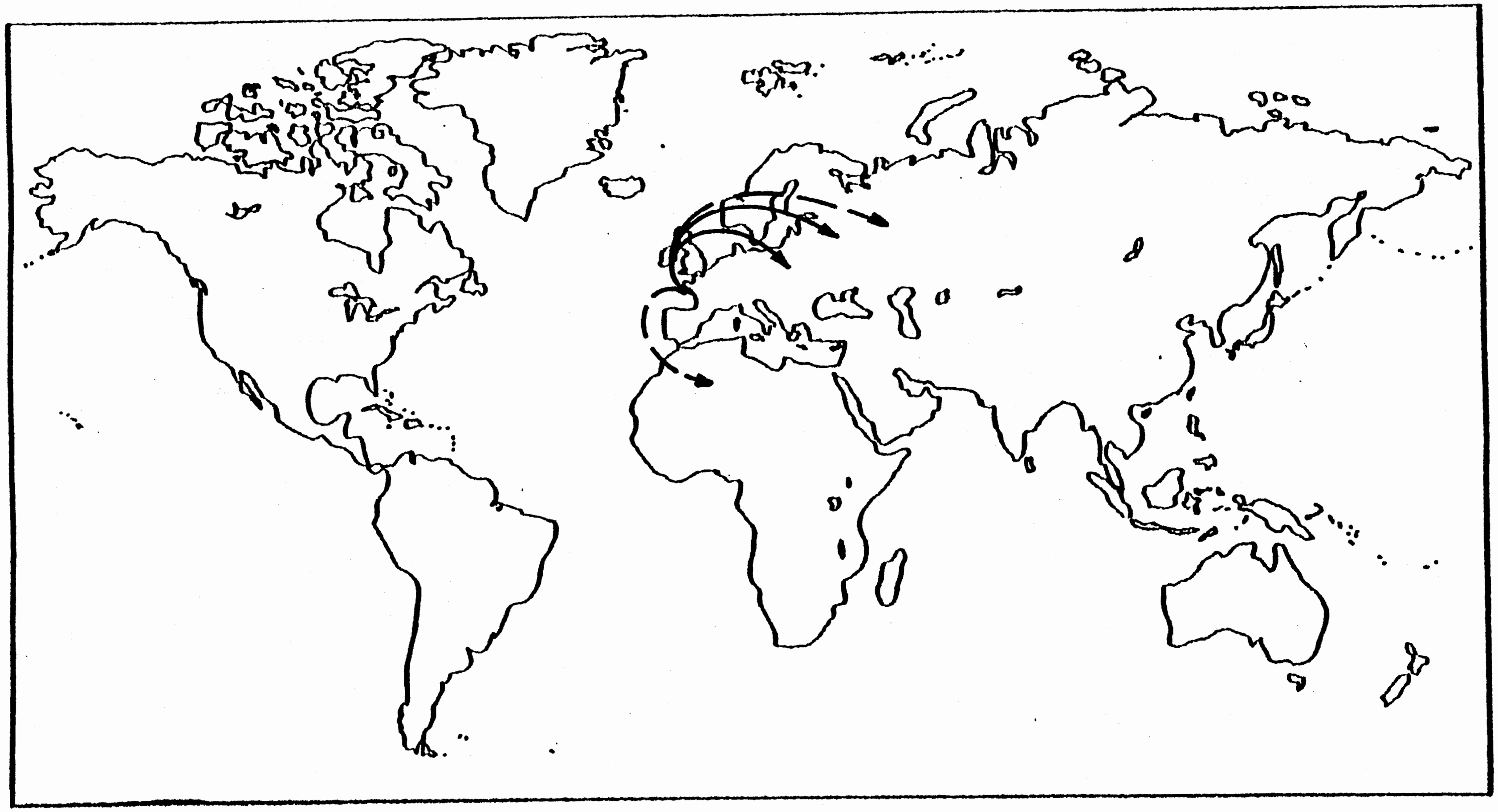
Ocean freight rates from Canadian Atlantic to Middle East Asia on vessel size 10-19 thousand metric ton are also highly sensitive to changes. Any change in ocean freight rates will force this activity out of the solution.

Canadian St. Lawrence Seaway shipments serve only Egyptian demand. The activity, 20-29 thousand metric ton vessel, is sensitive to changes in its ocean freight rate. A 50 cent per MT increase in the rate would force the activity out of solution and force into solution grain shipments from the U.S. Atlantic to Eastern Europe (Baltic) on a 20-29 thousand metric ton vessel.

For every unit change from 7,159,026 to 7,284,210 MT for the Canadian Atlantic, Great Lakes Shipment Only, Great Lakes Top-Off, St. Lawrence Seaway Shipment Only activities the transportation bill is 12.56 dollars per MT.

France. France is a major supplier of North Africa, Figure 18. An increase in rates from France to North Africa would encourage the transhipment activity through France to come into the solution. One additional unit forced from France would increase the transportation bill, 15.81 dollars per MT.

Transhipment Through France. U.S. Gulf supplies France 1,376,377 MT, on 50-59 thousand metric ton vessels, for transhipment to Eastern Europe (Baltic) and USSR (Baltic). All transhipment activities are sensitive to increases in each of their respective ocean freight rates. An increase in the France to Eastern Europe



*Note: Straight shipment (— — —) and transhipment (———).

Figure 18. France Shipment and Transhipment Wheat Flows

(Baltic) leg would force the transhipment activity out of solution and France as a major supplier to Eastern Europe (Baltic) would go into the solution. A rate increase in the France to USSR (Baltic) leg forces the transhipment activity to North Africa into solution and forces out of solution the USSR (Baltic) transhipment activity.

The Four Scenarios -- A Comparison

The total transportation bill for scenarios 1, 2, 3, and 4 are 1,049,154,000 dollars, 800,070,030 dollars 1,049,154,000 dollars and 808,670,210 dollars, respectively. Removal of the vessel flow pattern restrictions result in a 25 percent reduction in the transportation bill from scenario 1 and to 2 and 23 percent reduction between scenario 3 and 4. Likewise, the total transportation bill is lower when the world wheat exports from other exporting countries are at a high level than when the U.S. wheat exports are at a high level. Thus, in 1985 with U.S. high level of exports, if wheat exporting countries follow the shipping patterns established in 1981 these exporting countries could reduce their total transportation bill by 260,429,970 dollars or 25 percent by taking advantage of economies of size by shipping wheat on larger vessels. Each major supply region with regard to optimal trade flows are examined and compared in the following sections.

Argentina. Composition of countries supplied by Argentina is identical in all four scenarios, Table XXII. The entire wheat shipment to the USSR (Baltic) in scenario 2 is shipped on a larger vessel size (30-39 thousand MT) than the two vessel sizes utilized in

TABLE XXII

OPTIMAL SET OF ACTIVITIES FOR EACH SCENARIO

Supply (Demand)	Vessel Size	High Level of U.S. Exports		High Level of World Exports	
		With Vessel Size Restriction	Without Vessel Size Restriction	With Vessel Size Restriction	Without Vessel Size Restriction
	tmts				
Argentina					
Baltic Region	20-29	6,837	6,837	6,837	6,837
USSR (Baltic Region)	20-29	1,607,246	—	—	—
USSR (Baltic Region)	30-39	1,599,784	3,207,030	4,113,320	4,113,320
Australia					
Far East Asia	20-29	6,304,986	—	5,886,525	—
Far East Asia	70 +	—	7,385,412	—	6,691,766
Egypt	20-29	1,893,655	—	2,465,786	—
Japan	10-19	—	—	406,000	—
Japan	20-29	—	—	1,286,880	—
Japan	30-39	—	—	465,426	—
Japan	50-59	—	813,229	—	3,818,851
U.S. Gulf					
North Africa	20-29	153,121	—	—	—
East Africa	40-49	135,965	—	135,965	—
East Africa	50-59	33,991	—	33,991	—
East Africa	60-69	33,073	927,800	33,073	124,577
Middle East Asia	30-39	1,369,123	—	1,369,123	—
Middle East Asia	40-49	426,649	—	426,649	—
Middle East Asia	50-59	914,497	—	914,497	—
Middle East Asia	60-69	122,399	—	122,399	—
Middle East Asia	70 +	181,850	5,817,460	181,850	5,817,460
South America - Atlantic	20-29	2,550,200	—	2,550,200	—
South America - Atlantic	30-39	—	—	—	607,609
South America - Pacific	20-29	1,660,545	—	1,660,545	—
Eastern Europe (Baltic Sea)	30-39	787,520	—	940,258	—
Eastern Europe (Baltic Sea)	40-49	197,800	—	197,800	—
Eastern Europe (Baltic Sea)	50-59	74,060	2,024,000	74,060	2,024,000
Eastern Europe (Black Sea)	30-39	276,000	232,777	123,262	—
Spain - Atlantic	50-59	7,669	—	—	—
Spain - Mediterranean	60-69	—	7,669	—	—
Adreatic	0- 9	92,390	—	—	—
Adreatic	10-19	924,174	—	532,486	—
Adreatic	20-29	1,106,936	—	1,102,397	—
Adreatic	30-39	240,215	—	240,892	—
Adreatic	40-49	92,390	—	92,650	—
Adreatic	50-59	203,259	—	203,832	—
Adreatic	60-69	55,706	2,481,960	55,863	—
Antwerp-Hamburg Range	70 +	206,010	206,010	206,010	—
United Kingdom	0- 9	—	—	17,999	—
United Kingdom	10-19	275,970	—	274,322	—
United Kingdom	20-29	186,559	—	185,405	—
United Kingdom	30-39	123,082	—	94,315	—
United Kingdom	40-49	59,788	—	69,187	—
United Kingdom	50-59	224,381	—	230,665	—
United Kingdom	60-69	147,266	489,961	145,157	—
Scandanavia	30-39	18,690	—	18,690	—

TABLE XXII (Continued)

Supply (Demand)	Vessel Size	High Level of U.S. Exports: With Vessel Size Restriction	High Level of U.S. Exports: Without Vessel Size Restriction	High Level of World Exports: With Vessel Size Restriction	High Level of World Exports: Without Vessel Size Restriction
	tmts				
U.S. Gulf					
Portugal	0- 9	18,107	—	—	—
Portugal	30-39	—	—	27,921	—
Portugal	40-49	9,813	—	—	—
Portugal	50-59	—	17,352	—	27,921
USSR (Baltic Sea)	30-39	2,885,496	—	371,960	—
USSR (Baltic Sea)	40-49	834,200	6,492,970	834,200	—
USSR (Baltic Sea)	50-59	312,340	—	312,340	5,586,680
Egypt	20-29	125,184	—	—	—
Egypt	30-39	148,680	—	148,680	—
Egypt	40-49	37,170	—	37,170	—
Egypt	50-59	222,430	—	222,430	—
U.S. Pacific					
Far East Asia	20-29	389,194	—	—	—
Far East Asia	30-39	458,122	—	—	—
Mexico, Central America, and Caribbean	10-19	3,076,763	3,687,200	3,076,763	3,687,200
Mexico, Central America, and Caribbean	20-29	610,437	—	610,437	—
South America - Pacific	0- 9	2,212,733	3,987,800	2,212,733	3,987,800
South America - Pacific	30-39	114,522	—	114,522	—
Japan	10-19	406,000	—	—	—
Japan	20-29	1,286,880	—	—	—
Japan	30-39	1,618,400	—	1,152,974	—
Japan	40-49	406,000	—	406,000	—
Japan	50-59	1,882,720	4,786,771	1,882,720	1,781,149
U.S. Atlantic					
East Africa	30-39	169,956	—	—	—
West Africa	20-29	—	1,611,062	—	—
Middle East Asia	10-19	1,348,286	—	—	—
Scandanavia	50-59	—	18,690	—	18,690
USSR (Baltic Sea)	20-29	—	—	1,125,167	—
Egypt	0- 9	111,510	—	111,510	1,217,987
U.S. Great Lakes Topoff					
East Africa	20-29	554,815	—	554,815	—
Eastern Europe (Baltic Sea)	20-29	692,530	—	—	—
Aegean	20-29	2,290	2,290	2,290	2,290
South America - Atlantic	20-29	—	2,550,200	—	1,942,591
Portugal	20-29	—	10,569	—	—
USSR (Baltic Sea)	20-29	1,313,424	—	1,387,776	—
Canada Pacific					
Far East Asia	20-29	4,515,838	—	5,323,493	—
Far East Asia	30-39	—	—	458,122	—
Far East Asia	70 +	—	4,282,728	—	4,976,374
Adreatic	50-59	—	233,110	—	805,241
Spain - Mediterranean	20-29	—	—	7,669	7,669

TABLE XXII (Continued)

Supply (Demand)	Vessel Size	High Level of U.S. Exports: With Vessel Size Restriction	High Level of U.S. Exports: Without Vessel Size Restriction	High Level of World Exports: With Vessel Size Restriction	High Level of World Exports: Without Vessel Size Restriction
	tmts				
Canada Atlantic					
West Africa	20-29	2,343,000	731,938	2,343,000	2,343,000
East Africa	30-39	---	---	169,956	803,223
Middle East Asia	0- 9	183,599	---	183,599	---
Middle East Asia	10-19	1,271,057	---	2,619,343	---
Eastern Europe (Baltic Sea)	20-29	---	---	539,792	---
USSR (Baltic Sea)	20-29	---	---	407,727	---
Egypt	0- 9	---	5,900,00	---	4,682,013
Canada St. Lawrence Seaway					
Egypt	10-19	333,940	---	333,940	---
Egypt	20-29	3,027,431	---	2,580,484	126,545
Antwerp-Hamburg Range	70 +	---	---	---	206,010
United Kingdom	60-69	---	527,089	---	1,017,050
France					
North Africa	0- 9	813,950	---	813,950	---
North Africa	10-19	4,948,929	5,916,000	4,948,929	---
North Africa	20-29	---	---	153,121	5,916,000
Adreatic	0- 9	---	---	92,650	---
Adreatic	10-19	---	---	394,295	---
Adreatic	40-49	---	---	---	1,783,284
Eastern Europe (Baltic Sea)	10-19	---	43,223	272,090	---
Eastern Europe (Black Sea)	10-19	---	---	---	276,000
Eastern Europe (Black Sea)	20-29	---	---	152,738	---
USSR (Baltic Sea)	10-19	196,344	---	1,147,510	---

scenario 1 (20-29 and 30-39 thousand metric ton). Argentina's increased wheat supply in scenario 3 and 4 goes entirely to the Soviet Union.

Australia. If Australia is allowed to ship wheat without vessel size restrictions (scenario 2), then the Egyptian demand region is no longer serviced by Australia and wheat shipments to Japan (50-59 thousand metric ton vessels) enter the solution. Wheat shipments to Far East Asia from Australia remain in solution under the assumptions of scenario 2, but wheat is exported on vessels with bulk hauling capacity in excess of 70 thousand metric tons.

In scenario 3, Australia exported 2,158,306 MT of wheat to Japan. Exports from Australia to Japan (scenario 3) account for 39 percent of Japaneese wheat imports. Exports to Egypt increased 30 percent under scenario 3 when compared the scenario 1, however, exports to Far East Asia decreased seven percent.

Far East Asia and Japan are the only demand areas serviced by Austrailian ports when vessel size restrictions are removed in scenario 3. Without vessel size restrictions, exports to Japan (50-59 thousand metric ton vessel) account for 68 pecent of Japan's demand. Although scenario 1 is considered more representative of major wheat suppliers' export positions, scenario 3's results, including Japan as an area serviced by Australia, are more representative of Australian exports.

U.S. Gulf. Although the quantity of wheat available under scenario 3 is 4.5 million MT less than the quantity available under scenario 1, the U.S. Gulf services the same regions of the world except for North Africa and Spain-Atlantic. Loss of North Africa and Spain-Atlantic as demand areas serviced, and the loss of exports to the Adreatic, USSR (Baltic Sea) and Egypt account for the reduction in exports from the US Gulf. Wheat shipments to the USSR (30-39 thousand metric ton vessel) dropped from 2,885,496 MT in scenario 1 to 371,960 MT in scenario 3. However, exports to the Soviet Union (Baltic Sea) from the U.S. Gulf in scenario 4 are sizeable when compared to the quantity exported to the USSR from other major supply areas.

Composition of major demand areas serviced from the U.S. Gulf remain stable across all scenarios. However, the size of vessel employed in scenario 2 and 4 tend to gravitate toward the largest vessel size given the restrictions of the demand area. This phenomena is expected since ocean freight rates for bulk grains tend to decrease as vessel hauling capacity increases.

U.S. Pacific. In the world high export level scenario, wheat exports from the U.S. Pacific Coast to Far East Asia are not in solution. Exports to Japan on 10-19 and 20-29 thousand metric ton vessels also go out of solution. The 1,692,880 MT decrease in wheat shipments to Japan is accounted by the export activities from Australia to Japan, scenario 3. Wheat exports from the U.S. Pacific to South America-Pacific and Mexico, Central America, and Caribbean are the same under all four scenarios.

U.S. Atlantic. East Africa and Middle East Asia are not supplied wheat from the US Atlantic seaboard in scenario 3. However, the Soviet Union enters the solution as a major demand area serviced by U.S. Atlantic ports. In fact, wheat exports to the Soviet Union under scenario 3 account for 91 percent of U.S. Atlantic wheat exports. The Soviet Union goes out of solution and U.S. Atlantic to Egypt comes into solution after the vessel size restrictions are removed in scenario 4.

U.S. Great Lakes Top-Off. Eastern Europe is not supplied by U.S. Great Lakes in scenario 3. East Africa and Aegean subregions are supplied the same quantity under scenario 1 and 3, and exports to the Soviet Union (Baltic Sea) increase by 74,000 MT in scenario 3. The removal of vessel size restrictions in scenario 2 and 4 forces the U.S. Great Lakes Top-Off to the Soviet Union and East Africa shipment activities out of solution and forces U.S. Great Lakes Top-Off to South America-Atlantic shipment activity into solution.

Canadian Pacific. Exports to Far East Asia are increased and another ship size to Far East Asia is added to the mix of activities in scenario 3. Spain-Mediterranean is a new demand area serviced by Canadian Pacific ports in scenario 3.

Far East Asia is serviced by Canadian Pacific on the largest possible vessel size when vessel size restrictions are removed. Again, the relationship of decreasing ocean freight rates for bulk grains as vessel hauling capacity increases is directly responsible for selection of larger vessels transporting wheat.

Canadian Atlantic. The increased quantity available for export in the world high export level scenario allows Canadian Atlantic port areas to service East Africa, Eastern Europe (Baltic

Sea), and USSR (Baltic Sea) as new demand areas not previously reported in scenario 1. Exports to Middle East Asia increase 106 percent over exports previously reported in scenario 1.

Egypt becomes a major demand area for Canadian Atlantic ports after vessel size restrictions have been removed. In fact, the Canadian Atlantic region services all of Egypt's demand in scenario 2 and 79 percent of Egypt's demand in scenario 4. In scenario 4, Middle East Asia, Eastern Europe (Baltic Sea) and USSR (Baltic Sea) are no longer serviced by Canadian Atlantic ports.

Canadian St. Lawrence Seaway Shipment Only. Canadian St. Lawrence Seaway Shipment Only activity services the same demand region, Egypt, in scenarios 1 and 3. Shipments from Canadian St. Lawrence Seaway are smaller in scenario 3 than in scenario 1. The difference in exports is assigned to the Canadian Atlantic region.

Removal of vessel size restrictions alter the mix of demand regions. Scenario 2 contains only one activity representing wheat shipments to the United Kingdon. Shipments to Egypt are maintained in scenario 4, however, the quantity exported to Egypt is less than 5 percent of the original quantity exported from the St. Lawrence Seaway. The United Kingdom receives a larger quantity in scenario 4 than in scenario 2 (over a 100 percent increase) and shipments to Antwerp-Hamburg enter as a new activity.

France. France as a major supplier of wheat contains a diversified mix of shipment activities in scenario 3. Adreatic and Eastern Europe (Baltic Sea) enter the solution in scenario 3. Shipments to the Soviet Union increase from 196,344 MT (scenario 1) to 1,147,750 MT (scenario 3). Shipments to Communist Bloc countries account for 20 percent of France's wheat exports. However, if vessel size restrictions are removed (scenario 4) the Soviet Union leaves solution as a demand area serviced by France and the Adreatic enters solution.

Parametric Programming Results

Sensitive C_j parameters are identified in the scenario where the U.S. has the high level of wheat exports, and where vessel size shipping pattern restrictions are maintained. Parametric programming procedures are applied to each of these sensitive C_j values. As shipping rates vary, the solution at each iteration is recorded and graphed for examination. Each graph displays the demand curve for ocean transportation services for wheat from a particular origin to a destination by some specified vessel size. However, each iteration must adhere to vessel size restrictions imposed on the model. Activities possessing sensitive C_j values are listed in Table XXIII.

Firgure 19 contains a graphic illustration of the demand curve for ocean transportation services for wheat from Argentina to the Soviet Union (Baltic Sea) on a 20-29 thousand metric ton vessel. Three demand levels are found 22.42 dollars to 20.64 dollars, per metric ton. There is a slight change in quantity demanded at 21.42 dollars per MT for the transportation services. The quantity demanded increases by 45 percent with a sixty cent decrease from the 21.24 to 20.64 dollars per MT. The range, 21.24 to 20.64 dollars per MT, is relatively more sensitive than other rate ranges, or the more

TABLE XXIII

ACTIVITIES SENSITIVE TO CHANGING OCEAN FREIGHT RATES

Origin	Destination	Vessel Size
Argentina	Soviet Union	20-30,000
Australia	Far East Asia	20-30,000
US Gulf	United Kingdom	10-20,000
US Gulf	United Kingdom	20-30,000
US Gulf	United Kingdom	30-40,000
US Gulf	United Kingdom	40-50,000
US Gulf	United Kingdom	50-60,000
US Gulf	Far East Asia	30-40,000
US Gulf	Soviet Union	30-40,000
US Pacific	Far East Asia	20-30,000
US Great Lakes Top-Off	Soviet Union	20-30,000
Canadian Pacific	Far East Asia	20-30,000
Canadian Atlantic	Middle East Asia	10-20,000
Canadian St. Lawrence Seaway	Egypt	20-30,000

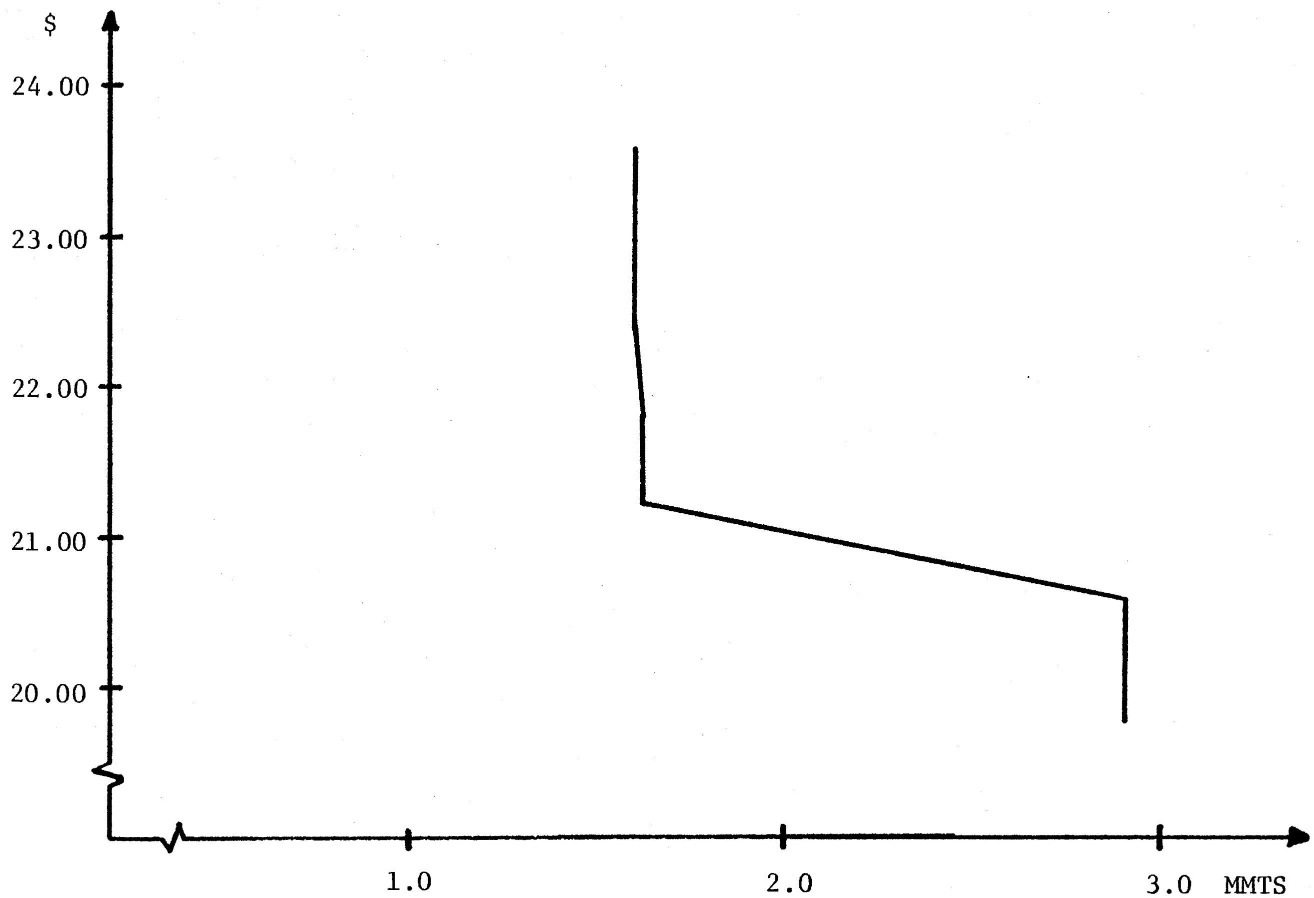


Figure 19. Demand Curve for Transportation Services from Argentina to the Soviet Union, 20-29 Thousand Metric Ton Vessel

elastic demand area (21.24 to 20.64 dollars per MT) is representative of a larger percentage change in transportation services demanded by the Soviet Union for Argentine wheat than each one dollar change outside of the range.

Of the activities which represent Australian wheat exports, Figure 20, shipments to Far East Asia on a 20-29 thousand metric ton vesel is sensitive to changes in the ocean freight rate regarding the shipping activity. The quantity demanded for transportation services for Australian wheat to the Far East Asia subregion increases in larger incremental quantities from 23.87 to 19.72 dollars per MT than from the 19.72 to 16.76 dollars per MT range. The elasticity of demand for transportation services for Australian wheat by Far East Asia is more elastic over the 23.87 to 19.72 dollars per MT range than the elasticity of demand from 19.72 to 16.76 dollars per MT.

Figure 21 contains demand curves for U.S. wheat transportation services through Gulf Coast ports to the United Kingdom. For each ship size (ship sizes T through X), quantities demanded for these transportation services are sensitive to changing ocean freight rates which range from 14.00 to 10.50 dollars per MT. Limitations imposed upon the model are credited for the successive shifting inward of each transportation demand curve for the larger vessel size. The demand curve for ship size X (50-59 thousand metric ton vesel) is in the proper place in Figure 21 because of restrictions on vessel size patterns. The percentage imported on vessel size X is less than vessel size T but greater than vessel sizes U, V, and W. Thus, lower rates for the smaller sizes into United Kingdom and the vessel

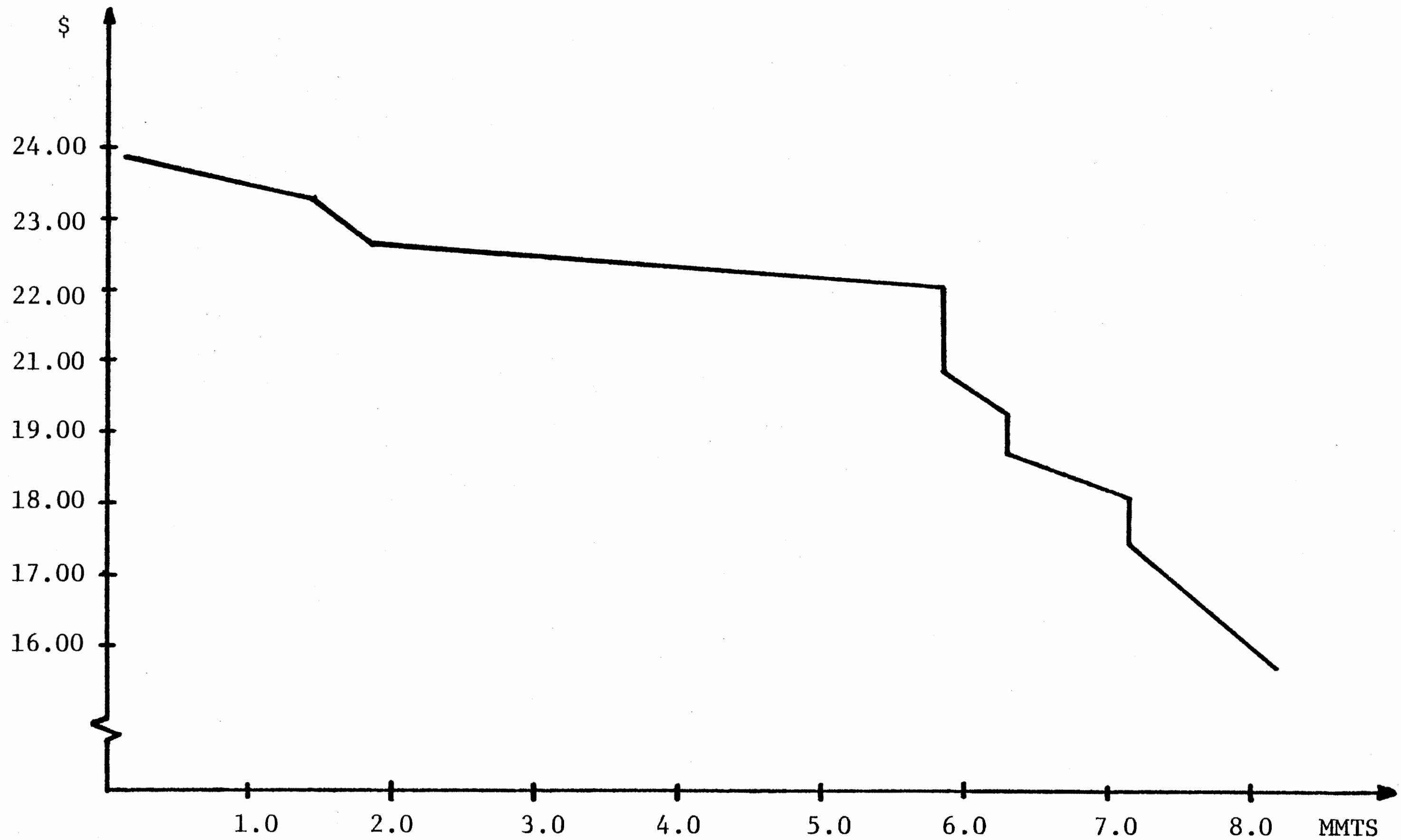


Figure 20. Demand Curve for Transportation Services from Australia to Far East Asia, 20-29 Thousand Metric Ton Vessel

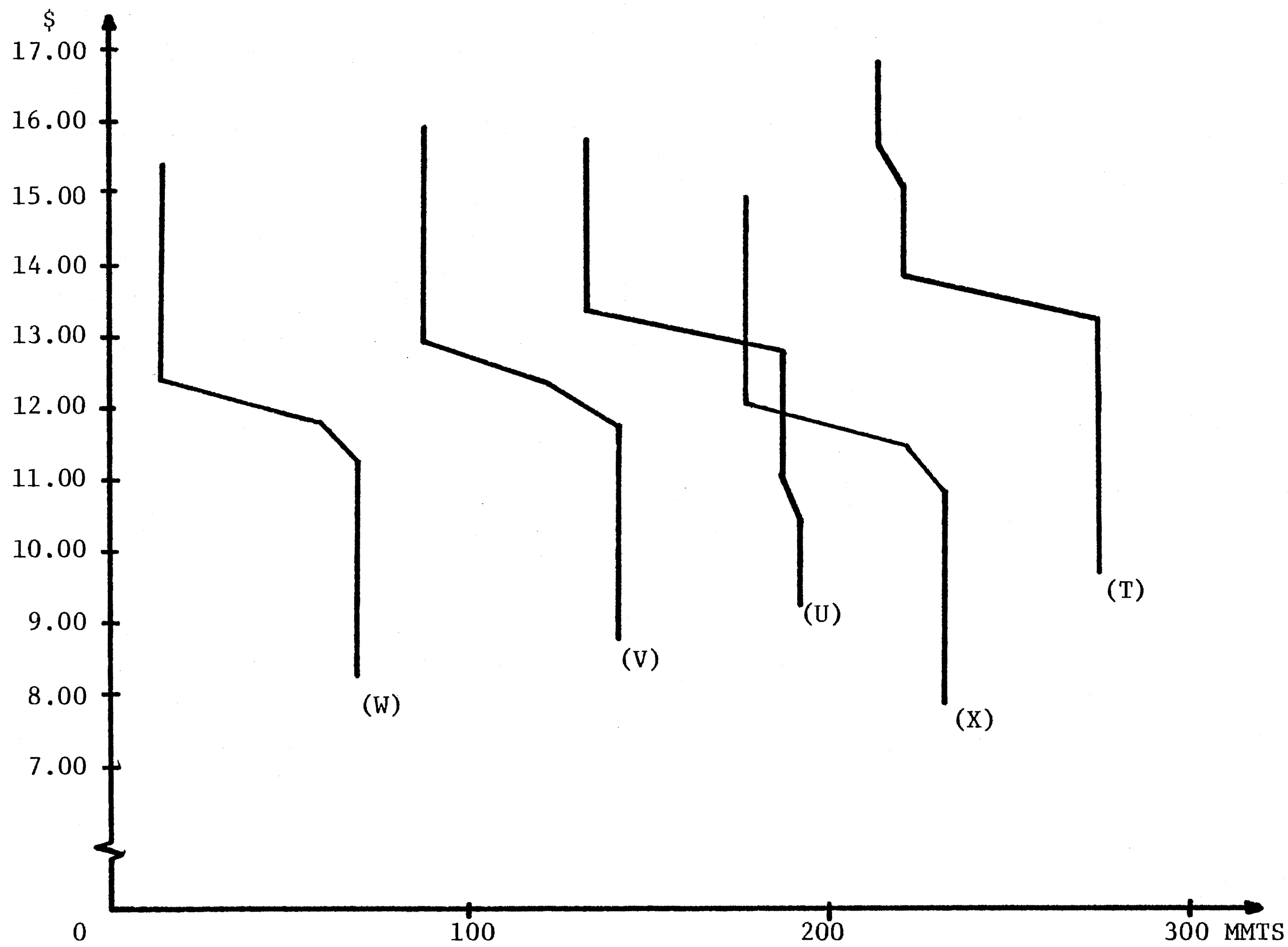


Figure 21. Demand Curves for Transportation Services from the U.S. Gulf Coast to the United Kingdom, Various Vessel Sizes

pattern size restrictions contributed for the large quantities demanded on these vessel sizes.

Figures 22-28 contain demand curves for the rest of the transportation activities sensitive to changes in ocean freight rates. From fourteen activities subjected to parametric programming, five activities are to the United Kingdom, three to Far East Asia, three to the Soviet Union, one to Middle East Asia and one to Egypt. Seven activities are for vessels with a hauling capacity of 20-29 thousand metric tons, three for 30-39 thousand metric tons, two for 10-19 thousand metric tons, one for 40-49 and 50-59 thousand metric tons.

Wheat shipments on a 20-29 thousand metric ton vessel are relatively more sensitive to changes in their respective ocean freight rates than changes in ocean freight rates for wheat shipments on other vessel sizes. Likewise, wheat shipments to the United Kingdom, Far East Asia, and the Soviet Union are relatively more sensitive to change in ocean freight rates than wheat shipment activities to other subregions of the world.

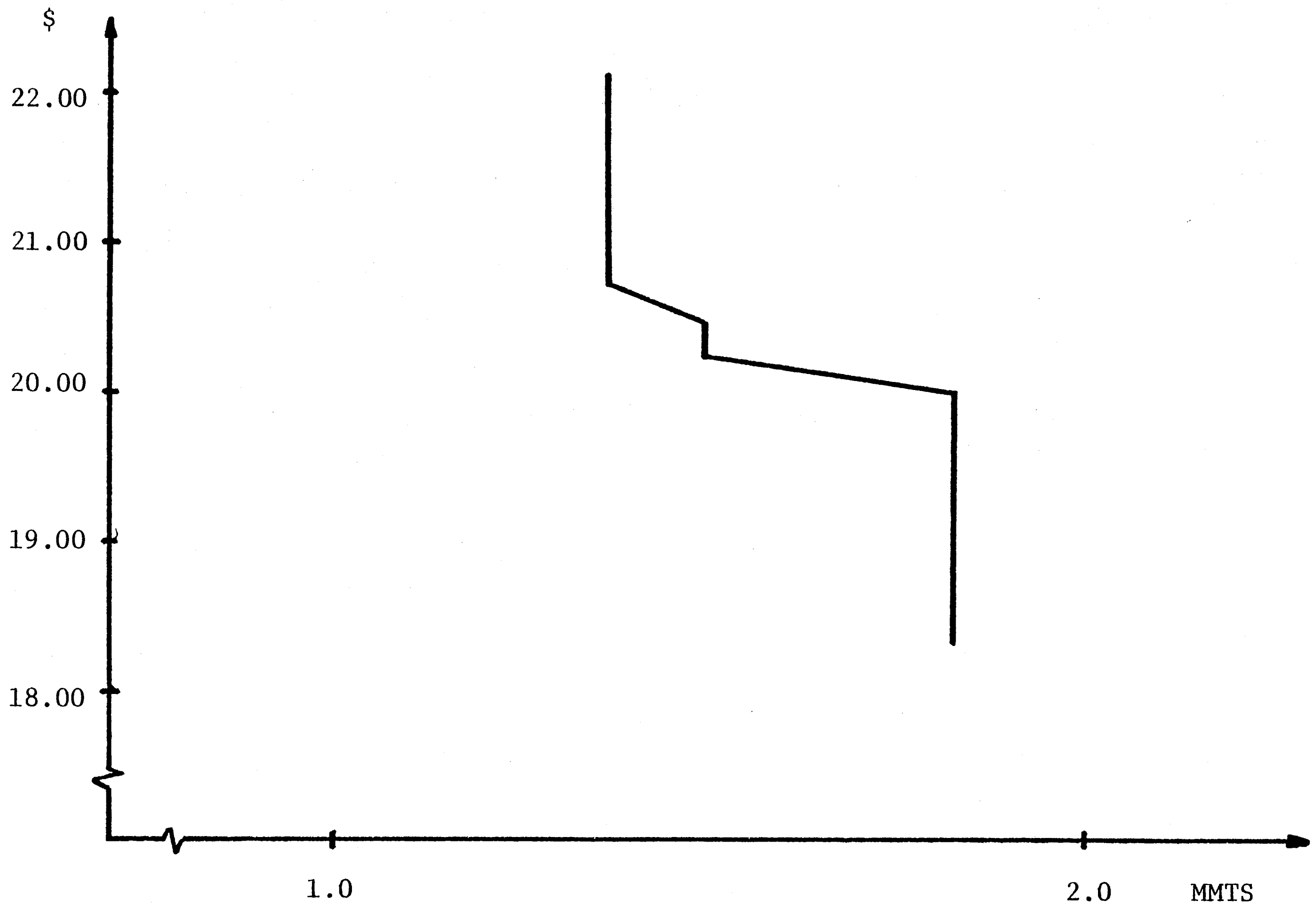


Figure 22. Demand Curve for Transportation Services from the U.S. Gulf Coast to Far East Asia, 30-39 Thousand Metric Ton Vessel

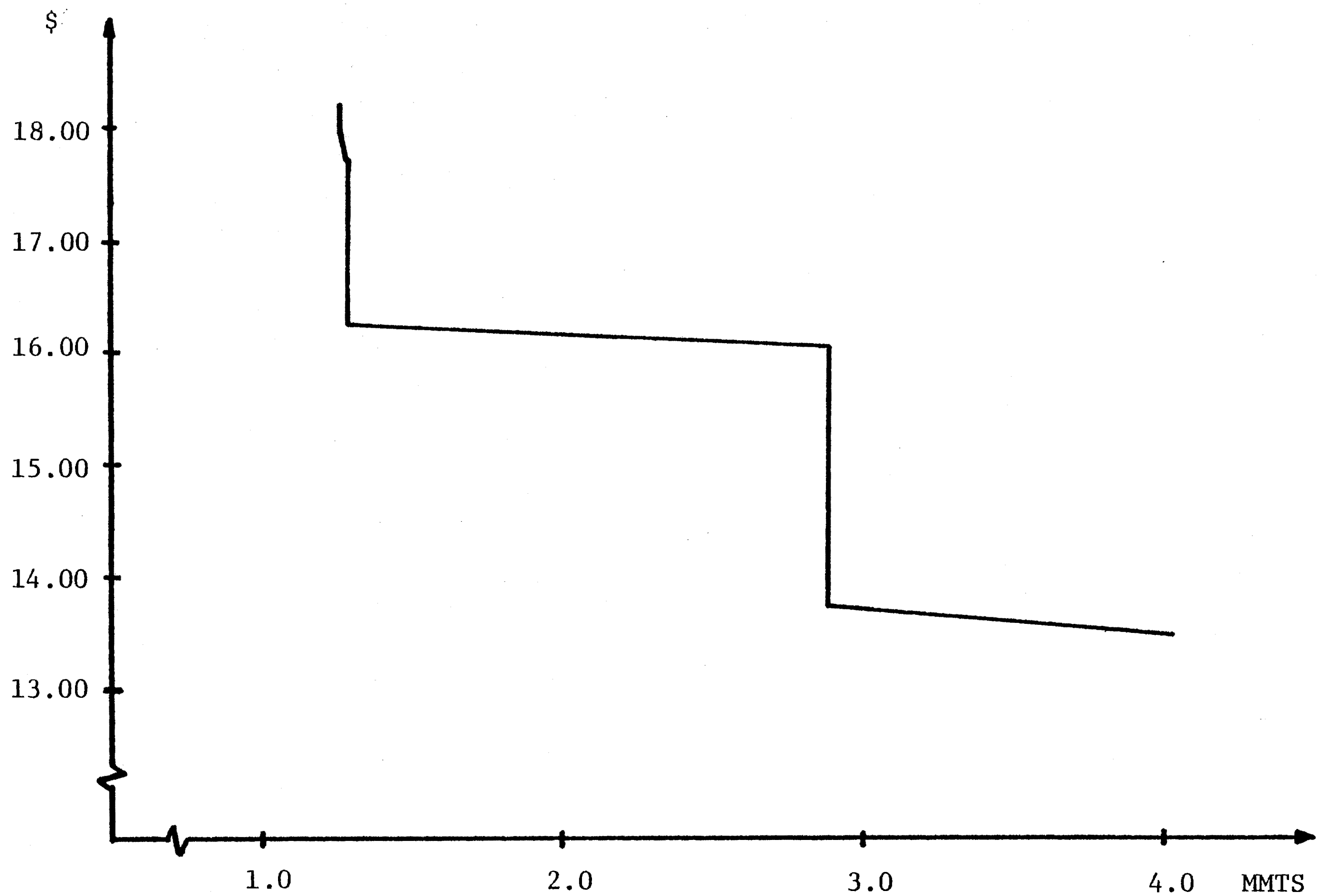


Figure 23. Demand Curve for Transportation Services from the U.S. Gulf Coast to the Soviet Union, 30-39 Thousand Metric Ton Vessel

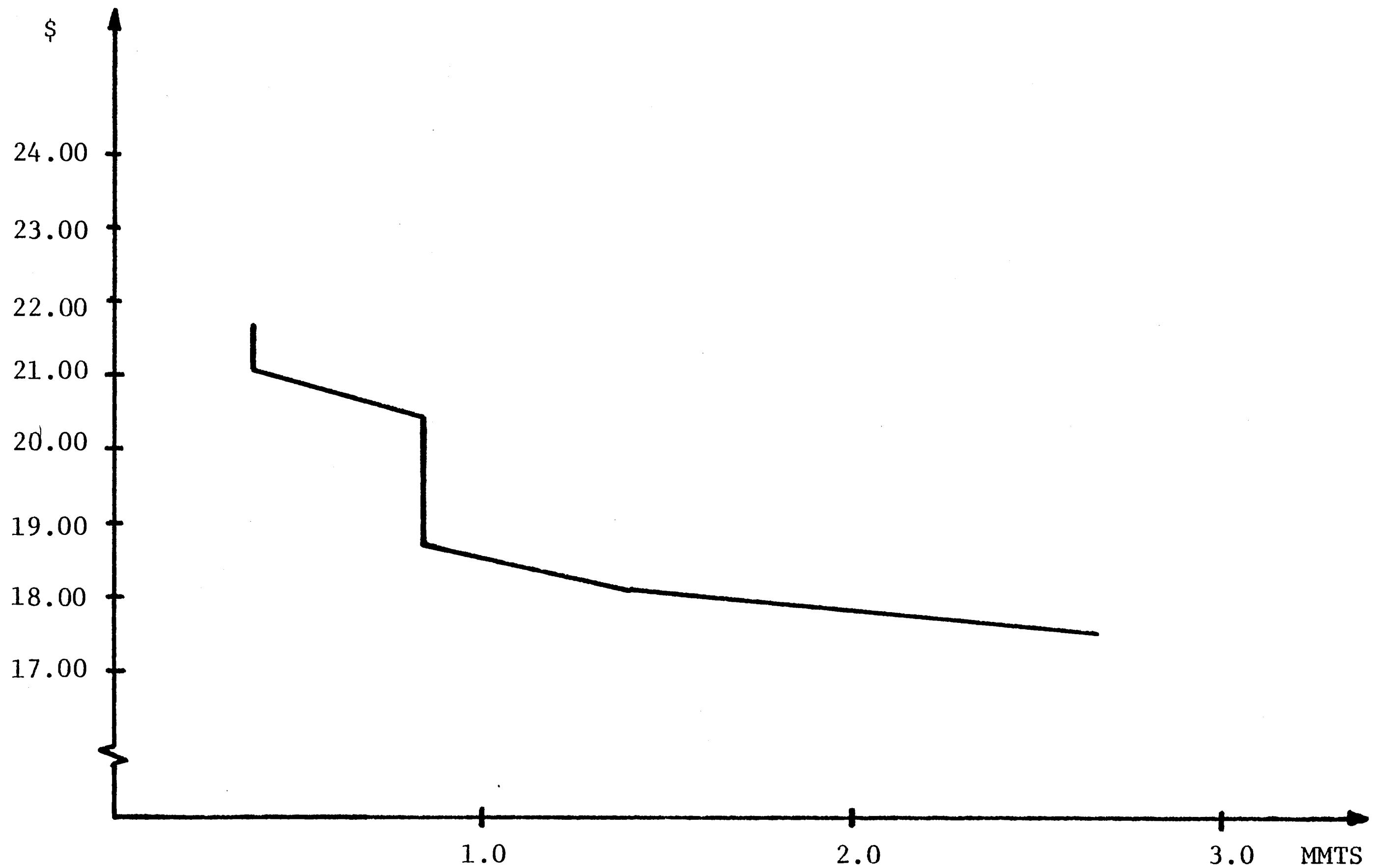


Figure 24. Demand Curve for Transportation Services from the U.S. Pacific Coast to Far East Asia, 20-29 Thousand Metric Ton Vessel

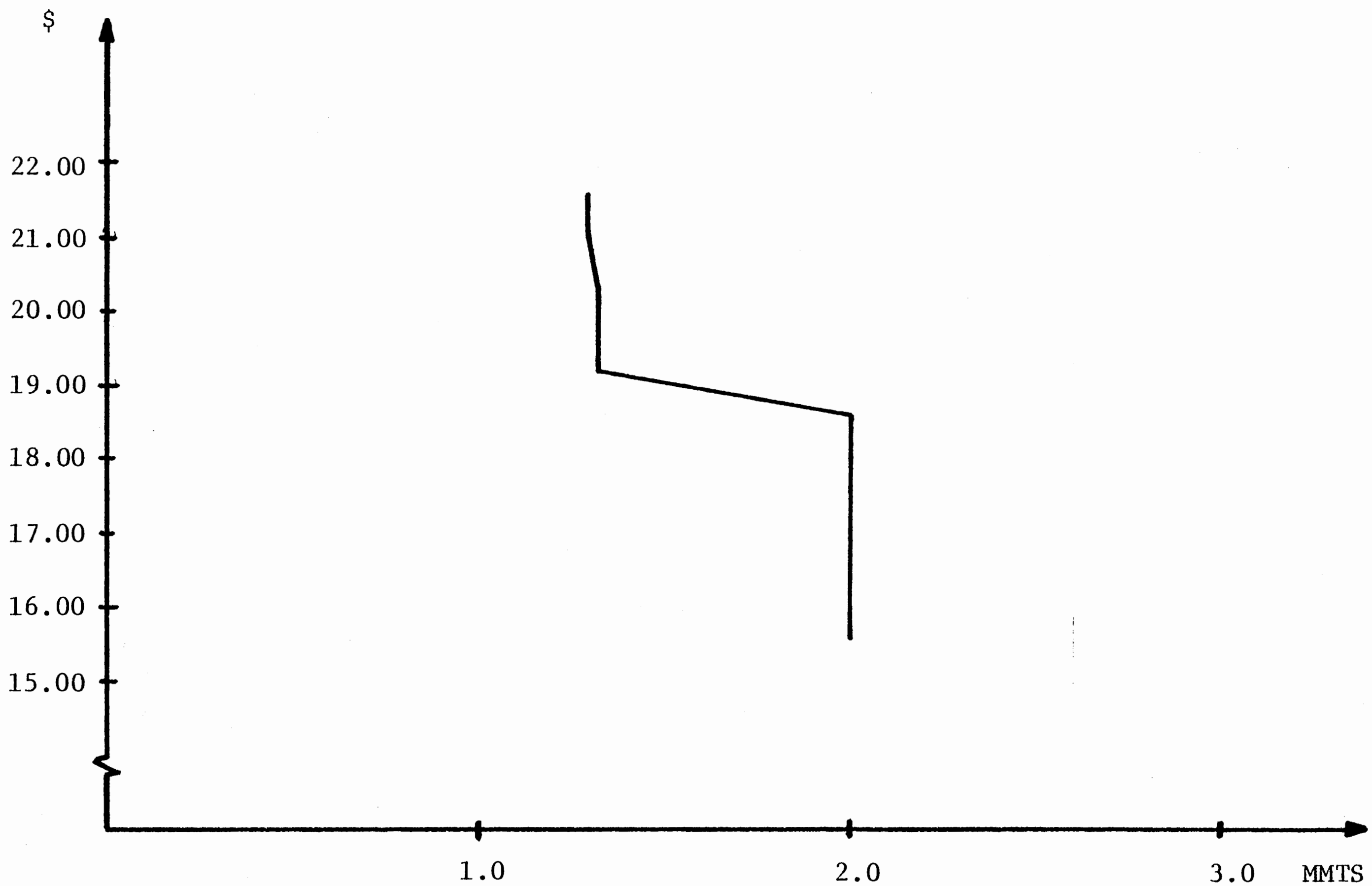


Figure 25. Demand Curve for Transportation Services from the U.S. Great Lakes Top-Off to the Soviet Union, 20-29 Thousand Metric Ton Vessel

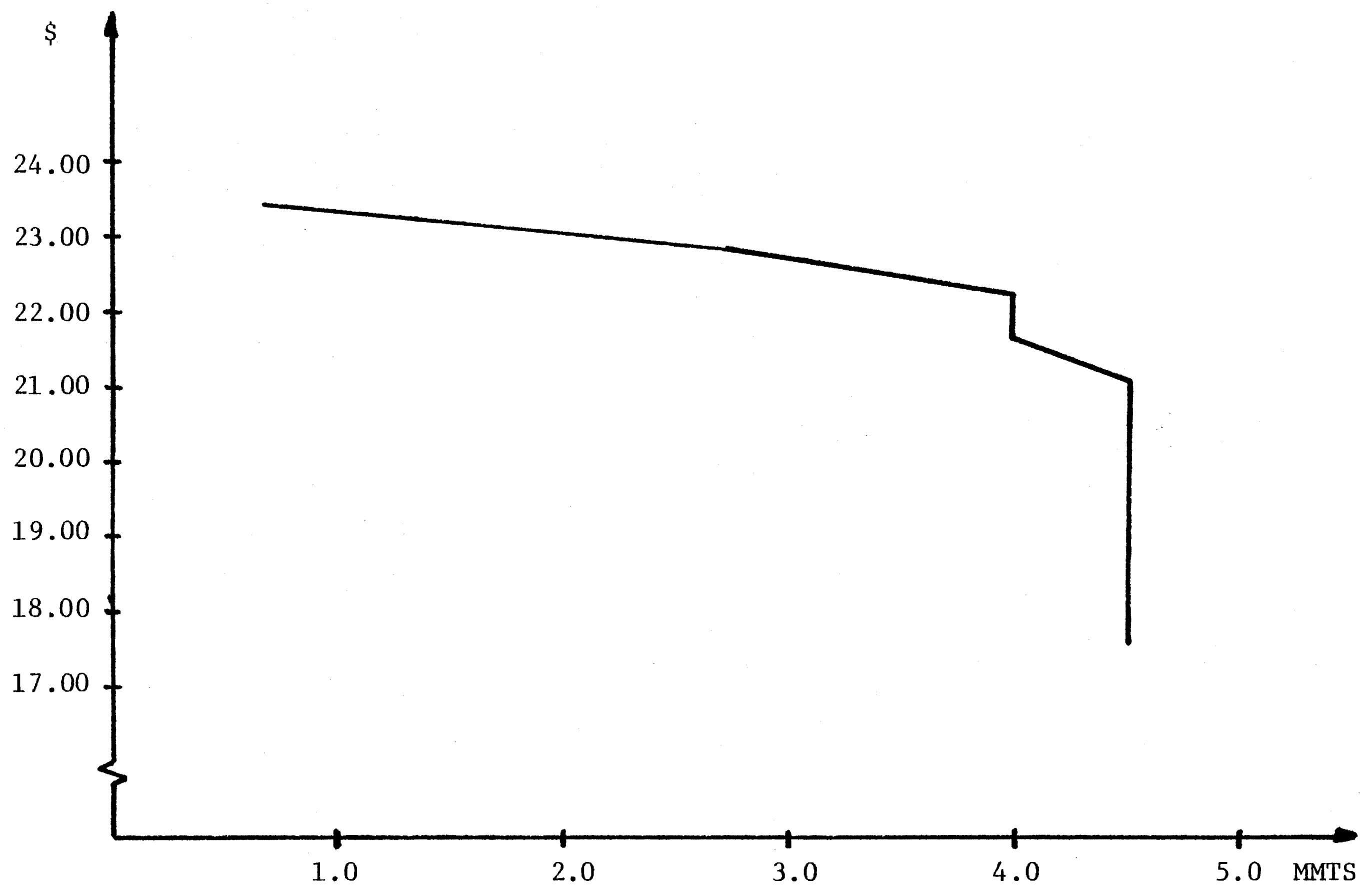


Figure 26. Demand Curve for Transportation Services from the Canadian Pacific Coast to Far East Asia, 20-29 Thousand Metric Ton Vessel

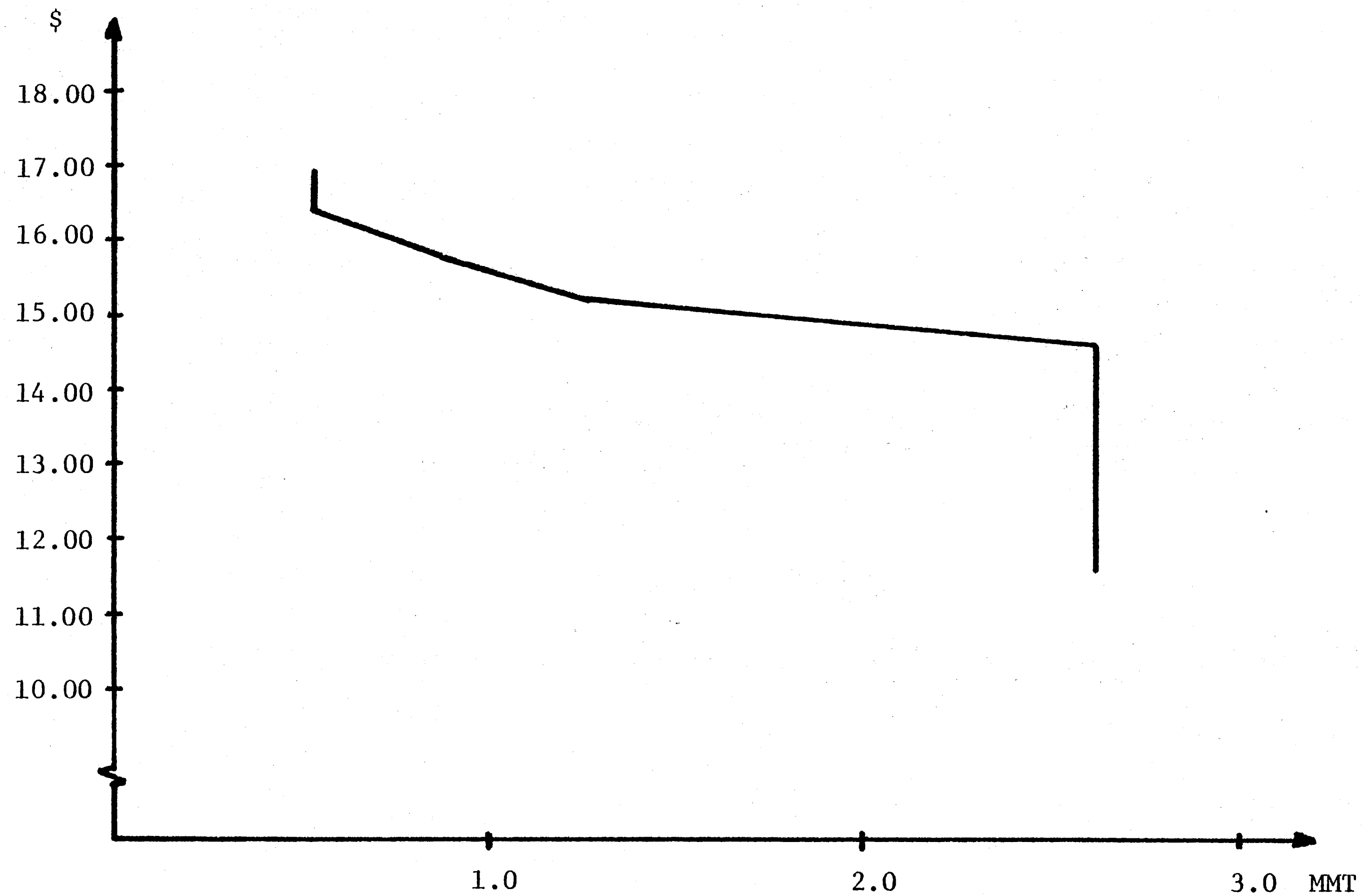


Figure 27. Demand Curve for Transportation Services from the Canadian Atlantic to Middle East Asia, 10-19 Thousand Metric Ton Vessel

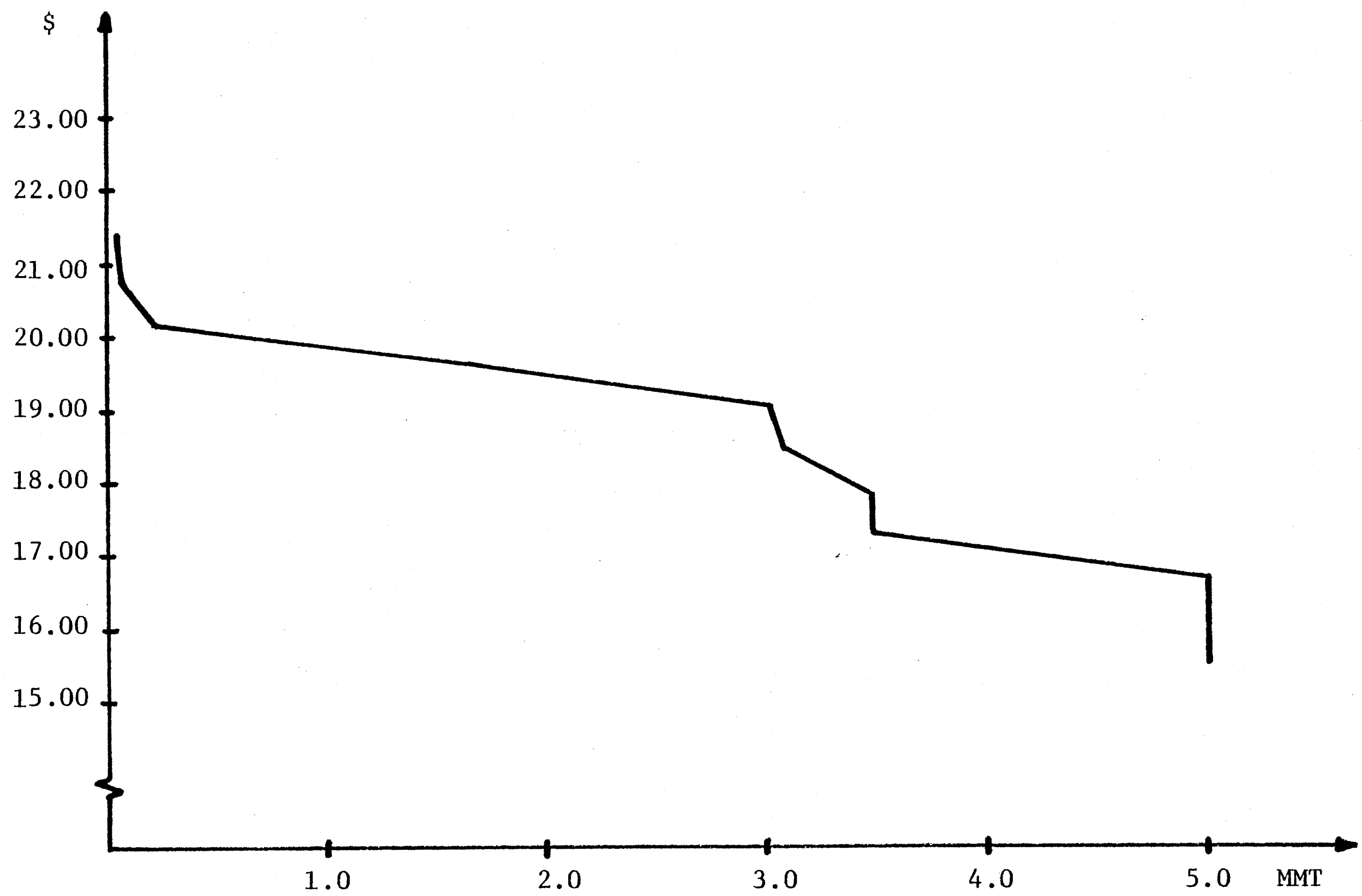


Figure 28. Demand Curve for Transportation Services from the Canadian St. Lawrence Seaway to Egypt, 20-29 Thousand Metric Ton Vessel

FOOTNOTES

[1]Transcontinental Freight Bureau, Transcontinental Freight Bureau, 3029-P, Item Number 2615 (Chicago, 1982).

[2]Sante Fe Railway Company, Sante Fe 4000, Item Number 3778 (Chicago, 1982).

CHAPTER VIII

SUMMARY OF RESULTS AND CONCLUSION

Summary of Problem and Procedures

In order for the United States to adjust to changing economic situations and changing world wheat trade patterns it is imparative to analyze and understand ocean transportation costs for wheat exports. Along with ocean freight rates, proper identification of ocean freight costs should incorporate port handling facilities at both shipping and receiving ports. Specifically, the objective of this study is to identify a least-cost trade flow for wheat exports in 1985 given projected shipping rates, available supplies, and projected world demand while considering bulk wheat handling capacity of shipping and receiving ports.

Parameter ranges are identified in order to determine the extent an activity or ocean freight rate can vary without altering the optimal solution. The analysis culminates with specifying demand curves for wheat transportation services from a specific port area by a demand area on some vessel size.

A linear programming transportation algorithm is employed to identify an optimal wheat flow solution under four different scenarios. The scenarios are: 1) U.S. high level of wheat exports with 1981 vessel size flow pattern restrictions, 2) U.S. high level of wheat exports without 1981 vessel size flow pattern restrictions,

3) U.S. low level of wheat exports with 1981 vessel size flow pattern restrictions, and 4) U.S. low level of wheat exports without 1981 vessel size flow pattern restrictions. Demand curves for transportation activities are developed from parametric programming.

Summary of Results

The total transportation bill in each scenario is:

Scenario 1	1,068,500,000 dollars,
Scenario 2	800,070,030 dollars,
Scenario 3	1,049,154,900 dollars, and
Scenario 4	808,670,210 dollars.

Removal of the vessel size restrictions in scenarios 2 and 4 result in a reduction of the total transportation bill of 25 percent and 23 percent, respectively. The total transportation bill is reduced 1.8 percent when the world has a high level of wheat exports than when the U.S. has a high level of wheat exports.

In each scenario, wheat shipments originating from Argentina service the Soviet Union (Baltic Region) and the Western Europe subregion, Baltic Region. Wheat shipments occur on two vessel sizes, 20-29 and 30-39 thousand metric tons.

Australia services Far East Asia and Egypt in scenarios 1 and 2. Japan enters as a major demand area serviced by Australia in the world high level of wheat exports scenarios. Vessels with a bulk hauling capacity of 20-29 thousand metric tons are the most prominent vessels used in wheat shipment activities orginating from Australia. When vessel size shipment pattern restrictions are removed, bulk wheat is assigned to shipment activities possessing the largest hauling capacity.

East Africa, Middle East Asia, South America-Pacific Eastern Europe (Baltic Sea), Eastern Europe (Black Sea), Adreatic, Antwerp-Hamburg Range, United Kingdom, Scandanavia, Portugal, USSR (Baltic Sea), and Egypt receive wheat shipments from the U.S. Gulf Coast in scenarios 1 and 3. North Africa and Spain-Atlantic are also found in the set of shipment activities serviced from the U.S. Gulf Coast in scenario 1, but they are not included in scenario 3.

In general, wheat shipments to a demand area from the U.S. Gulf are satisfied on the largest vessel size reported in scenarios 1 and 3. This phenomena holds true for wheat shipments from any origin in scenarios 2 and 4 given the relationship of ocean freight rates for bulk grains. That is, as a vessel's hauling capacity increases the ocean freight rate has the tendency to decrease.

In scenario 1, bulk wheat is shipped from the U.S. Pacific to the Far East Asia subregion, Mexico, Central America, and Caribbean subregion, South America-Pacific and Japan. The U.S. Pacific is the sole supplier to Japan and Mexico, Central America, and Caribbean. Assuming the world maintains high level of wheat exports, Far East Asia and approximately 62 percent of Japan's domestic wheat demand is lost to Australia.

U.S. Atlantic exports wheat to East Africa, Middle East Asia and Egypt in scenario 1, and the USSR (Baltic Sea) and Egypt receive wheat shipments from the U.S. Atlantic in scenario 3. Scandanavia is serviced by U.S. Atlantic ports when vessel size restrictions are removed in scenarios 2 and 4, and West Africa receives wheat shipments in scenario 2.

U.S. Great Lakes Top-Off supplies wheat to East Africa, Eastern Europe (Baltic Sea), Aegean, and USSR (Baltic Sea) in scenario 1, and in scenario 3 the same subregions are serviced, excluding Eastern Europe (Baltic Sea). Removal of vessel size restrictions forces into solution wheat shipments to South America-Atlantic and Portugal. Shipments to Aegean from the U.S. Great Lakes Top-Off remain in solution in scenarios 2 and 4. Most notably, East Africa and the USSR (Baltic Sea) go out of solution in scenarios 2 and 4.

Canada Pacafic supplies one subregion in scenario 1, Far East Asia. In scenario 3, Spain-Mediterranean is added as a new subregion serviced by Canada Pacific. Removal of vessel size flow pattern restrictions in scenarios 2 and 4 allows the Adreatic to enter as a subregion serviced by Canada Pacific. As in earlier cases, removal of vessel size restrictions requires grain to be shipped on the largest vessel size allowed into the subregion.

West Africa and Middle East Asia are the only two subregions which receive wheat shipments from Canada Atlantic. However, West Africa, East Africa, Middle East Asias, Eastern Europe (Baltic Sea) and the USSR (Baltic Sea) are supplied in scenario 3. Egypt becomes a major receiver of Canadian wheat from Atlantic ports when vessel size restrictions are removed from the model. For the Canadian St. Lawrence Seaway, Egypt is the sole receiver of wheat shipments in scenarios 1 and 3. Antwerp-Hamburg Range and the United Kingdom enter as subregions serviced when the world has a high level of wheat exports without vessel size flow pattern restrictions.

France supplies North Africa and the USSR (Baltic Sea) in scenario 1 and North Africa, Adreatic, Eastern Europe (Baltic Sea), Eastern Europe (Black Sea), and the USSR (Baltic Sea) in scenario 3. North Africa is France's major outlet for wheat exports. The USSR (Baltic Sea) is a distant second. North Africa's position as a prominent importer of French wheat is strengthened with the removal of vessel size flow pattern restrictions. France is involved in transhipment activities in scenario 1. Wheat shipments orignate from the U.S. Gulf Coast, and from France the wheat is dispensed to Eastern Europe (Baltic Sea) and USSR (Baltic Sea).

Parametric programming was applied only to sensitive parameters in scenario 1 under the pretense that scenario 1 is aligned with the real world. That is, the U.S. maintains a high level of wheat exports. Of the activities in solution, fourteen activities are sensitive to changes in their respective ocean freight rates. These fourteen activities can be broken down as: 1) five activities to the United Kingdom, 2) three activities to Far East Asia, 3) three activities to the USSR (Baltic Sea), 4) one activity to Middle East Asia and 5) one activity to Egypt. Seven activities are for vessels with a hauling capacity of 20-29 thousand metric tons, three for 30-39 thousand metric tons, two for 10-19 thousand metric tons, and one each for 40-49 and 50-59 thousand metric tons.

Evaluation of Results

This study makes available in one source several important facts concerning the world wheat market. For one, port facilities in Australia, Argentina, Canada, and the United States have been identified and analyzed for future export levels. Ocean freight rates for bulk grains (which wheat is a component) have been differentiated by vessel size and trade route. More concisely, the study achieved the objectives outlined in the problem statement. According to the assumptions made in the modeling process, the following statements can be made form the results.

Defining economic efficiency of ocean transportation systems as the least-cost method of suppling a good between two regions, then the Soviet Union would be a major receiver of Argentine wheat. In light of the recent Argentine and United Kingdom conflict over the Falkland Islands, projected large wheat shipments to the USSR represents potential economic and political problems for the United States. Economic problems are defined as a shift from U.S. wheat to Argentine wheat. Politically, one can speculate on the consequences associated with an Argentine and Soviet Union pact.

Typically, each supply area servicing a demand area is dictated by geographic forces to service demand areas located in close proximity to the supply area. The U.S. Gulf has the most diversified mixture of demand areas supplied wheat by a surplus region. This finding reinforces earlier studies which indicate the U.S. Gulf has a comparative advantage in wheat shipments to all other supply areas.

Wheat shipments into the United Kingdom, Far East Asia, and the USSR (Baltic Sea) subregions are competitive with regard to the supply source chosen. In each of these markets, the United States must be constantly alert to changing market conditions in order to penetrate and maintain a competitive advantage in each market.

The 20-29 thousand metric ton vessel is by far the most sought after vessel size to transport wheat. An adequate supply of this ship size is needed to facilitate a smooth world wheat market.

If all wheat exporting countries are able to export on larger vessel sizes thus taking advantage of economies of size when the U.S. has a high level of wheat exports, and follow 1981 shipping flow patterns, these countries can reduce their total transportation bill by 260,429,970 dollars or 25 percent.

Limitations and Suggestions for Further Research

Several shortcomings of this research due to lack of data and time constraints should be pointed out at this time. Shipping rates from all origins to the Soviet Union have been nonexistent. In all cases, ocean freight rates to a subregion closest to the Soviet Union was used as its replacement. Also, ocean freight rates have been defined for heavy grain. Thus, it has been assumed wheat transportation costs are aligned with these rates.

The import capacity evaluation method for Far East Asia, Latin America, and Africa is tenuous. Also since load-out/load-in rates are reported at full efficiency peak levels, knowledge of working hours and the domestic transportation infrastructure is unknown, there are built-in incentives to over estimate the load-out/load-in capacity for exporting countries.

Throughout the analysis the product shipped has been defined as wheat. There has not been any differentiation between wheat classes or characteristics inherent to each wheat class grown and exported from a supply area. That is, substitutability has been assumed for all wheat exported.

Specifically, the suggestions for further research are:

(1) Shipping rates to the Soviet Union should be estimated by vessel hauling capacity,

(2) Time charters according to vessel hauling capacity need to be identified and entered into the least-cost optimization process,

(3) Research is needed to identify differences in ocean freights due to the type of grain hauled,

(4) Methods determining discharge rates for ports around the world need to be improved and refined,

(5) Introduction of seasonal and time factors (the actual time required to move the grain between two ocean ports) would contribute additional information with regard to potential bottlenecks,

(6) Wheat variaties should be diffentiated when examining the world wheat market, and

(7) Differences in quality, institutional, and political preferences with regard to the wheat produced by major exporters could be introduced into the model.

However, whatever the shortcomings of this research to model the world wheat market, the research does provide an excellent foundation to proceed in accomplishing any suggestion for further research.

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APPENDIXES

APPENDIX A

COUNTRIES CONTAINED IN REGION AND SUBREGION AGGREGATIONS

COUNTRIES CONTAINED IN REGION AND SUBREGION AGGREGATIONS

Africa

North Africa
- Algeria
- Libya
- Mauritius
- Morocco
- Tunisia

West Africa
- Angola
- Cameroon
- Ghana
- Guinea
- Ivory Coast
- Nigeria
- Senegal
- Sierra Leone
- Upper Volta
- Zaire

East Africa
- Kenya
- Madagascar
- Mozambique
- South Africa
- Sudan
- Tanzania
- Zambia

Egypt

Asia

Middle East
- Afghanastan
- Cyprus
- Iran
- Iraq
- Isreal
- Jordan
- Labanon
- Saudi Arabia
- Syria
- Turkey
- Yemem

Far East
- Bangladesh
- Burma
- Democratic Kampuchea
- Hong Kong
- Indonesia
- Korea
- Korea, Republic of
- Malaysia
- Pakistan
- Philippines
- Singapore
- South Vietnam
- Sri Lanka
- Taiwan
- Thailand
- Vietnam, North

Latin America

Mexico, Central America, and Caribbean
- Costa Rica
- Cuba
- Dominican Republic
- El Salvador
- Guadaloupe
- Haiti
- Honduras
- Jamica
- Martinique
- Mexico
- Nicaragua
- Panama
- Trinidad and Tobago

South America - Atlantic Coast
- Brazil
- Colombia
- Guyana
- Paraguay
- Venezuela

South America - Pacific Coast
- Bolivia
- Chile
- Ecuador
- Peru

Eastern Europe

Eastern Europe - Baltic Sea
- Czechoslovakia
- East Germany
- Poland

Eastern Europe - Black Sea
- Albania
- Bulgaria
- Hungary
- Romania

Western Europe Mediterranean

Spanish Mediterranean
- Spain

Adreatic
- Austria
- Italy
- Yugoslavia

Aegean
- Greece
- Malta

Western Europe Atlantic

Antwerp-Hamburg Range
- West Germany
- Netherland
- Belgium/Luxemburg

United Kingdom
- England
- Ireland

Scandanavia
- Norway
- Finland
- Sweden

Baltic Region
- Denmark

France Region
- France
- Switzerland

Spanish Region
- Spain

Portugal
- Portugal

APPENDIX B

EXPORT TERMINAL STORAGE CAPACITIES

AND LOAD OUT RATES

UNITED STATES

U. S. Gulf

Alabama

Mobile

Elevator Name: Public Grain Elevator
Elevator Company: Alabama Public Grain Elevator
Storage Capacity: 3,300,000 bu.
Shiploading Rate: 40,000 bu.
Number of Spouts to Ship: 6
Number of Belts to Ship: 3

Louisiana

Ama

Elevator Name: Farmers Export
Elevator Company: Farmers Export Company
Storage Capacity: 5,000,000 bu.
Shiploading Rate: 80,000 bu.
Number of Spouts to Ship: 4
Number of Belts to Ship: 2

Belle Chase

Elevator Name: Mississippi River Grain Elevator
Elevator Company: Ditta Feruzzi Serafino and Company
Storage Capacity: 6,000,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: 3
Number of Belts to Ship: 1

Convent

Elevator Name: Delta Conveyor (Floating Rig)
Elevator Company: Delta Bulk Terminal
Storage Capacity:
Shiploading Rate: 50,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

Destrehan

Elevator Name: Bunge Grain Elevator
Elevator Company: Bunge Corporation
Storage Capacity: 8,000,000 bu.
Shiploading Rate: 80,000 bu.
Number of Spouts to Ship: 7
Number of Belts to Ship: 2

Elevator Name: Gemini (Floating Rig)
Elevator Company: Midstream Transfer
Storage Capacity: 2 blending Bins
Shiploading Rate: 40,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

Elevator Name: St. Charles Grain Elevator
Elevator Company: Garnac Grain, Inc. & ADM Export Company
Storage Capacity: 5,200,000
Shiploading Rate: 80,000 bu.
Number of Spouts to Ship: 8
Number of Belts to Ship: 2

Lake Charles

Elevator Name: Continental Grain
Elevator Company: Continental Grain Company
Storage Capacity: 600,000 bu.
Shiploading Rate: 25,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

New Orleans

Elevator Name: Bussco I (Floating Rig)
Elevator Company: Cooper Stevedoring, Inc.
Storage Capacity:
Shiploading Rate: 18,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

Elevator Name: Commit II (Floating Rig)
Elevator Company: International Grain Trns., Inc.
Storage Capacity:
Shiploading Rate: 12,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

Elevator Name: LST (Floating Rig)
Elevator Company: Dockside Elevator, Inc.
Storage Capacity:
Shiploading Rate: 15-20,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: N/A

Elevator Name: Market Street Wharf
Elevator Company: Ryan-Walsh Stevedoring Company
Storage Capacity: 5,000 M.T.
Shiploading Rate: Handles primarily inbound bulk and outbound sack movements

Elevator Name: Mr. Bert (Floating Rig)
Elevator Company: Dockside Elevator, Inc.
Storage Capacity:
Shiploading Rate: 10-15,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: N/A

Elevator Name: Public Grain Elevator
Elevator Company: Pike Grain Co., Peavey, and C.B. Fox Co.
Storage Capacity: 7,200,000 bu.
Shiploading Rate: 100,000 bu.
Number of Spouts to Ship: 26
Number of Belts to Ship: 6

Elevator Name: RG-1 (Floating Rig)
Elevator Company: Cooper Stevedore, Inc.
Storage Capacity: 1 Blending Bin
Shiploading Rate: 12,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

Paulina

Elevator Name: Margaret G (Floating Rig)
Elevator Company: Atlantic Gulf Stevedores, RG-1
Storage Capacity:
Shiploading Rate: 300 tons/hr.
Number of Spouts to Ship: 1
Number of Belts to Ship: N/A

Elevator Name: Peavey Grain Elevator
Elevator Company: Peavey Grain Company
Storage Capacity: 2,000,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: N/A
Number of Belts to Ship: 1

Port Allen

Elevator Name: Cargill Elevator
Elevator Company: Cargil, Inc.
Storage Capacity: 7,000,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: N/A
Number of Belts to Ship: 1

Reserve

Elevator Name: Cargill Elevator
Elevator Company: Cargill, Inc.
Storage Capacity: 7,743,000 bu.
Shiploading Rate: 100,000 bu.
Number of Spouts to Ship: 4
Number of Belts to Ship: 2

Elevator Name: Continental Elevator
Elevator Company: Continental Reserve Elevator Company
Storage Capacity: 3,600,000 bu.
Shiploading Rate: 80,000 bu.
Number of Spouts to Ship: 7
Number of Belts to Ship: 3

Sulphur
Elevator Name: Paktank Bulk Services
Elevator Company: American Grain Related Industries
Storage Capacity: 950,000 bu.
Shiploading Rate: 40,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

Westwego
Elevator Name: Continental Elevator:
Elevator Company: Continental Grain Company
Storage Capacity: Under construction
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: 6
Number of Belts to Ship: 2

Missisippi
Pascagoula
Elevator Name: Jackson County Terminal Elevator
Elevataor Company: Louis Dreyfus Company
Storage Capacity: 3,000,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: 7
Number of Belts to Ship: 3

Texas
Beaumont
Elevator Name: Beumont Elevator
Elevator Company: Continental Grain Company
Storage Capacity: 3,500,00 bu.
Shiploading Rate: 50,000 bu.
Number of Spouts to Ship: 4
Number of Belts to Ship: N/A

Brownsville
Elevator Name: Brownsville Public Elevator
Elevator Company:
Storage Capacity: 3,000,000 bu.
Shiploading Rate: 40,000 bu.
Number of Spouts to Ship: 2
Number of Belts to Ship: 2

Channelview
Elevator Name: Cargill Elevator
Elevator Company: Cargill, Inc.
Storage Capacity: 6,000,000 bu.
Shiploading Rate: 190,000 bu.
Number of Spouts to Ship: 12
Number of Belts to Ship: 2

Corpus Christi
Elevator Name: Corpus Christi Public Elevator
Elevator Company:
Storage Capacity: 5,000,000 bu.
Shiploading Rate: 100,000 bu.
Number of Spouts to Ship: 5
Number of Belts to Ship: 4

Elevator Name: Producers Grain Port Terminal
Elevator Company: Producers Grain Corporation
Storage Capacity: 6,300,000 bu.
Shiploading Rate: 40,000 bu.
Number of Spouts to Ship: 5
Number of Belts to Ship: 2

Deer Park
Elevator Name: Equity Export Elevator
Elevator Company: Union Export Coop. Ex.
Storage Capacity: 8,500,000 bu.
Shiploading Rate: 120,000 bu.
Number of Spouts to Ship: 6
Number of Belts to Ship: 4

Galena Park
Elevator Name: Agri Export
Elevator Company: Agri Industries
Storage Capacity: 6,354,000 bu.
Shiploading Rate: 115,000 bu.
Number of Spouts to Ship: 3
Number of Belts to Ship: 2

Galveston
Elevator Name: Bunge Elevator
Elevator Company: Bunge Corporation
Storage Capacity: 8,000,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: 8
Number of Belts to Ship: 8

Elevator Name: Farmers Export Corporation
Elevator Company: Farmers Export Corporation
Storage Capacity: 2,800,000 bu.
Shiploading Rate: 120,000 bu.
Number of Spouts to Ship: 3
Number of Belts to Ship: 2

Houston
Elevator Name: Houston PUblic Grain Elevator
Elevator Company: Port of Houston Authority
Storage Capacity: 6,000,000 bu.
Shiploading Rate: 75,000 bu.
Number of Spouts to Ship: 6
Number of Belts to Ship: 4

Port Author
Elevator Name: Cargill Elevator
Elevator Company: Cargill, Inc.
Storage Capacity: 3,700,000 bu.
Shiploading Rate: 40,000 bu.
Number of Spouts to Ship: 4
Number of Belts to Ship: 4

U. S. Pacific

California

Long Beach
Elevator Name: Koppel Bulk Terminal
Elevator Company:
Storage Capacity: 2,250,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

Sacramento
Elevator Name: Cargill Elevator Sacramento
Elevator Company: Cargill California, Inc.
Storage Capacity: 1,250,000 bu.
Shiploading Rate: 21,200 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

San Diego
Elevator Name: San Diego Public Bulk Terminal
Elevator Company: Garnac Grain, Inc.
Storage Capacity: 500,000 bu.
Shiploading Rate: 36,666 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

San Francisco
Elevator Name: Port of San Fransico Grain Terminal, Pier 90
Elevator Company: Stockton-Continental Elevator
Storage Capacity: 2,000,000 bu.
Shiploading Rate: 50,000 bu.
Number of Spouts to Ship: 6
Number of Belts to Ship: 2

Stockton
Elevator Name: Stockton-Continental Elevator
Elevator Company:
Storage Capacity: 6,500,000 bu.
Shiploading Rate: 21,200 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

Oregon

Portland

Elevator Name: Columbia Grain, Inc. Terminal #5
Elevator Company: Marubeni America Corporation
Storage Capacity: 1,500,000 bu.
Shiploading Rate: 70,000 bu.
Number of Spouts to Ship: 2
Number of Belts to Ship: 2

Elevator Name: Cargill Terminal #4
Elevator Company: Cargill, Inc.
Storage Capacity: 8,000,000 bu.
Shiploading Rate: 99,000 bu.
Number of Spouts to Ship: 2
Number of Belts to Ship: 1

Elevator Name: Louis Dreyful Elevator
Elevator Company: Louis Dreyfus
Storage Capacity: 1,800,000 bu.
Shiploading Rate: 45,000 bu.
Number of Spouts to Ship: 6
Number of Belts to Ship: 2

Elevator Name: Portland Grain Terminal
Elevator Company: Bunge Grain Corporation
Storage Capacity: 1,500,000 bu.
Shiploading Rate: 40,000 bu.
Number of Spouts to Ship: 5
Number of Belts to Ship: 1

Washington

Kalama

Elevator Name: North Pacific Grain Growers
Elevator Company: North Pacific Grain Growers, Inc.
Storage Capacity: 4,000,000 bu.
Shiploading Rate: 60,000 BU.
Number of Spouts to Ship: 6
Number of Belts to Ship: 2

Longview

Elevator Name: Continental Elevator
Elevator Company: Continental Grain Company
Storage Capacity: 5,000,000 bu.
Shiploading Rate: 30,000 bu.
Number of Spouts to Ship: 6
Number of Belts to Ship: 2

Seattle

Elevator Name: Cargill Elevator-Pier 86
Elevator Company: Cargill, Inc.
Storage Capacity: 4,200,000 bu.
Shiploading Rate: 100,000 bu.
Number of Spouts to Ship: 5
Number of Belts to Ship: 2

Tacoma

Elevator Name: Continental Elevator
Elevator Company: Continental Grain Company
Storage Capacity: 3,200,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: 3
Number of Belts to Ship: 3

Elevator Name: United Grain Corporation Elevator
Elevator Company: Mitsubishi Int. Corporation
Storage Capacity: 4,100,000 bu.
Shiploading Rate: 30,000 bu.
Number of Spouts to Ship: 7
Number of Belts to Ship: 2

Vancouver

Elevator Name: United Grain Corporation Elevator
Elevator Company: Mitsubishi Int. Corporation
Storage Capacity: 4,500,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: 7
Number of Belts to Ship: 2

U. S. Atlantic

Georgia

Savannah (Port Wentworth)

Elevator Name: Savannah State Dock Elevator
Elevator Company: Continental Grain Company
Storage Capacity: 1,500,000 bu.
Shiploading Rate: 30,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

Maryland

Baltimore

Elevator Name: Canton Grain Elevator
Elevator Company: Central Soya Company, Inc.
Storage Capacity: 3,500,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: East 9 - - West 3
Number of Belts to Ship: East 1 to 4 - - West 1 to 3

Elevator Name: Louis Point Grain Elevator
Elevator Company: Indiana Grain Corporation
Storage Capacity: 3,800,000 bu.
Shiploading Rate: 36,000 bu.
Number of Spouts to Ship: 7
Number of Belts to Ship: 3

Elevator Name: Port Covington Elevator
Elevator Company: Louis Dreyfus Corporation
Storage Capacity: 5,000,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: 7
Number of Belts to Ship: 4

New York

Albany

Elevator Name: Cargill Elevator
Elevator Company: Cargill, Inc.
Storage Capacity: 10,926,000 bu.
Shiploading Rate: 50,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

Pennsylvania

Philadelphia

Elevator Name: Port Richmond Elevator
Elevator Company: Farmers Export Company
Storage Capacity: 3,500,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: 8 (in use and 8 not in use)
Number of Belts to Ship: 4

Elevator Name: Tidewater Grain Elevator
Elevator Company: Tidewater Grain Company
Storage Capacity: 2,250,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: 8
Number of Belts to Ship: 4

South Carolina

Charleston

Elevator Name: South Carolina Farm Market Association
Elevator Company: South Carolina Farm Market Association
Storage Capacity: 1,800,000 bu.
Shiploading Rate: 25,000 bu.
Number of Spouts to Ship: 5
Number of Belts to Ship: 1

Virginia

Chesapeake

Elevator Name: Cargill Elevator
Elevator Company: Cargill, Incl
Storage Capacity: 6,800,000 bu.
Shiploading Rate: 70,000 bu.
Number of Spouts to Ship: 2
Number of Belts to Ship: 1

Norfolk

Elevator Name: N & W Elevator
Elevator Company: Continental Grain Company
Storage Capacity: 3,500,000 bu.
Shiploading Rate: 50,000 bu.
Number of Spouts to Ship: 3
Number of Belts to Ship: 2

U. S. Great Lakes

Illinois

Chicago

Elevator Name: Cargill Elevator
Elevator Company: Cargill, Inc.
Storage Capacity: 23,000,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: 5
Number of Belts to Ship: 1

Elevator Name: Continental "B"
Elevator Company: Continental Grain Company
Storage Capacity: 10,500,000 bu.
Shiploading Rate: 30,000 bu.
Number of Spouts to Ship: 5
Number of Belts to Ship: 2

Elevator Name: Contintal "C"
Elevator Company: Continental "C"
Storage Capacity: 6,500,000 bu.
Shiploading Capacity: 40,000 bu.
Number of Spouts to Ship: 8
Number of Belts to Ship: 4

Elevator Name: Gateway Elevator
Elevator Company: Indiana Grain Company
Storage Capacity: 7,500,000 bu.
Shiploading Rate: 90,000 bu.
Number of Spouts to Ship: 8
Number of Belts to Ship: 5

Elevator Name: Rialto Elevator
Elevator Company: General Mills
Storage Capacity: 3,000,000 bu.
Shiploading Rate: 40,000 bu.
Number of Spouts to Ship: 6
Number of Belts to Ship: 1

Michigan

Carrollton

Elevator Name: Michigan Elevator Exchange
Elevator Company: Division of Farm Bureau Service
Storage Capacity: 2,000,000 bu.
Shiploading Rate: 20,000 bu.
Number of Spouts to Ship: 3 (only 1 used)
Number of Belts to Ship: 1

Elevator Name: Wickes Agriculture Elevator
Elevator Company: Wickes Agriculture
Storage Capacity: 2,700,000 bu.
Shiploading Rate: 20,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

Minnesota

Duluth

Elevator Name: Cargill "B"
Elevator Company: Cargill, Inc.
Storage Capacity: 8,500,000 bu.
Shiploading Rate: 140,000 bu. (2 docks)
Number of Spouts to Ship: 8
Number of Belts to Ship: 5

Elevator Name: Cargill "C"
Elevator Company: Cargill, Inc.
Storage Capacity: 4,500,000 bu.
Shiploading Rate: 50,000 bu.
Number of Spouts to Ship: 5
Number of Belts to Ship: 2

Elevator Name: Elevator "A"
Elevator Company: General Mills
Storage Capacity: 2,500,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

Elevator Name: Multi Foods
Elevator Company: International Multi Foods
Storage Capacity: 4,200,000 bu.
Shiploading Rate: 50,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: N/A

Ohio

Huron

Elevator Name: Pillsbury Elevator
Elevator Company: Pillsbury
Storage Capacity: 1,750,000 bu.
Shiploading Rate: 15,000 bu.
Number of Spouts to Ship: N/A
Number of Belts to Ship: N/A

Maumee

Elevator Name: The Andersons Elevator
Elevator Company: The Andersons
Storage Capacity: 7,000,000 bu.
Shiploading Rate: 50,000 bu.
Number of Spouts to Ship: 7
Number of Belts to Ship: N/A

Toledo

Elevator Name: Cargill River "E"
Elevator Company: Cargill, Inc.
Storage Capacity: 1,600,000 bu.
Shiploading Capacity: 45,000 bu.
Number of Spouts to Ship: 5
Number of Belts to Ship: 2

Elevator Name: Cargill-Toledo Elevator
Elevator Company: Cargill, Inc.
Storage Capacity: 4,000,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: 1
Number of Belts to Ship: 1

Elevator Name: Mid-States Elevator
Elevator Company: Mid-States Company
Storage Capacity: 6,000,000 bu.
Shiploading Rate: 45,000 bu.
Number of Spouts to Ship: 10
Number of Belts to Ship: N/A

Wisconsin

Milwaukee

Elevator Name: Elevator "E"
Elevator Company: Cargill, Inc.
Storage Capacity: 2,500,000 bu.
Shiploading Rate: 24,000 bu.
Number of Spouts to Ship: 2
Number of Belts to Ship: N/A

Elevator Name: Elevator "K"
Elevator Company: Continental Grain Company
Storage Capacity: 3,500,000 bu.
Shiploading Rate: 40,000 bu.
Number of Spouts to Ship: 6
Number of Belts to Ship: 6

Superior

Elevator Name: ADM Elevator "S"
Elevator Company: ADM Grain Company
Storage Capacity: 12,500,000 bu.
Shiploading Rate: 60,000 bu.
Number of Spouts to Ship: 5
Number of Belts to Ship: 2

Elevator Name: Continental Elevator
Elevator Company: Continental Grain
Storage Capacity: 5,000,000 bu.
Shiploading Rate: 75,000 bu.
Number of Spouts to Ship: 6
Number of Belts to Ship: 4

Elevator Name: Elevator "M"
Elevator Company: ConAgra, Inc.
Storage Capacity: 2,500,000 bu.
Shiploading Rate: 66,000 bu.
Number of Spouts to Ship: 3
Number of Belts to Ship: N/A

Elevator Name: Farmers Union Elevator #1
Elevator Company: Farmers Union Grain Terminal Association
Storage Capacity: 7,500,000 bu.
Shiploading Rate: 65,000 bu.
Number of Spouts to Ship: 11
Number of Belts to Ship: 3

Elevator Name: Farmers Union Elevator #2
Elevator Company: Farmers Union Grain Terminal Association
Storage Capacity: 11,000,000 bu.
Shiploading Rate: 65,000 bu.
Number of Spouts to Ship: 6
Number of Belts to Ship: N/A

Elevator Name: Farmers Union Elevator #3
Elevator Company: Farmers Union Grain Terminal Association
Storage Capacity: N/A
Shiploading Rate: N/A
Number of Spouts to Ship: N/A
Number of Belts to Ship: N/A

Elevator Name: Globe Elevator
Elevator Company: Peavey
Storage Capacity: 4,000,000 bu.
Shiploading Rate: 50,000 bu.
Number of Spouts to Ship: 3
Number of Belts to Ship: 2

Source: U.S. Department of Agriculture, Export Elevators at Export Port Locations, Federal Grain Inspection Service, (Washington: 1981).

CANADA

British Columbia

North Vancouver
Saskatchewan Wheat Pool
Storage Capacity: 8,400,000 bushels/upright bins
Load-Out Capacity: 125,000 bushels per hour
Berths: 2 Draft: 45 feet

Prince Rupert
Canadian Government Elevators
Storage Capacity: 2,250,000 bushels/upright bins
Load-Out Capacity: 90,000 bushels per hour
Berths: 1 Draft: 40 feet

Vancouver
Alberta Wheat Pool
Storage Capacity: 10,100,000 bushels/upright bins
Load-Out Capacity: 120,000 bushels per hour
Berths: 3 Draft: 50 feet

Pacific Elevators Ltd.
Storage Capacity: 7,111,500 bushels/upright bins
Load-Out Capacity: 80,000
Berths: 3 Draft: 35 feet

United Grain Growers Ltd.
Storage Capacity: N.A.
Load-Out Capacity: 50,000 bushels per hour
Berths: 2 Draft: 40 feet

Manitoba

Churchill
National Harbors Board
Storage Capacity: 5,000,000 bushels/upright bins
Load-Out Capacity: 60,000 bushels per hour
Berths: 2 Draft: 30 feet

Ontario

Thunder Bay
Cargill Grain Company, Ltd.
Storage Capacity: 5,700,000 bushels/upright bins
Load-Out Capacity: 35,000 bushels per hour
Berths: 1

Manitoba Pool Elevators, Elevator #1
Storage Capacity: 5,980,000 bushels/upright bins
Load-Out Capacity: 90,000 bushels per hour
Berths: 1 Draft: 27 feet

Manitoba Pool Elevators, Elevator #3
Storage Capacity: 7,000,000 bushels/upright bins
Load-Out Capacity: 80,000 bushels per hour
Berths: 1 Draft: 27 feet

Parrish & Heim Becker Ltd.
Storage Capacity: 1,500,000 bushels/upright bins
Load-Out Capacity: 40,000 bushels per hour
Berths: 1 Draft: 17 feet

Saskatchewan Wheat Pool, Elevator #4
Storage Capacity: 8,000,000 bushels/upright bins
Load-Out Capacity: 100,000 bushels per hour
Berths: 1 Draft: 28 feet

Saskatchewan Wheat Popol, Elevator #6
Storage Capacity: 6,000,000 bushels/upright bins
Load-Out Capacity: 75,000 bushels per hour
Berths: 1 Draft: 24 feet

Saskatchewan Wheat Pool, Elevator #7
Storage Capacity: 13,500,000 bushels/upright bins
Load-Out Capacity: 165,000 bushels per hour
Berths: 2 Draft: 27 feet

Saskatchewan kWheat Pool, Elevator #8
Storage Capacity: 2,500,000 bushels/upright bins
Load-Out Capacity: 60,000 bushels per hour
Berths: 1 Draft: 25 feet

Saskatchewan Wheat Pool
Strage Capacity: 4,300,000 bushels/upright bins
Load-Out Capacity: 60,000 bushels per hour
Berths: 1 Draft: 27 feet

United Grain Growers (A)
Storage Capacity: N.A.
Load-Out Capacity: 80,000 bushels per hour
Berths: 1 Draft: 19 feet

United Grain Growers (M)
Storage Capacity: N.A.
Load-Out Capacity: 60,000 bushels per hour
Berths: 1 Draft: 28 feet

Collingwood

Collingwood Terminals Ltd.
Storage Capacity: 2,000,000 bushels/upright bins
Load-Out Capacity: 22,000 bushels per hour
Berths: 1 Draft: 23 feet

Goderich

Goderich Elevator Ltd. #1 and #2
Storage Capacity: #1 - 3,000,000 and #2 - 1,600,000 bushels/upright bins
Load-Out Capacity: 22,000 bushels per hour
Berths: 2 Draft: 23 feet

Midland

Canadian National Railways (Tiffin II)
Storage Capacity: 4,650,000 bushels/upright bins
Load-Out Capacity: 120,000 bushels per hour
Berths: 1 Draft: 24.3 feet

Midland Sincoe Elevator Company, Ltd.
Storage Capacity: 4,250,000 bushels/upright bins
Load-Out Capacity: 15,000 bushels per hour
Berths: 1 Draft: 23 feet

Owen Sound

Great Lakes Elevator Company, Ltd.
Storage Capacity: 4,000,000 bushels/upright bins
Load-Out Capacity: 16,000 bushels per hour
Berths: 1 Draft: 21 feet

Port McNicoll

Marathon Reality Company, Ltd.
Storage Capacity: 6,500,000 bushels/upright bins
Load-Out Capacity: 30,000 bushels per hour
Berths: 1 Draft: 23 feet

Sarnia

Maple Leaf Miller, Ltd.
Storage Capacity: 3,000,000 bushels/upright bins and 2,400,000 flat
Load-Out Capacity: 30,000 bushels per hour
Berths: 1 Draft: 24 feet

Toronto

Maple Leaf Mills, Ltd.
Storage Capacity: 4,000,000 bushels/upright bins
Load-Out Capacity: 20,000 bushels per hour
Berths: 1 Draft: 24 feet

Quebec

Baie Comeau

Cargill Grain Company, Ltd.
Storage Capacity: 6,586,000 bushels/upright bins
Load-Out Capacity: 80,000 bushels per hour
Berths: 2

Montreal

National Harbors Board

Storage Capacity: Elevator #1 - 4,000,000 bushels/upright bins; Elevator #2 - 2,662,000 bushels/upright bins; Elevator #3 - 5,000 bushels/upright bins; Elevator #4 - 5,500,000 bushels/upright bins; Elevator #5 - 5,100,000 bushels/upright bins

Load-Out Capacity: Elevator #1 - 16,000 bushels per hour, Berths - 2; Elevator #2 - 30,000 bushels per hour, Berths - 3; Elevator #3 - 16,000 bushels per hour, Berths - 1; Elevator #4 - 54,000 bushels per hour, Berths - 2; Elevator #4 - 32,000 bushels per hour, Berths - 2

Port Cartier

Port Cartier Elevateur Compagnie

Storage Capacity: 10,783,190 bushels/upright bins

Load-Out Capacity: 100,000 bushels per hour

Berths: 2 Draft: 50 feet

Quebec City

Bunge of Canada Ltd.

Storage Capacity: 8,000,000 bushels/upright bins

Load-Out Capaicty: 100,000 bushels per hour

Berths: 2 Draft: 41 feet

Sorel

Sorel Elevators Ltd.

Storage Capacity: 5,500,000 bushels/upright bins

Load-Out Capacity: 100,000 bushels per hour

Berths: 1 Draft: 36 feet

Trois Rivieres

Three River Elevators Ltd.

Storage Capacity: 6,000,000 bushels/upright bins

Load-Out Capcity: 55,000 bushels per hour

Berths: 1 Draft: 35 feet

Source: "Grain Director/Buyers Guide." Milling and Baking News, 16 November, 1979.

AUSTRALIA

TABLE XVIII

AUSTRALIAN PORT STORAGE CAPACITY, INLOAD/OUTLOAD RATES AND DRAFT

Port	Storage (1000 MT)	Rates of Inload/Outload	Draft Meters
		MT/hour	
Western Australia			
Geraldton	348.1	800/800	9.1
Kwinana	1111.0	4000/5000	12.3
Bunbury	81.6	300/400	8.7
Albany	173.4	1330/1600	11.2
Esperence	214.2	600/600	10.0
Queensland			
Gladstone	40.0	/400	10.8
Brisbane	67.0	/1600	9.7
New South Wales			
Sydney	245.0	/800	13.2
Newcastle	145.0	/4000	10.9
Victoria			
Geelong	894.2	/1600	10.4
Portland	163.3	/800	11.6
South Australia			
Port Adelaide	340.4	/800 (1450) a/	10.4
Port Lincoln	336.2	/1600	14.3
Wallaroo	233.2	/800	9.1
Thevenard	207.0	/800	9.0
Port Pirie	170.1	/800	8.1
Port Giles (Included with Ardrassan)		/800	12.2
Ardrassan	425.2	/400 (1200) b/	9.2
Total Australia	5203.3		

a/ b/ Plans for updated outload 1981/82

Working Hours at Harbors:		
	Monday-Friday	0730-2200
	Saturday	0800-1200
	Sunday	0730-2200

Sources: Love. G. P. Terryford-Jones, and J. Woolcock, "An Econometric Evaluation Alternative Grain Insect Control Measures; BAE Occasional Paper, Canberra, Australia Gov. Pub. Soc., 1982.

Australian Wheat Board, "Port Information Booklet", Melbourne, September, 1980.

ARGENTINA

TABLE XX

ARGENTINE PORT STORAGE CAPACITY, INLOAD/OUTLOAD RATES, DRAFT AND LENGTH OF PIERS

Port	Storage (1000 MT)	Rates of Inload/Outload	Truck Receiving (TPH)	Rail Receiving (TPH)	Draft (Ft)	Length (M)
		MT/HOUR				
Rosario	311.0	11,350	3,950	3,975		
Unit 1	19.0		150	200	17.5	200
Unit 2	31.0		200	225	28.3	150
Unit 3	83.0		350	300	21.6	200
Unit 4	32.0		500	500	26.7	220
Unit 5	21.0		350	350	18.3	256
Unit 6	125.0		1,200	1,200	23.3	240
Bahia Blanca	206.1	5,400	2,800	3,000		
Unit 3	141.5	4,000	—	3,000		
Unit 4	2.1	—	400	—		
Unit 5	62.5	1,400	2,400	—		
Buenos Aires	170.0	4.2 mil/year	—	—	30.0	
Quequen	93.0					
Unit 1	80.0	2,200	600	800	30.0	324
Unit 2	13.0	850	340	—		
San Nicolas	67.5	1,200	350	700	33.0	141
Santa Fe	64.0					
Unit 1	50.0	700	NA (490)*	NA	20.0	263
Unit 2	14.0	300	NA (170)*	NA		
Villa Constitucion	55.0	1,000	800	1,000	33.0	165
Mar Del Plata	25.0	700	NA (480)*	NA	27.0	250
Conception del Uruguay	23.2	1,000	500	500	21.0	99
Diamarte	20.0	1,000	350	150	19.0	177
Barranqueros	19.6	1,000	NA (300)*	NA	11.0	
San Lorenzo (Unit 8 & 9)	15.2	880	NA (680)*	NA	26.0	
San Pedro	7.5	1,000	450	NA	35.0	190

*Combined Truck and Rail Receiving Rates

APPENDIX C

OCEAN FREIGHT RATES FOR BULK GRAIN

KEY

Vessel Hauling Capacity by Size

S = 0 - 09 thousand metric tons
T = 10 - 19 thousand metric tons
U = 20 - 29 thousand metric tons
V = 30 - 39 thousand metric tons
W = 40 - 49 thousand metric tons
X = 50 - 59 thousand metric tons
Y = 60 - 69 thousand metric tons
Z = 70 plus thousand metric tons

Note: The rates are reported in indexed form.

OCEAN FREIGHT RATES

UNITED STATES GULF COAST

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
NORTH AFRICA	S	14.79	13.14	16.45
NORTH AFRICA	T	11.43	10.12	12.75
NORTH AFRICA	U	8.08	6.63	9.52
WEST AFRICA	S	17.60	15.91	19.30
WEST AFRICA	T	14.25	13.17	15.32
WEST AFRICA	U	10.89	10.00	11.78
EAST AFRICA	S	17.60	15.91	19.30
EAST AFRICA	T	14.25	13.17	15.32
EAST AFRICA	U	10.89	10.00	11.30
EAST AFRICA	V	7.53	6.19	8.87
EAST AFRICA	W	4.18	2.14	6.22
EAST AFRICA	X	4.06	0.00	0.00
EAST AFRICA	Y	3.94	0.00	0.00
MIDDLE EAST ASIA	S	12.06	10.31	13.81
MIDDLE EAST ASIA	T	10.95	9.77	12.13
MIDDLE EAST ASIA	U	9.84	8.96	10.72
MIDDLE EAST ASIA	V	8.74	7.64	9.82
MIDDLE EAST ASIA	W	7.63	6.00	9.25
MIDDLE EAST ASIA	X	6.52	4.25	8.78
MIDDLE EAST ASIA	Y	5.41	2.46	8.36
MIDDLE EAST ASIA	Z	3.75	-0.24	7.74
FAR EAST ASIA	S	11.67	11.37	11.95
FAR EAST ASIA	T	11.21	10.97	11.45
FAR EAST ASIA	U	10.76	10.56	10.97
FAR EAST ASIA	V	10.32	10.11	10.52
FAR EAST ASIA	W	9.87	9.63	10.10
FAR EAST ASIA	X	9.42	9.14	9.70
FAR EAST ASIA	Y	8.97	8.62	9.31
FAR EAST ASIA	Z	8.30	7.85	8.74
MEXICO, CENTRAL AMERICA, AND CARIBBEAN SEA	S	9.15	8.75	9.55
MEXICO, CENTRAL AMERICA, AND CARIBBEAN SEA	T	8.62	8.31	8.92
MEXICO, CENTRAL AMERICA, AND CARIBBEAN SEA	U	8.08	7.68	8.46
SOUTH AMERICA ATLANTIC COAST SIDE	S	7.14	6.74	7.53
SOUTH AMERICA ATLANTIC COAST SIDE	T	6.60	6.32	6.88
SOUTH AMERICA ATLANTIC COAST SIDE	U	6.07	5.71	6.42
SOUTH AMERICA ATLANTIC COAST SIDE	V	5.53	4.97	6.08
SOUTH AMERICA PACIFIC COAST SIDE	S	9.15	8.75	9.55
SOUTH AMERICA PACIFIC COAST SIDE	T	8.62	8.31	8.92
SOUTH AMERICA PACIFIC COAST SIDE	U	8.08	7.68	8.46
SOUTH AMERICA PACIFIC COAST SIDE	V	7.54	6.95	8.12
EASTERN EUROPE BALTIC SEA	T	8.97	5.41	12.52
EASTERN EUROPE BALTIC SEA	U	7.83	5.28	10.36
EASTERN EUROPE BALTIC SEA	V	6.68	5.06	8.30
EASTERN EUROPE BALTIC SEA	W	5.54	4.45	6.61
EASTERN EUROPE BLACK SEA	T	10.38	8.34	12.41
EASTERN EUROPE BLACK SEA	U	9.23	8.11	10.34

OCEAN FREIGHT RATES

UNITED STATES GULF COAST

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
EASTERN EUROPE BLACK SEA	V	8.09	7.25	8.92
SPANISH MEDITERRANEAN	S	7.04	6.20	7.86
SPANISH MEDITERRANEAN	T	6.54	5.89	7.18
SPANISH MEDITERRANEAN	U	6.05	5.56	6.53
SPANISH MEDITERRANEAN	V	5.56	5.19	5.92
SPANISH MEDITERRANEAN	W	5.07	4.71	5.42
SPANISH MEDITERRANEAN	X	4.57	4.12	5.02
SPANISH MEDITERRANEAN	Y	4.08	3.47	4.68
SPANISH ATLANTIC	S	5.77	5.42	6.11
SPANISH ATLANTIC	T	5.58	5.24	5.90
SPANISH ATLANTIC	U	5.38	5.06	5.70
SPANISH ATLANTIC	V	5.19	4.67	5.31
SPANISH ATLANTIC	W	4.99	4.67	5.31
SPANISH ATLANTIC	X	4.80	4.25	4.95
ADREATIC SEA	S	7.82	7.06	8.56
ADREATIC SEA	T	7.33	6.69	7.95
ADREATIC SEA	U	6.83	6.27	7.39
ADREATIC SEA	V	6.34	5.77	6.90
ADREATIC SEA	W	5.85	5.28	6.48
ADREATIC SEA	X	5.35	4.58	6.12
ADREATIC SEA	Y	4.86	3.93	5.78
AEGEAN SEA	S	8.95	8.37	9.51
AEGEAN SEA	T	8.46	8.01	8.90
AEGEAN SEA	U	7.96	7.56	8.36
AEGEAN SEA	V	7.47	7.01	7.92
ANTWERP HAMBURG RANGE	T	5.17	4.91	5.42
ANTWERP HAMBURG RANGE	U	4.98	4.76	5.18
ANTWERP HAMBURG RANGE	V	4.78	4.61	4.94
ANTWERP HAMBURG RANGE	W	4.59	4.46	4.71
ANTWERP HAMBURG RANGE	X	4.39	4.30	4.48
ANTWERP HAMBURG RANGE	Y	4.20	4.12	4.27
ANTWERP HAMBURG RANGE	Z	3.91	3.80	4.01
UNITED KINGDOM	S	5.79	5.41	6.15
UNITED KINGDOM	T	5.59	5.25	5.93
UNITED KINGDOM	U	5.40	5.08	5.71
UNITED KINGDOM	V	5.21	4.90	5.50
UNITED KINGDOM	W	5.01	4.71	5.30
UNITED KINGDOM	X	4.82	4.52	5.11
UNITED KINGDOM	Y	4.62	4.32	4.92
SCANDANAVIA	S	6.28	5.71	6.84
SCANDANAVIA	T	6.08	5.52	6.63
SCANDANAVIA	U	5.89	5.33	6.43
SCANDANAVIA	V	5.69	5.14	6.24
SCANDANAVIA	W	5.50	4.94	6.05
SCANDANAVIA	X	5.31	4.74	5.86
FRANCE	S	5.36	5.06	5.66
FRANCE	T	5.17	4.91	5.42

OCEAN FREIGHT RATES

UNITED STATES GULF COAST

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
FRANCE	U	4.98	4.76	5.18
FRANCE	V	4.78	4.61	4.94
FRANCE	W	4.59	4.46	4.71
FRANCE	X	4.39	4.30	4.48
PORTUGAL	S	5.77	5.42	6.11
PORTUGAL	T	5.58	5.26	5.91
PORTUGAL	U	5.38	5.06	5.70
PORTUGAL	V	5.19	4.87	5.50
PORTUGAL	W	4.99	4.67	5.31
PORTUGAL	X	4.80	4.46	5.13
JAPAN	T	9.00	8.76	9.22
JAPAN	U	8.55	8.38	8.71
JAPAN	V	8.10	7.97	8.21
JAPAN	X	7.20	7.03	7.36
CHINA	T	11.74	11.50	11.98
CHINA	U	11.29	11.08	11.50
CHINA	V	10.39	10.16	10.62
CHINA	X	4.39	2.96	5.82
USSR BALTIC SEA	T	8.97	5.41	12.52
USSR BALTIC SEA	U	7.83	5.28	10.36
USSR BALTIC SEA	V	6.68	5.05	8.30
USSR BALTIC SEA	W	5.54	4.45	6.61
USSR BALTIC SEA	X	4.39	2.96	5.82
USSR BLACK SEA	T	10.38	8.34	12.41
USSR BLACK SEA	U	9.23	8.11	10.34
USSR BLACK SEA	V	8.09	7.25	8.92
EGYPT	S	13.27	11.67	14.86
EGYPT	T	12.16	11.17	13.15
EGYPT	U	11.06	10.38	11.72
EGYPT	V	9.95	8.95	10.93
EGYPT	W	8.84	7.24	10.43
EGYPT	X	7.73	5.46	9.99

OCEAN FREIGHT RATES

UNITED STATES AND CANADIAN PACIFIC COAST

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
NORTH AFRICA	S	14.73	13.60	15.86
NORTH AFRICA	T	13.85	13.12	14.57
NORTH AFRICA	U	12.97	12.52	13.41
WEST AFRICA	S	12.67	10.80	14.53
WEST AFRICA	T	11.79	10.10	13.47
WEST AFRICA	U	10.91	9.28	12.52
EAST AFRICA	S	14.73	13.60	15.86
EAST AFRICA	T	13.85	13.12	14.57
EAST AFRICA	U	12.97	12.52	13.41
EAST AFRICA	V	12.09	11.55	12.62
EAST AFRICA	W	11.21	10.31	12.09
EAST AFRICA	X	10.32	9.01	11.63
EAST AFRICA	Y	9.45	7.69	11.19
MIDDLE EAST ASIA	S	15.69	14.03	17.34
MIDDLE EAST ASIA	T	15.23	13.77	16.67
MIDDLE EAST ASIA	U	14.76	13.38	16.13
MIDDLE EAST ASIA	V	14.30	13.84	15.75
MIDDLE EAST ASIA	W	13.84	12.18	15.49
MIDDLE EAST ASIA	X	13.37	11.42	15.32
MIDDLE EAST ASIA	Y	12.91	10.61	15.20
MIDDLE EAST ASIA	Z	12.21	9.33	15.08
FAR EAST ASIA	S	9.81	8.58	10.03
FAR EAST ASIA	T	9.35	8.51	10.18
FAR EAST ASIA	U	8.89	8.32	9.44
FAR EAST ASIA	V	8.42	7.83	9.01
FAR EAST ASIA	W	7.96	7.06	8.89
FAR EAST ASIA	X	7.50	6.19	8.79
FAR EAST ASIA	Y	7.03	5.30	8.76
FAR EAST ASIA	Z	6.34	3.94	8.73
EGYPT	S	14.73	13.60	15.86
EGYPT	T	13.85	13.12	14.57
EGYPT	U	12.97	12.52	13.41
EGYPT	V	12.09	11.55	12.62
EGYPT	W	11.21	10.31	12.09
EGYPT	X	10.32	9.01	11.63

OCEAN FREIGHT RATES

UNITED STATES PACIFIC COAST

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
MEXICO, CENTRAL AMERICA, AND CARIBBEAN SEA	T	5.44	0.00	0.00
MEXICO, CENTRAL AMERICA, AND CARIBBEAN SEA	U	5.49	0.00	0.00
SOUTH AMERICA PACIFIC COAST SIDE	S	6.14	0.00	0.00
SOUTH AMERICA PACIFIC COAST SIDE	T	8.74	0.00	0.00
SOUTH AMERICA PACIFIC COAST SIDE	V	6.71	0.00	0.00
EASTERN EUROPE BALTIC SEA	U	9.57	0.00	0.00
EASTERN EUROPE BLACK SEA	V	11.15	0.00	0.00
SPANISH MEDITERRANEAN	T	7.75	0.00	0.00
SPANISH ATLANTIC	T	10.54	0.00	0.00
SPANISH ATLANTIC	V	10.14	0.00	0.00
ADREATIC SEA	U	8.32	0.00	0.00
PORTUGAL	T	10.54	0.00	0.00
PORTUGAL	V	10.14	0.00	0.00
JAPAN	T	6.55	6.03	7.06
JAPAN	U	5.96	5.58	6.33
JAPAN	V	5.37	5.10	5.64
JAPAN	W	4.79	4.55	5.01
JAPAN	X	4.20	3.90	4.50
CHINA	U	7.94	0.00	0.00
CHINA	V	7.67	0.00	0.00

OCEAN FREIGHT RATES

CANADIAN PACIFIC COAST

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
MEXICO, CENTRAL AMERICA, AND CARIBBEAN SEA	U	7.26	0.00	0.00
SPANISH MEDITERRANEAN	U	6.24	0.00	0.00
ADREATIC SEA	X	6.95	0.00	0.00
UNITED KINGDOM	U	9.68	0.00	0.00
JAPAN	T	8.40	7.98	8.81
JAPAN	U	7.82	7.40	8.23
JAPAN	V	7.23	6.75	7.70
JAPAN	W	6.64	6.07	7.21
JAPAN	X	6.06	5.36	6.75

OCEAN FREIGHT RATES

UNITED STATES AND CANADIAN ATLANTIC COAST

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
NORTH AFRICA	S	14.31	12.14	16.46
NORTH AFRICA	T	10.42	9.45	11.39
NORTH AFRICA	U	6.54	5.59	7.48
WEST AFRICA	S	14.31	12.14	16.46
WEST AFRICA	T	10.42	9.45	11.39
WEST AFRICA	U	6.54	5.59	7.48
EAST AFRICA	S	14.31	12.14	16.46
EAST AFRICA	T	10.42	9.45	11.39
EAST AFRICA	U	6.54	5.59	7.48
EAST AFRICA	V	2.66	0.53	4.78
MIDDLE EAST ASIA	S	3.06	-0.87	7.00
MIDDLE EAST ASIA	T	6.42	4.31	8.51
MIDDLE EAST ASIA	U	9.77	9.00	10.53
MIDDLE EAST ASIA	V	13.12	11.10	15.13
MIDDLE EAST ASIA	W	16.47	12.61	20.32
MIDDLE EAST ASIA	X	19.82	14.07	25.56
MIDDLE EAST ASIA	Y	23.17	15.52	30.81
MIDDLE EAST ASIA	Z	28.20	17.69	38.70
FAR EAST ASIA	S	14.78	11.88	17.66
FAR EAST ASIA	T	14.11	12.02	16.19
FAR EAST ASIA	U	13.45	11.98	14.91
FAR EAST ASIA	V	12.78	11.46	14.10
FAR EAST ASIA	W	12.12	10.35	13.89
FAR EAST ASIA	X	11.46	8.94	13.96
FAR EAST ASIA	Y	10.79	7.43	14.15
FAR EAST ASIA	Z	9.80	5.09	14.50
EASTERN EUROPE BALTIC SEA	T	5.01	4.03	5.98
EASTERN EUROPE BALTIC SEA	U	4.87	4.22	5.51
EASTERN EUROPE BALTIC SEA	V	4.72	4.23	5.21
EASTERN EUROPE BALTIC SEA	W	4.58	3.93	5.22
EASTERN EUROPE BALTIC SEA	X	4.43	3.45	5.41
EASTERN EUROPE BLACK SEA	T	7.33	6.49	8.16
EASTERN EUROPE BLACK SEA	U	7.18	6.71	7.65
EASTERN EUROPE BLACK SEA	V	7.04	6.71	7.36
SPANISH MEDITERRANEAN	S	6.47	5.68	7.25
SPANISH MEDITERRANEAN	T	6.15	5.60	6.68
SPANISH MEDITERRANEAN	U	5.82	5.45	6.19
SPANISH MEDITERRANEAN	V	5.50	5.12	5.87
SPANISH MEDITERRANEAN	W	5.17	4.61	5.72
SPANISH MEDITERRANEAN	X	4.85	4.05	5.64
SPANISH MEDITERRANEAN	Y	4.53	3.46	5.89
SPANISH ATLANTIC	S	6.88	6.26	7.48
SPANISH ATLANTIC	T	6.37	5.83	6.89
SPANISH ATLANTIC	U	5.86	5.35	6.35
SPANISH ATLANTIC	V	5.35	4.82	5.86
SPANISH ATLANTIC	W	4.83	4.24	5.42

OCEAN FREIGHT RATES

UNITED STATES AND CANADIAN ATLANTIC COAST

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
SPANISH ATLANTIC	X	4.32	3.62	5.02
ADREATIC SEA	S	6.47	5.68	7.25
ADREATIC SEA	T	6.15	5.60	6.68
ADREATIC SEA	U	5.82	5.45	6.19
ADREATIC SEA	V	5.50	5.12	5.87
ADREATIC SEA	W	5.17	4.61	5.72
ADREATIC SEA	X	4.85	4.05	5.64
ADREATIC SEA	Y	4.53	3.46	5.89
AEGEAN SEA	S	8.52	7.65	9.38
AEGEAN SEA	T	8.20	7.43	8.96
AEGEAN SEA	U	7.87	7.10	8.63
AEGEAN SEA	V	7.55	6.68	8.41
ANTWERP HAMBURG RANGE	T	5.37	4.83	5.90
ANTWERP HAMBURG RANGE	U	4.86	4.45	5.26
ANTWERP HAMBURG RANGE	V	4.35	4.04	4.65
ANTWERP HAMBURG RANGE	W	3.84	3.54	4.12
ANTWERP HAMBURG RANGE	X	3.33	2.96	3.68
ANTWERP HAMBURG RANGE	Y	2.82	2.33	3.29
UNITED KINGDOM	S	6.29	5.75	6.82
UNITED KINGDOM	T	5.78	5.25	6.30
UNITED KINGDOM	U	5.27	4.95	5.58
UNITED KINGDOM	V	4.76	4.45	5.06
UNITED KINGDOM	W	4.25	3.87	4.62
UNITED KINGDOM	X	3.73	2.58	3.86
UNITED KINGDOM	Y	3.23	2.58	3.86
SCANDANAVIA	S	5.88	5.19	6.56
SCANDANAVIA	T	5.37	4.83	5.90
SCANDANAVIA	U	4.86	4.45	5.26
SCANDANAVIA	V	4.35	4.04	4.65
SCANDANAVIA	W	3.84	3.54	4.12
SCANDANAVIA	X	3.33	2.96	3.68
BALTIC REGION	S	7.13	6.55	7.70
BALTIC REGION	T	6.62	6.07	7.17
FRANCE	S	5.88	5.19	6.56
FRANCE	T	5.37	4.83	5.90
FRANCE	U	4.86	4.45	5.26
FRANCE	V	4.35	4.04	4.65
FRANCE	W	3.84	3.54	4.12
FRANCE	X	3.33	2.96	3.68
PORTUGAL	S	6.88	6.26	7.48
PORTUGAL	T	6.37	5.83	6.89
PORTUGAL	U	5.86	5.35	6.35
PORTUGAL	V	5.35	4.82	5.86
PORTUGAL	W	4.83	4.24	5.42
PORTUGAL	X	4.32	3.62	5.02
JAPAN	T	9.35	7.74	10.96
JAPAN	U	8.69	7.44	9.93

OCEAN FREIGHT RATES

UNITED STATES AND CANADIAN ATLANTIC COAST

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
JAPAN	V	8.02	6.50	9.53
JAPAN	W	7.36	5.16	9.55
JAPAN	X	6.70	3.66	9.72
CHINA	T	12.13	9.86	14.38
CHINA	U	11.46	9.64	13.28
CHINA	V	10.80	8.98	12.61
CHINA	W	10.14	7.87	12.39
USSR BALTIC SEA	T	5.01	4.03	5.98
USSR BALTIC SEA	U	4.87	4.22	5.51
USSR BALTIC SEA	V	4.72	4.23	5.21
USSR BALTIC SEA	W	4.58	3.93	5.22
USSR BALTIC SEA	X	4.43	3.45	5.41
USSR BLACK SEA	T	7.33	6.49	8.16
USSR BLACK SEA	U	7.18	6.71	7.65
USSR BLACK SEA	V	7.04	6.71	7.36
EGYPT	S	3.06	-0.87	7.00
EGYPT	T	6.42	4.31	8.51
EGYPT	U	9.77	9.00	10.53
EGYPT	V	13.12	11.10	15.13
EGYPT	W	16.47	12.61	20.32
EGYPT	X	19.82	14.07	25.56

OCEAN FREIGHT RATES

UNITED STATES ATLANTIC COAST

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
MEXICO, CENTRAL AMERICA, AND CARIBBEAN SEA	U	9.42	0.00	0.00

OCEAN FREIGHT RATES

UNITED STATES AND CANADIAN GREAT LAKES SHIPMENT ONLY

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
NORTH AFRICA	T	15.57	0.00	0.00
WEST AFRICA	T	18.32	0.00	0.00
MIDDLE EAST ASIA	T	15.00	0.00	0.00
SOUTH AMERICA ATLANTIC COAST SIDE	T	12.41	0.00	0.00
EASTERN EUROPE BALTIC SEA	T	9.73	0.00	0.00
SPANISH ATLANTIC	T	11.38	0.00	0.00
AEGEAN SEA	T	13.23	0.00	0.00
ANTWERP HAMBURG RANGE	T	9.51	0.00	0.00
UNITED KINGDOM	T	9.51	0.00	0.00
SCANDANAVIA	T	11.63	0.00	0.00
BALTIC REGION	T	9.51	0.00	0.00
FRANCE	T	11.38	0.00	0.00
PORTUGAL	T	11.38	0.00	0.00
USSR BALTIC SEA	T	9.73	0.00	0.00

OCEAN FREIGHT RATES

UNITED STATES AND CANADIAN GREAT LAKES WITH ST. LAWRENCE TOPOFF

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
NORTH AFRICA	U	13.35	0.00	0.00
EAST AFRICA	U	7.19	0.00	0.00
MIDDLE EAST ASIA	U	11.06	0.00	0.00
FAR EAST ASIA	U	14.85	0.00	0.00
SOUTH AMERICA ATLANTIC COAST SIDE	U	7.65	0.00	0.00
EASTERN EUROPE BALTIC SEA	U	8.11	0.00	0.00
SPANISH MEDITERRANEAN	U	8.12	0.00	0.00
SPANISH ATLANTIC	U	7.24	0.00	0.00
ADREATIC SEA	U	8.33	0.00	0.00
AEGEAN SEA	U	8.16	0.00	0.00
ANTWERP HAMBURG RANGE	U	7.13	0.00	0.00
UNITED KINGDOM	U	7.17	0.00	0.00
BALTIC REGION	U	8.85	0.00	0.00
FRANCE	U	7.39	0.00	0.00
PORTUGAL	U	7.24	0.00	0.00
USSR BALTIC SEA	U	8.11	0.00	0.00

OCEAN FREIGHT RATES

CANADIAN ST. LAWRENCE SEAWAY SHIPMENT ONLY

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
NORTH AFRICA	S	6.87	2.49	11.25
NORTH AFRICA	T	9.23	7.27	11.19
NORTH AFRICA	U	11.59	9.62	13.54
EAST AFRICA	V	13.76	0.00	0.00
EASTERN EUROPE BLACK SEA	V	6.72	0.00	0.00
SPANISH MEDITERRANEAN	S	7.35	5.44	9.25
SPANISH MEDITERRANEAN	T	6.70	5.30	8.09
SPANISH MEDITERRANEAN	U	6.04	5.07	7.00
SPANISH MEDITERRANEAN	V	5.39	4.62	6.16
SPANISH MEDITERRANEAN	W	4.73	3.77	5.70
SPANISH MEDITERRANEAN	X	4.08	2.68	5.48
SPANISH MEDITERRANEAN	Y	3.43	1.52	5.33
ADREATIC SEA	S	7.35	5.44	9.25
ADREATIC SEA	T	6.70	5.30	8.09
ADREATIC SEA	U	6.04	5.07	7.00
ADREATIC SEA	V	5.39	4.62	6.16
ADREATIC SEA	W	4.73	3.77	5.70
ADREATIC SEA	X	4.08	2.68	5.48
ADREATIC SEA	Y	3.43	1.52	5.33
ANTWERP HAMBURG RANGE	T	5.01	4.43	5.59
ANTWERP HAMBURG RANGE	U	4.62	4.22	5.02
ANTWERP HAMBURG RANGE	V	4.23	3.98	4.47
ANTWERP HAMBURG RANGE	W	3.84	3.64	4.03
ANTWERP HAMBURG RANGE	X	3.44	3.14	3.74
ANTWERP HAMBURG RANGE	Y	3.05	2.58	3.51
ANTWERP HAMBURG RANGE	Z	2.46	1.72	3.20
UNITED KINGDOM	S	5.41	4.64	6.16
UNITED KINGDOM	T	5.01	4.43	5.59
UNITED KINGDOM	U	4.62	4.22	5.02
UNITED KINGDOM	V	4.23	3.98	4.47
UNITED KINGDOM	W	3.84	3.64	4.03
UNITED KINGDOM	X	3.44	3.14	3.74
UNITED KINGDOM	Y	3.05	2.58	3.51
USSR BLACK SEA	V	6.72	0.00	0.00
EGYPT	S	3.33	-2.21	8.96
EGYPT	T	5.69	2.74	8.62
EGYPT	U	8.04	7.06	9.02
EGYPT	V	10.40	7.46	13.33
EGYPT	W	12.76	7.12	18.38
EGYPT	X	15.11	6.73	23.48

OCEAN FREIGHT RATES

AUSTRALIA

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
NORTH AFRICA	T	13.67	0.00	0.00
EAST AFRICA	T	14.66	0.00	0.00
MIDDLE EAST ASIA	T	13.12	11.80	14.42
MIDDLE EAST ASIA	U	12.84	11.78	13.90
MIDDLE EAST ASIA	V	12.57	11.59	13.53
MIDDLE EAST ASIA	W	12.29	11.20	13.37
MIDDLE EAST ASIA	X	12.02	10.66	13.36
MIDDLE EAST ASIA	Y	11.74	10.04	13.43
MIDDLE EAST ASIA	Z	11.33	9.04	13.62
FAR EAST ASIA	S	9.12	7.53	10.70
FAR EAST ASIA	T	8.85	7.47	10.21
FAR EAST ASIA	U	8.57	7.27	9.86
FAR EAST ASIA	V	8.30	6.92	9.66
FAR EAST ASIA	W	8.02	6.44	9.60
FAR EAST ASIA	X	7.74	5.86	9.62
FAR EAST ASIA	Y	7.47	5.24	9.70
FAR EAST ASIA	Z	7.06	4.25	9.87
SOUTH AMERICA PACIFIC COAST SIDE	T	13.56	0.00	0.00
ANTWERP HAMBURG RANGE	U	10.81	0.00	0.00
PORTUGAL	T	14.10	0.00	0.00
JAPAN	T	7.29	5.32	9.26
JAPAN	U	7.02	5.07	8.96
JAPAN	V	6.75	4.72	8.76
JAPAN	W	6.47	6.27	8.66
JAPAN	X	6.20	3.75	8.63

OCEAN FREIGHT RATES

FRANCE

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
NORTH AFRICA	S	5.23	4.48	5.97
NORTH AFRICA	T	4.59	4.22	4.95
NORTH AFRICA	U	3.94	3.43	4.45
WEST AFRICA	S	11.60	10.22	12.98
WEST AFRICA	T	10.96	9.57	12.34
WEST AFRICA	U	10.32	8.74	11.88
EAST AFRICA	S	10.66	9.24	12.08
EAST AFRICA	T	10.02	8.78	11.25
EAST AFRICA	U	9.38	8.12	10.36
EAST AFRICA	V	8.73	7.25	10.20
EAST AFRICA	W	8.09	6.26	9.91
MIDDLE EAST ASIA	T	8.16	0.00	0.00
FAR EAST ASIA	T	14.69	0.00	0.00
FAR EAST ASIA	U	13.21	0.00	0.00
MEXICO, CENTRAL AMERICA, AND CARIBBEAN SEA	S	6.79	0.00	0.00
EASTERN EUROPE BALTIC SEA	T	3.33	0.00	0.00
EASTERN EUROPE BLACK SEA	T	5.22	0.00	0.00
EASTERN EUROPE BLACK SEA	U	5.49	0.00	0.00
EASTERN EUROPE BLACK SEA	V	6.20	0.00	0.00
SPANISH MEDITERRANEAN	S	6.97	5.10	8.82
SPANISH MEDITERRANEAN	T	6.58	5.32	7.83
SPANISH MEDITERRANEAN	U	6.19	5.39	6.99
SPANISH MEDITERRANEAN	V	5.81	5.00	6.60
SPANISH MEDITERRANEAN	W	5.42	4.16	6.67
ADREATIC SEA	S	4.73	4.04	5.42
ADREATIC SEA	T	4.35	4.14	4.54
ADREATIC SEA	U	3.96	3.22	4.69
ADREATIC SEA	V	3.57	2.16	4.98
ADREATIC SEA	W	3.19	1.09	5.27
AEGEAN SEA	S	5.80	4.49	7.10
AEGEAN SEA	T	5.41	4.68	6.13
AEGEAN SEA	U	5.03	4.48	5.56
AEGEAN SEA	V	4.64	3.64	5.63
USSR BALTIC SEA	T	3.33	0.00	0.00
USSR BLACK SEA	T	5.22	0.00	0.00
USSR BLACK SEA	U	5.49	0.00	0.00
USSR BLACK SEA	V	6.20	0.00	0.00
EGYPT	T	8.68	0.00	0.00
EGYPT	U	8.07	0.00	0.00

OCEAN FREIGHT RATES

ARGENTINA

DESTINATION	VESSEL SIZE	OCEAN FREIGHT RATE	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
FAR EAST ASIA	T	15.31	0.00	0.00
MEXICO, CENTRAL AMERICA, AND CARIBBEAN SEA	T	14.44	0.00	0.00
MEXICO, CENTRAL AMERICA, AND CARIBBEAN SEA	U	15.55	0.00	0.00
SPANISH MEDITERRANEAN	S	13.07	11.53	14.59
SPANISH MEDITERRANEAN	T	12.07	10.81	13.31
SPANISH MEDITERRANEAN	U	11.06	8.95	13.16
ADREATIC SEA	S	13.07	11.53	14.59
ADREATIC SEA	T	12.07	10.81	13.31
ADREATIC SEA	U	11.06	8.95	13.16
AEGEAN SEA	S	13.07	11.53	14.59
AEGEAN SEA	T	12.07	10.81	13.31
AEGEAN SEA	U	11.06	8.95	13.66
ANTWERP HAMBURG RANGE	S	11.96	10.16	13.76
ANTWERP HAMBURG RANGE	T	10.96	9.77	12.15
ANTWERP HAMBURG RANGE	U	9.96	8.16	11.76
UNITED KINGDOM	S	11.96	10.16	13.76
UNITED KINGDOM	T	10.96	9.77	12.15
UNITED KINGDOM	U	9.96	8.16	11.76
SCANDANAVIA	S	11.96	10.16	13.76
SCANDANAVIA	T	10.96	9.77	12.15
SCANDANAVIA	U	9.96	8.16	11.76
BALTIC REGION	S	11.96	10.16	13.76
BALTIC REGION	T	10.96	9.77	12.15
BALTIC REGION	U	9.96	8.16	11.76
FRANCE	S	11.96	10.16	13.76
FRANCE	T	10.96	9.77	12.15
FRANCE	U	9.96	8.16	11.76
PORTUGAL	S	11.96	10.16	13.76
PORTUGAL	T	10.96	9.77	12.15
PORTUGAL	U	9.96	8.16	11.76
JAPAN	U	13.21	0.00	0.00
JAPAN	V	11.45	0.00	0.00
USSR BALTIC SEA	T	10.96	9.77	12.15
USSR BALTIC SEA	U	9.96	8.16	11.76
USSR BALTIC SEA	V	8.96	6.00	11.91
USSR BLACK SEA	T	12.07	10.81	13.31
USSR BLACK SEA	U	11.07	8.95	13.16
USSR BLACK SEA	V	10.07	6.75	13.37

APPENDIX D

METHOD OF ESTIMATING OCEAN BULK GRAIN FREIGHT RATES FOR VARIOUS INTER-REGIONAL SHIPPING ROUTES

The following sections contain information on the procedures used to estimate ocean freight rates for inter-regional shipping routes.

United States Gulf Coast to Africa

Africa consists of three subregions plus the Egyptian region. Several different combinations of African subregions and Egypt were subjected to the AOV procedure. In each of the following combinations: 1) North Africa and West Africa, 2) North Africa and Egypt, 3) North, West, and East Africa, and 4) Egypt and North, West, and East Africa, the null hypohtesis was rejected at the 96 percent confidence level. The combination of subregions West Africa and East Africa did not account for any significant variation in shipping rates. Failure to reject the null hypothesis at the 80 percent confidence level was the result of the combination of West and East Africa's analysis of variance. West and East Africa are combined into a single unit for estimating shipping rates. Egypt did not distract or enhance in explaining variation in shipping rates to Africa. Since Egypt's geographic location is close to the Middle East, Egypt is included in the Middle East section.

The model used to estimate grain freight rates to Africa is:

$$\text{Rate} = \alpha + \beta_1 \text{SIZE} + \beta_2 \text{Z13} \tag{D.1}$$

where,

Z13 = dummy variable for the North Africa subregion,

and the intercept term contains West and East Africa. The parameters for each variable are significant at the 99 percent confidence level.

The R-square value for the model is . 510. The predicted shipping rates to Africa are located in Appendix C.

United States Gulf Coast to Egypt and Middle East Asia

Shipping rules from the United States Gulf Coast to Middle East Asia and Egypt are statistically different. The null hypothesis for the combination of the two subregion was rejected at the 95 percent confidence level. Hence, Egypt and the Middle East Asia cannot be combined when estimating the ocean grain freight rates for the geographic region. However, Equation D.2 is used to estimate the ocean freight rates to Egypt and the Middle East Asia. Equation D.2 is:

$$\text{Rate} = \alpha + \beta_1 \text{SIZE} + \beta_2 \text{Z8} \qquad (D.2)$$

where,

Z8 = dummy variable for Egypt,

and the Middle East Asia subregion is explained by the intercept term.

The parameters for the variable are signficant at the 96 percent confidence level. The null hypothesis is rejected for the model at the 99 percent confidence level and the R-square value for this model is 23. Appendix C contains the ocean freight rate to Egypt and the Middle East.

United States Gulf Coast to Latin America

Latin America consists of three subregions. These subregions are "Mexico, Central America, and Caribbean", South America-Atlantic, and South America-Pacific. Each subregion was combined with one other subregion from Latin America and tested for a feasible combination of two subregions into one aggregated region. The null hyothesis for any two combination of subregions was rejected at the 99 percent confidence level in all cases except for the combination of "Mexico, Central America, and Caribbean" subregion, and South America-Pacific subregion. Failure to reject the null hypothesis at the 80 percent confidence level for this combination of two subregions was the result.

Equation D.3 includes one dummy variable to account for the different subregions in Latin America.

$$\text{Rate} = \alpha + \beta_1 \text{SIZE} + \beta_2 \text{Z10} \qquad (D.3)$$

where,

Z10 = dummy variable for South America-Atlantic,

and the subregions "Mexico, Central America, and Caribbean" and South America-Pacific are explained in the intercept term. The R-square value for the model is .423 and the null hypothesis for the full model is rejected at the 99 percent confidence level. The null hypothesis for the coefficients for size and Z10 are rejected at the 99 percent confidence level and Appendix C contains the estimated shipping rates by size and subregion along with their confidence intervals.

United States Gulf Coast to Eastern Europe

Baltic Sea and Black Sea are the two subregions in the Eastern Europe region. The variation in shipping rates to the Baltic Sea and Black Sea subregions are statistically different from zero, thus, the two subregions are not combined. The results of AOV provides a basis for rejecting the null hypothesis at the 99 percent confidence level for the combination of these two subregions. Equation D.4 is representative of shipping rates to Eastern Europe.

$$\text{Rate} = \alpha + \beta_1\text{SIZE} + \beta_2\text{Z12} \qquad \text{(D.4)}$$

where,

Z12 = dummy variable for Black Sea subregion,

and the Baltic Sea subregion is contained in the intercept term. For the size variable, the null hypothesis is rejected at the 96 percent confidence level. The null hypothesis is rejected at the 85 percent confidence level for the subregion variable. R-square value is .576 and the null hypothesis for the full model is rejected at the 99 percent confidence level. Shipping rates and confidence limits are in Appendix C.

United States Gulf Coast to Japan, Far East Asia and China

All possible combinations of Japan, Far East, and China were evaluated using AOV. In each case the null hypothesis was rejected at the 95 percent confidence level. Equation D.5:

$$\text{Rate} = \alpha + \beta_1\text{SIZE} + \beta_2\text{Z9} + \beta_3\text{Z15} \qquad \text{(D.5)}$$

estimates shipping rates into Japan, Far East Asia, and China. The variables are:

Z9 = dummy variable for the Far East Asia subregion,

Z15 = dummy variable for the China region,

and the intercept term contains Japan. The null hypothesis is rejected for all parameters at the 99 percent confidence level and the null hypothesis is rejected for the full model at the 99 percent confidence level. The R-square value for this model is .755 and the Durbin-Watson Statistic (1.65) indicates no first-order correlation. Shipping rates and confidence limits are in Appendix C.

U.S. and Canadian Pacific to Rest of Africa and Egypt

The only observations to the Rest of Africa region from the U.S. and Canadian Pacific are to North African and East African subregions. Shipping rates are initially grouped according to their origin; that is, United States Pacific or Canadian Pacific. Using the AOV procedure as the basis, ocean freight rates from the United States Pacific and Canadian Pacific to North Africa, United States Pacific and Canada Pacific to East Africa, and United States Pacific to Egypt were combined after the failure to reject the null hypothesis at the 80 percent confidence level. U.S. Pacific and Canadian Pacific are considered one region when estimating rates to Rest of Africa and Egypt. Equation D.6 was used initially to estimate shipping rates.

$$\text{Rate} = \alpha + \beta_1\text{SIZE} + \beta_2\text{Z1} + \beta_3\text{Z2} \qquad \text{(D.6)}$$

The variables are:

Z1 = dummy variable for the North Africa subregion,

Z2 = dummy variable for the East Africa subregion,

and Egypt is represented by the intercept term. The parameter for Z2 was insignificant at the 80 percent confidence level. Shipping rates to Egypt and East Africa are not statistically different. Equation D.6 is re-estimated after the Z2 variable is omitted from the equation.

Parameters for the intercept term, size, and Z1 variables are significant at the 99 percent confidence level. The full model is significant at the 99 percent confidence level and the R-square value of this model is .245. Appendix C contains these predicted rates and confidence limits for these predicted rates.

U.S. Canadian Pacific to the Far East and Middle East Asia

Shipments from Canadian Pacific and U.S. Pacific to either the Far East Asia or Middle East Asia were not statistically different. Failure to reject the null hypothesis at the 80 percent confidence level allowed the combination of Canadian Pacific and United States Pacific regions. However, the Far East Asia and Middle East Asia subregions are statistically different from each other or the null hypothesis was not rejected for subregion at the 80 percent confidence level. Z3 is the dummy variable representing the Middle East Asia in Equation D.7.

$$\text{Rate} = \alpha + \beta_1 \text{SIZE} + \beta_2 \text{Z3} \tag{D.7}$$

The intercept term contains the Far East Asia subregion.

The parameter for the size variable is significant at the 96 percent confidence level and the Z3 variable is significant at the 99 percent confidence level. There are 63 observations from the U.S. and Canadian Pacific to both the Far East Asia and Middle East Asia subregions. The full model is significant at the 99 pecent confidence level and the R-square value for this model is .545. Appendix C contains the shipping rates and confidence limits from the United States and Canadian Pacific to the Far East Asia and Middle East Asia subregions of Asia.

U.S. and Canadian Pacific to Japan

Shipping rates from the U.S. Pacific to Japan and shipping rates from the Canadian Pacific to Japan are statistically different. The null hypothesis is rejected at the 99 pecent confidence level. Equation D.8 is used to estimate rates from the U.S. and Canadian Pacific to Japan.

$$\text{Rate} = \alpha + \beta_1\text{SIZE} + \beta_2\text{Z4} \qquad \text{(D.8)}$$

The Z4 variable is a dummy variable representing grain shipments from Canadian Pacific to Japan. U.S. Pacific grain shipments are represented in the intercept term.

The R-square value for the model is .71 and the full model is significant at the 99 percent confidence level. Also, each parameter is significant at the 99 percent confidence level. The predicted rates and confidence limits are found in Appendix C.

U.S. and Canadian Pacific to Latin America

U.S. and Canadian Pacific grain shipments to Latin American subregions, "Mexico, Central America, and Caribbean," and South America-Pacific, are combined into one origin region. There are no observations for grain shipments to the Latin American subregion, South America-Atlantic. "Mexico, Central America, and Caribean" and

South America-Pacific cannot be combined since the variation in shipping rates due to the subregions is statistically significant. The null hypothesis is rejected for subregion at the 80 percent confidence level. Equation D.9 is used to estimate shipping rates.

$$\text{Rate} = \alpha + \beta_1 \text{SIZE} + \beta_2 \text{Z5} \qquad \text{(D.9)}$$

where,

Z5 = dummy variable for the "Mexico, Central America, and Caribbean" subregion. The South America-Pacific subregion is contained in the intercept term.

The total number of recorded observations into Latin America from the U.S. and Canadian Pacific is 35. The majority of shipping rates are associated with the vessel size category, 20-29 thousand metric tons. Lack of variation in the ship size variable results in an insignificant parameter for ship size at the 80 percent confidence level. The null hypothesis for the full model is rejected at the 99 percent confidence level and the R-square value for this model is .596. When considering the predicted rates from equation D.9, the grain shipment flows from the U.S. and Canadian Pacific to Latin America are examined with caution.

U.S. and Canadian Atlantic to Western Europe-Atlantic

Variation in shipping rates to the Wesern Europe-Atlantic subregions which originate from either United States or Canadian Atlantic ports is not statistically significant. U.S. and Canadian ports in the Atlantic region are treated as one origin to the Western

Europe-Atlantic region. The level of subregion aggregation is examined next.

From the AOV procedure on the Antwerp-Hamburg Range, France, and Scandanavian subregions, failure to reject the null hypothesis at the 85 percent confidence level indicates these three subregions can be combined into one subregion for estimating shipping rates. The model used is:

$$Rate = \alpha + \beta_1 SIZE + \beta_2 Z1 + \beta_3 Z2 + \beta_4 Z3 \quad (D.10)$$

where,

Z1 = dummy variable for the United Kingdom subregion,

Z2 = dummy variable for the Baltic subregion,

Z3 = dummy variable for the Spain to Portugal subregion,

and the combined subregion of Antwerp-Hamburg Range, France, and Scandanavia is represented in the intercept term.

The null hypothesis is rejected at the 99 percent confidence level for the full model and the R-square value for this model is .616. The parameter of the dummy variable for Baltic and Spain to Portugal subregions and the parameter of the size variable are both significant at the 99 percent confidence level. The parameter for the United Kingdom dummy variable is significant at the 90 percent confidence level. The predicted ocean grain freight rates are in Appendix C.

U.S. and Canadian Atlantic to Western Europe-Mediterranean

Variation in shipping rates due to the origins (U.S. Atlantic and Canadian Atlantic) is not statistically significant; thus, the two origins are combined and shipping rates are estimated accordingly. The AOV procedure was applied to "Spain to Italy" and Adreatic subregions, and the variation in shipping rates due to the two subregions was not statistically significant at the 80 percent confidence level. Hence, the two subregions are combined into one subregion. Equation D.11 is the best equation explored for estimating shipping rates into Western Europe-Mediterranean.

$$\text{Rate} = \alpha + \beta_i \text{SIZE} + \beta_2 \text{Z4} \qquad \text{(D.11)}$$

where

Z4 = dummy variable for the Aegean subregion,

and the intercept term explains shipping rates to "Spain to Italy" and Adreatic subregions.

The parameters for these variables are significant at the 96 percent confidence level. The full model is statistically significant at the 99 percent confidence level and the R-square value for this model is .674. Appendix C contains the shipping rates from the U.S. and Canadian Atlantic to Western Europe-Mediterranean.

U.S. and Canadian Atlantic to Rest of Africa

There are 37 observations of grain shipments from the United States Atlantic and Canada Atlantic regions to Rest of Africa. Grain shipments are made into two of three subregions in the Rest of Africa region, North Africa and East Africa. The AOV procedure was performed to determine if the variation in shipping rates was due to the origin of grain shipment, destination of grain shipments or both. The null hypothesis was rejected for both the origin variable and subregion variable at the 86 percent confidence level. U.S. Atlantic and Canadian Atlantic ports are combined into one origin and North Africa and East Africa subregion destinations are combined together for one destination region. The equation used to estimate shipping rates is:

$$\text{Rate} = \alpha + \beta_1 \text{SIZE} \tag{D.12}$$

The parameters for all variables are significant at the 99 percent confidence level and the full model is significant at the 99 percent confidence level. The R-square value for this model is .492 and the Durbin-Watson statistic is 2.33. Although there are two subregions which observed grain shipments, the predicted rates are assumed to be representative of all three subregions. The predicted shipping rates and confidence limits are in Appendix C.

U.S. and Canadian Atlantic to Egypt and the Middle East

U.S. and Canadian ports are combined into one region representing the Atlantic coast. Variation in shipping rates to Middle East Asia and Egypt subregions is not significant at the 80 percent confidence level. Ocean grain freight rates are estimated by an equation identical to equation D.12.

Parameters for these variables and the full model are significant at the 99 percent confidence level. R-square value for this model is .229. The slope of the equation is positive as opposed to the slope of all previous equations. The positive sign is because the majority of the observations are in one vessel size category. The observations in the next largest vessel size category are fewer but are at a higher level, thus, a positive slope. Rates are found in Appendix C.

U.S. and Canadian Atlantic to Japan, China, and the Far East

To estimate ocean grain freight rates to Japan, China, and the Far East, U.S. and Canadian Atlantic ports are combined. The equation used to estimate grain freight rates is:

$$\text{Rate} = \alpha + \beta_1 \text{SIZE} + \beta_2 Z9 + \beta_3 Z15 \qquad (D.13)$$

where,

Z9 = dummy variable for the Far East Asia subregion,

Z15 = dummy variable for the China region,

and the intercept term contains Japan.

Variables Z9 and Z15 are significant at the 99 percent confidence level. The size variable is significant at the 80 percent confidence level. The R-square value for this model is .519 and the full model is significant at the 99 pecent confidence level.

U.S. and Canadian Atlantic to Eastern Europe

Variation in shipping rates due to grain shipments to Eastern Europe from the two Atlantic regions is not signficant at the 80 percent confidence level. However, variation in shipping rates due to the subregions, Baltic Sea and Black Sea, are significant at the 80 percent confidence level. Equation E.14 is used to accomodate the variation in shipping rates due to each subregions.

$$\text{Rate} = \alpha + \beta_1 \text{SIZE} + \beta_2 \text{Z12} \quad \text{(D.14)}$$

where,

Z12 = dummy variable for the Black Sea subregion,

and the Baltic Sea subregion is contained in the intercept term. The Z12 variable is significant at the 99 percent confidence level. The size variable is not significant at the 80 percent confidence level, but the variable is left in the model to estimate shipping rates by size. The predicted rates are in Appendix C. The full model is significant at the 99 percent confidence level and the R-square value for this model is .637.

U.S. and Canadian Great Lakes

Ocean freight rates are reported as originating from the Great Lakes region and not by country. Grain shipments from the Great Lakes region are classified as two types. First, initial loading occurs at a port located on one of the interior lakes and topped-off at a port on the St. Lawrence Seaway. Next, grain shipments from the Great Lakes region will originate from either an interior lake or the St. Lawrence Seaway. There are no topping-off procedures involved in this grain hauling activity. Each type of shipping activity is discussed as a separate activity in two different sections.

Great Lakes and St. Lawrence Seaway Topping-off Activities. The Great Lakes topping-off activities involve one ship size loaded to a certain capacity at each leg of the topping off activity. The vessel size used in all topping off activities is from 20-29 thousand MT. The vessel is loaded with 15 thousand MT of wheat at interior lake ports and is topped-off to 25 thousand MT at the St. Lawrence Seaway before completing the grain shipment. Rates for the first 15 thousand MT are higher than rates for the last 10 thousand MT.

There are observed rates from the Great Lakes to Antwerp-Hamburg Range, United Kingdom, Baltic, France, "Spain to Portugal", "Spain to Italy", Adreatic, Aegean, North Africa, East Africa, and Far East subregions. Since there is one ship size involved in the topping-off activity, a weighted average of the shipping rates to each subregion is used to represent the rates in the linear programming model. The shipping rates are found in Appendix C.

Great Lakes and St. Lawrence Seaway Shipment Only. Shipping rates representing wheat shipments from the Great Lakes are the means of all reported rates from the Great Lakes to any subregion. Ocean freight rates are reported to the following subregions: 1) Antwerp-Hamburg Range, 2) United Kingdom, 3) Baltic Region, 4) Scandanavia, 5) France, and 6) "Spain to Portugal". The mean of the shipping rates to Rest of Africa is used to represent all of Africa. The ship size, 10-19 thousand metric ton, is used as the sole vessel size for Great Lakes shipment with no topping-off procedure.

Shipments from the St. Lawrence Seaway do utilize different vessel sizes. The general equation is used to estimate shipping rates from the St. Lawrence Seaway to all world regions. There are observations to Western Europe-Atlantic, Western Europe-Mediterranean, Rest of Africa (North Africa only), and

Egyptian subregions. Shipping rates in Western Europe-Atlantic and Western Europe-Mediterranean are estimated without dummy variables for subregions. Lack of observations in each region necessitate the aggregation of subregions. Parameters for the size variable in each equation is significant at the 95 percent confidence level. The R-square value for the Western Europe-Atlantic model is .472 and for the Western Europe-Mediterranean model is .557. The full model for both equations is significant at the 96 percent confidence level.

Equation D.15 is used to estimate rates for Egypt and North Africa.

$$\text{Rate} = \alpha + \beta_1\text{SIZE} + \beta_2\text{Z7} \qquad \text{(D.15)}$$

where,

Z7 = dummy variable for the North Africa subregion,

and Egypt is contained in the intercept term. The size variable is significant at the 90 percent confidence level and Z7 is significant at the 99 percent confidence level. The R-square value for this model is .602. Shipping rates for all observed grain movements out of the St. Lawrence Seaway and Great Lakes area are located in Appendix C.

Australia to Rest of Asia and Japan

Shipping rates from Australia to the Far East, Middle East, and Japan are estimated with an equation containing dummy variables for Japan (Z1) and the Middle East (Z2).

$$\text{Rate} = \alpha + \beta_1\text{SIZE} + \beta_2\text{Z2} \qquad \text{(D.16)}$$

Z2 is significant at the 99 percent confidence level and Z1 is significant at the 80 percent confidence level. The size variable is significant at the 78 percent confidence level. The R-square value for this model is .635. The full model is significant at the 99 percent confidence level.

Australia to Selected Subregions

Antwerp-Hamburg Range, "Spain to Portugal," North Africa, and East Africa have one grain shipment observation from Australia. The actual rate and vessel size observed is used in the linear programming model. Egypt and South America-Pacific have two grain shipment observations each. The rates are averaged and the mean will represent the grain freight rate over each route from Australia in the linear programming model.

Argentina to Western Europe

Rates to Western Europe-Atlantic and Western Europe-Mediterranean are estimated from a single equation with shipments to the Mediterranean given recognition with a dummy variable (Z1). There are not enough observations (14) for subregion identification. The model is:

$$\text{Rate} = \alpha + \beta_1 \text{SIZE} + \beta_2 \text{Z1} \qquad (D.17)$$

The parameters for the variables are significant at the 80 percent confidence level and the full model is significant at the 90 percent confidence level. The R-square value for this model is .351.

Argentina to Japan, Far East, and "Mexico, Central America, and Caribbean"

There are single observations in two vessel size categories to Japan. Far East, and "Mexico, Central America, and Caribbean" contain enough observations for averaging by vessel size. Rates per vessel size for Japan, Far East, and "Mexico, Central America, and Caribbean" are found in Appendix C.

France to Western Europe-Mediterranean

There are 32 recorded observations of grain shipments from France to Western Europe-Mediterranean. "Spain to Italy," and Aegean are represented by the dummy variables Z1 and Z2 in Equation E.18.

$$\text{Rate} = \alpha + \beta_1 \text{SIZE} + \beta_2 \text{Z1} + \beta_3 \text{Z2} \qquad \text{(D.18)}$$

The Adreatic subregion is represented by the intercept term. Parameters for Z1 and Z2 are significant at the 99 percent confidence level. The size variable is significant at the 75 percent confidence level. The full model is significant at the 99 percent confidence level and the R-square value for this model is .494.

France to Rest of Africa

All three subregions in Rest of Africa contain observations from France, West Africa corresponds with Z3 and East Africa with Z4. North Africa, the subregion containing grain shipments more frequently observed, is represented in the intercept term.

$$\text{Rate} = \alpha + \beta_1 \text{SIZE} + \beta_2 \text{Z3} + \beta_3 \text{Z4} \qquad \text{(D.19)}$$

All variable parameters and the full model are significant at the 99 percent confidence level. The R-square value for this model is .70.

France to Selected Regions

Egypt, the Middle East, Far East, "Mexico, Central America, and Caribbean," Baltic Sea and Black Sea have observed grain shipments from France, however, the number of grain shipments into each subregion does not facilitate the use of a regression equation to estimate shipping rates. Thus, the shipping rates means by subregion and vessel size are used as an alternative procedure to ocean freight rates. Predicted ocean grain freight rates from France are in Appendix C.

Shipping Rates to the Soviet Union

There are no observed grain shipments to the Soviet Union reported in the Journal of Commerce from January 1981 to December 1981. If the Soviet Union chartered tramp vessels for single voyages, the transaction would appear in Journal of Commerce. Thus, the Soviet Union must utilize time charters to transport grain. Rates to the Soviet Union are assumed to be comparable to shipping rates into the Baltic Sea and Black Sea subregions.

Australia and Argentina do not have estimated rates to either the Black Sea or Baltic Sea. For these two countries, Western Europe-Atlantic will represent the USSR (Baltic Sea) area and Western Europe-Mediterranean, the USSR (Black Sea) area.

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