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The Pacific Northwest grain industry is dependent on reliable and efficient ocean transportation for its rising grain exports. The cost of ocean shipping makes up as much as 20% of the landed price to importers of Pacific Northwest grain, and impacts both the quantities sold and prices received by farmers and exporters. Yet, no previous research has examined ocean freight rates for individual ports or port areas. A 1979 study by Harrar and Binkley analyzed ocean freight rates for grain by very broad export regions. However, a comparison of port-specific ocean freight rates often indicates considerable interport variation for grain shipments of equal size and distance. Conditions unique to individual ports limit the value of generalized information on the structure of ocean freight rate determinants.

The purpose of this study is to develop a port specific econometric model to identify and analyze the determinants of Lower Columbia River ocean freight rates for grain. Columbia River grain export shipments from 1978 through 1980 were analyzed for individual voyage and destination port characteristics. The model indicates that distance, shipment size, bunker fuel prices, the volume of U.S. West Coast grain exports, the vessel flag (U.S. or foreign), and the destination port size explain 90 percent of the variation between Lower Columbia River ocean freight rates for grain exports. Some implications of this study are:

The short run supply of tramp shipping to individual ports is not as inelastic as previously assumed. Tramp vessels in the North Pacific ocean react swiftly to changes in demand, possibly because of an oversupply of shipping capacity.

U.S. public policy is capable of influencing international ocean freight rates for grain through regional port investment decisions and waterway user charges. The price elasticity for bunker fuel suggests that user charges based on shipping input prices would be fully referred in the form of higher port specific ocean freight rates, with the possibility of causing major shifts in existing trade flows.

Finally, the structure of international ocean freight rates appear to vary across export origins, suggesting that further research of this nature would be useful.

An Economic Analysis of Ocean Freight Rates For Lower Columbia River Grain Exports

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CHAPTER I

INTRODUCTION

United States grain exports feed millions throughout the world, support U.S. foreign policy, improve U.S. balance of payments, and are vital to the agricultural economy of the Pacific Northwest. Over 80 percent of grains produced in the region are marketed overseas. The importance of foreign markets for grain makes the Pacific Northwest heavily dependent upon reliable and efficient ocean transportation services.

However, many people in the grain industry have little or no knowledge of commercial ocean shipping, or the extent to which it impacts the quantity of grain traded and the prices received by farmers and exporters. A primary reason for this unfamiliarity with the international transportation aspect of the business is that nearly all grain exported from the Columbia River is sold F.O.B. (Free-On-Board), so that the exporters' direct contact with the grain ceases as soon as it leaves the loading spout. It is left to the importer to make the arrangements for and bear the cost of ocean transportation. As importers are well aware, ocean transportation makes up a growing portion of the landed price of grain in the final market, which has a distinct effect on the quantity sold and prices received at the Columbia River.

In addition, ocean freight rates available from the Lower Columbia to export markets, relative to other U.S. ports (particularly in the

U.S. Gulf), can significantly influence U.S. internal grain flows. A sufficiently large change in relative ocean freight rates at a given port can result in a shift in internal movements and modes of transportation employed from production regions.

Although a large body of economic theory has been developed concerning international trade, very little attention has been given to the role of international transportation. Some of the more well known general equilibrium models assume transportation costs are zero. Those models which do include transportation costs usually assume they are a linear function of distance, ignoring the fact that ocean transportation is a volitile market where supply, demand, technology, politics, and natural phenomena all come into play.

The International Tramp Shipping Market

The majority of grain shipments from the Columbia River move on "tramp" ships - vessels for hire worldwide on a voyage basis. Hundreds of tramp shipping firms operate several thousand ships which take on cargoes wherever a satisfactory rate can be obtained. Although there is no rigorous definition of a tramp ship since vessels continuously move in and out of the trade, it can be contrasted with liner shipping.

Liner shipping companies operate vessels on fixed, scheduled routes and sell cargo space at published rates to a variety of shippers. Their cargoes are usually packaged semi-finished or finished goods which may necessitate special vessel design features such as refrigeration, electric winches, divided compartments and storage tanks. The large investment involved, regularity of service, high degree of specialization and large administrative apparatus had resulted in an oligopolistic market structure for liners. Liner companies usually belong to shipping conferences; organizations which legally divide up territories, collude to fix rates, and otherwise regulate the operations of conference members.

Alternatively, tramp shipping companies operate in a much more unregulated and competitive environment. There are no fixed itineraries, regulating organizations or divided territories. Rates are not published and must be negotiated individually for each charter subject to supply and demand. Many tramp vessel operators try to keep the design of their ships flexible enough to carry a wide variety of bulk cargoes, increasing the opportunity for gainful employment.

Rate competition appears to be keen in the tramp shipping market. A difference of a few cents per ton of cargo in rate negotiations often determines which vessel receives a cargo. In many charter contract negotiations, both the ship owner and potential shipper are represented by an independent ship broker. The cargo shipper may engage a ship broker to locate a suitable vessel for his merchandise to be available at the appropriate time. The ship owner hires a broker to locate a cargo for his ship at the highest rate he can obtain, given the current market situation. Although ship brokers are located all over the world, they communicate with each other continuously by telephone, telex, and face-to-face in the New York and Tokyo shipping market centers, or the Baltic Shipping Exchange in London. Ship brokers rely heavily on each other for news of possible cargoes, ships seeking employment, and potential new accounts. The value of this information should not be underestimated; contacts take years to develop and appear to be necessary for survival in the business. Brokers may cooperate in matching a cargo with a ship, and split the commission.

Although planning and calculations for transporting a cargo may be done several weeks before it is tendered, negotiations between brokers or agents seldom last more than a day or two. Initially, the major points are resolved, then lesser points, such as the length of lay days, demurrage, dispatch, and the vessel loading rate (tons/day) are specified in the contract. All agreements are verbal and binding, to be written later into a standard contract form.

The Lower Columbia River

International grain trade has a long tradition in the Columbia River Basin. As early as 1830 high masted schooners braved the Columbia River bar to load cargoes of grain bound for Russia.

Dryland wheat farmers filled wooden barges with sacked wheat which made their way downriver through dangerous rapids for delivery to Lower Columbia seaports. A major boost to the region occurred in 1870 when the port of Kalama was chosen as the terminus of the transcontinental railroad. Northern Pacific Railroad erected a sign proclaiming "Kalama: where rail meets sail."

With the steady growth in population, improved rail connections, and the construction of a bridge, the Portland-Vancouver area usurped Kalama's position as the river's leading grain port.

The growth of grain exports was encouraged at the turn of the century by a decrease in the real costs of shipping brought about by the introduction of iron and steam to marine technology. Likewise, agricultural technology advanced with the development of combines, tractors, and genetic improvement of grain hybrids. By the 1930's agriculture surpluses were rampant, and in 1933 the Commodity Credit Corporation (CCC) was formed to support agricultural prices. CCC operations helped to stabilize grain exports from the Lower Columbia through direct cash purchase of surplus grains and disposal by donations to needy foreign countries, trading for foreign currency, or long term credit sales to foreign governments under the provisions of Public Law 480. The years immediately following World War II saw rapid growth in grain exports to assist in feeding war-turn Europe under the Marshal plan.

The 1970's brought another period of Pacific Northwest grain export growth, primarily because of rising demand from Pacific rim countries.

However, export volumes through Columbia river grain terminals began to outpace regional production for the export market because of changes in both U.S. internal grain transportation and international ocean shipping.

Westward Grain Flow Patterns To Asian Markets

Increasing numbers of red wheat export shipments from midwest production regions have moved through Lower Columbia River terminals during the 1970's. At least seven factors can be identified as having contributed to this shift from traditional red wheat export terminals.

1) Prior to construction of the Columbia-Snake River lock and dam system, navigation on the upper river by shallow draft sternwheelers was very dangerous. This danger was not mitigated until opening of the Bonneville Lock and Dam in 1935. The lock was designed to accomodate

ocean-going vessels and the lower river channel was dredged to a depth of 27 feet. However, ocean-going vessels soon outgrew the capacity of the lock, and the 27 foot channel depth was reduced to 15 feet for use by shallow draft barges and towboats. With the completion of Lower Granite Dam in 1975, a system of eight dams had extended commercial inland barge navigation over 400 miles inland from the mouth of the Columbia. Lewiston, Idaho became a major transhipment point for grain, petroleum, fertilizer and wood products. Although Lewiston lacks extensive rail connections, a truck/barge modal combination began drawing increased grain movements from Idaho, Montana, Wyoming, and South Dakota. As more and more shippers found the truck/barge mode a viable alternative for westward bound shipments, railroads began lowering their rates in direct competition with Columbia River barge operations. Burlington-Northern adjusted rates to encourage midwestern shippers to use Pacific Northwest ocean ports, utilizing BN track the entire route.

2) A technological innovation of the railroads contributed to lowering the cost of westward overland grain shipments. Similar to eastbound coal movements from Colorado, Wyoming and Utah, railroads began offering unit trains (50 or more cars) for grain shipments to the Pacific Northwest. Rail cars could thus be more intensively utilized while reducing the turnaround time. The expansion of truck/barge operations and the introduction of unit trains and lower rates made a substantial impact on midwestern grain flows, shifting the "grain shed", or the geographic location where the cost of shipping grain to the west coast becomes competitive with shipping to the U.S. Gulf or Great Lakes ports. A 1977 study by Koo and Cramer found the grain shed to bisect central Montana. However, there is evidence that this break-

point has since moved further eastward to the Dakotas.

3) Rising incomes in Pacific Rim nations have greatly expanded U.S. grain export markets, and thereby increased the importance of the Lower Columbia as an export corridor. Japanese consumption of wheat has more than tripled since 1940, and similar increases have occurred in South Korea, Taiwan, the Phillipines and Indonesia. Per capital consumption of meat has risen with income growth, stimulating demand for feed grains and protein meal. Midwest corn exports through the Puget Sound in 1978-1979 nearly doubled the one million ton mark reached the previous year. In 1980, North Pacific Grain Growers, an export cooperative, began shipping corn through its' Kalama terminal on the Lower Columbia. While the Lower Columbia has dominated west coast wheat export shipments in the past, the potential for feed grain movements should not be underestimated. In 1977, U.S. wheat exports totalled 26 million tons, but corn exports were greater than 44 million tons. Although it appears that red wheat movements through the Lower Columbia will continue to rise at a modest rate, feed grain movements have a greater potential in terms of volume.

4) The Panama Canal has been the primary shipping route between the Atlantic and Pacific oceans since it's opening in 1914. With ratification of the Panama Canal treaties on April 18, 1978, the United States agreed to relinquish exclusive control of the Canal to a joint U.S.-Panamanian Commission on October 1, 1979. On December 31, 1999, Panama will gain complete sovereignty over the Canal. Included in the treaties were certain payments to the Republic of Panama, which are to be financed by raising Canal tolls. In February of 1979, Major General

Harold R. Parfitt, Governor of the Canal Zone, estimated that tolls would increase between 14 and 35 percent to cover the treaty payment obligation. Uncertainty about the extent of future toll increases and the long term stability of Canal operations has led to deeper investigation of alternative routes for cargoes moving the U.S. Gulf to Asian markets. Rail connections and port facilities on the Columbia River and Puget Sound make the Pacific Northwest a likely transhipment region for midwestern grain exports to Pacific Rim countries.

5) Cargo shipments tend to move on well established routes or trade flows, requiring significant lead time before new routes or modal combinations are widely accepted. Frequency, dependability, and convenience of transport are important considerations in addition to cost. Although many factors have contributed to increase grain exports through the Lower Columbia River, it appears that chance had a large part in drawing a portion of midwest grain export shipments away from Lake Superior and U.S. terminals. Between April 1978 and December 1979, a major port for red wheat export shipments, Duluth-Superior, was closed to grain traffic on two separate occasions. One closure of the port occurred when a merchant vessel sank in the Sault Ste Marie Channel, blocking maritime traffic to Lake Huron and the Atlantic Ocean. Duluth-Superior was again closed to grain traffic in the fall of 1979 during a strike by the American Federation of Grain Millers against port elevators. In the U.S. Gulf, two elevator explosions temporarily decreased export terminal operations. In 1978, an elevator in New Orleans exploded, followed by a similar incident in 1979 at an elevator in Houston. These events caused temporary rerouting of some Asia bound grain shipments to the Lower Columbia, helping demonstrate to

shippers the viability of this alternative.

6) The passage of the Motor Carriers Act of 1980 has allowed Columbia River truck/barge operations to draw grain from more distant production areas. Prior to this act, agricultural truckers could legally transport only unprocessed or bulk agricultural commodities, with a Common Carrier Permit required for any nonagricultural cargo. The Interstate Commerce Commission issued a limited number of Common Carrier Permits which were difficult to obtain and were highly valued. As a result, nearly all agricultural trucks were forced to make their return trips empty of cargo. This required agricultural shippers to pay a rate sufficiently high to cover costs for both the laden trip and the empty return trip. The Motor Carriers Act put an end to the cargo limitation of agricultural truckers, making more distant trips (with greater variable costs) economically feasible, since total truck transport costs are no longer limited to the revenue received for the agricultural half of the journey. While the Motor Carriers Act of 1980 will benefit most agricultural trucking, it is expected to benefit grain movements by truck/barge to a greater extent than truck/rail, since the distance covered by trucks hauling grain to rail terminals is typically much less than trucks moving grain to barge terminals. Rail transport costs per ton/mile are greater than barge costs, since an average of 750 B.T.U.s of energy are consumed per rail ton/mile, compared to 500 B.T.U.s per ton/mile by barge.

7) The rapid rise of energy costs in the 1970's has had great economic impact on the tramp shipping industry. In the early 1970's ocean freight rates for grain shipped from the U.S. Gulf to Japan were less than could be obtained from the Lower Columbia, even though ship-

ments from the U.S. Gulf had to travel nearly 4,500 miles further and were subject to Panama Canal tolls. The rising costs of bunker fuel appear to have increased the importance of distance as a factor in ocean freight rates, contributing to a decline in the competitive position of U.S. Gulf and Great Lake ports relative to the Pacific Northwest ports for Asia bound grain shipments.

Changes in the international tramp shipping market have greatly effected U.S. internal grain flows to Pacific Rim countries, contributed to growth in Columbia River export volumes, and have provided steadily rising prices to foreign national importing U.S. grain. Prices received by farmers for grain are approximately equal to the landed price in the importing country minus the cost of marketing.

For Columbia River grain exports, ocean transportation makes up as much as 20% of the cost of grain to importers. Consequently, prices received by farmers are directly influenced by international transportation rates.

Yet, very little research has been done on the ocean shipping market and international freight rates. Studies by Harrer and Binkley (13) and de Borger and Nonneman (8) have analyzed ocean freight rates for very broad geographic regions, but a comparison of port-specific ocean freight rates often indicates considerable interport variation for shipments of equal size and distance. Conditions unique to individual ports limit the value of generalized information on ocean freight rate determinants.

Purpose of this Thesis

The general purpose of this thesis is to expand on previous analyses of ocean freight rates by developing a case study of ocean freight rate determinants for a specific port area (Lower Columbia River). The objectives of the study will include:

1) Identification of data sources for port specific freight rates not examined in previous studies.

2) Hypothecizing additional determinants of ocean freight rates not examined in previous studies.

3) Developing an econometric model to explain and analyze the factors influencing international ocean freight rates for individual grain shipments for Lower Columbia River ports (Portland, Oregon; Vancouver, Washington; Kalama, Washington; Longview, Washington). For purposes of rate negotiations, ship operators view these five ports as a single port.

4) Using information from the econometric analysis to identify whether or not public policy may impact international ocean freight rates for grain.

A general description of the tramp shipping market and the chartering process will be presented, as well as a summary of some economic theory useful in understanding shipping market operations and their relationship to the grain market.

Unlike most previous analysis of ocean freight rates, it will not be assumed that the short run supply of shipping is completely inelastic. Therefore, included in the theory section is a discussion of factors which may impact the short run, regional supply of international shipping capacity to the Lower Columbia River.

CHAPTER II

LITERATURE REVIEW

A great deal of literature has been written on the general topic of commercial ocean shipping. It appears the romance of the sea has not been lost on writers, for histories and descriptive works abound. Yet, the topic of commercial shipping has been aptly characterized as an economic wasteland. Relatively few studies on the economics of ocean shipping exist, and the majority in this category are again descriptive in nature. Gripaios (11), O'Loughlin (26), Cufley (6), and Metaxas (25) have provided notable works on shipping markets and the application of economic principles.

In general, these authors delineate the liner shipping market from the tramp shipping market. The highly capital intensive liner firms with their regular schedules and rates set by organized conferences are portrayed as oligopolies, while the tramp market is set forth as a close approximation to perfect competition. The capital and operating costs of vessels are chronicled and the existence of economies of size detailed. These works provide a valuable understanding of shipping operations and market structure, and provide a broad base for analyzing the tramp shipping market with the competitive model.

As with all markets functioning in the real world, the tramp shipping market falls somewhat short of the high standards of the theoretical competitive model. Several authors have focused on market imperfections which appear to be on the increase, and thus may be of importance to the future of tramp shipping.

Vanags (37) has studied flag discrimination, the practices of shippers giving preference to ocean carriers whose vessels are registered to a particular country. Flag discrimination may be motivated by balance of payments accounting, development of a national fleet, or bilateral trade agreements which contain restrictive shipping clauses.

Vanags argues that with very few exceptions, flag discrimination will result in a net loss to the nation pursuing this policy.

A pillar of U.S. maritime policy is the Cargo Preference Act of 1954. This legislation requires that 50 percent of all cargoes shipped by the U.S. government must be transported on privately owned U.S. flag commerical vessels, including Department of Agriculture and Agency for International Development grain shipments. A study by Kilgour (19) indicates that ocean freight rates paid to U.S. flagships under this system are roughly twice those received by foreign flag carriers. Furthermore, no part of the United States maritime fleet is internationally competitive, and it's survival is tied to government subsidization.

Samuel Lawrence (22) points out a trend toward increasing concentration in they dry bulk trade through consolidation of ownership and management in shipping firms, bulk product companies acquiring company owned fleets because of specialized needs, and the increasingly capital intensive character of shipping acting as a barrier to entry.

The result of Heavers' study (14) on the relationship of shipping costs to vessel size lends credence to extreme capital requirements acting as a barrier to entry.

Although Kendall (18) and others have found substantial economies of size for ship operation at sea, Heaver extends this to include idle time spent in port. The costs of idle time in port are less for ships (more capital intensive) since the fixed cost per deadweight ton of carrying capacity is lower.

Economies of size was a very timely subject in the 1960's and 1970's, with dramatic increases occurring in the average size of bulk carriers. Treavor D. Heaver (14) conducted a 1968 study on the capital and operating costs of different vessel sizes utilizing an engineering cost estimation approach. Heaver calculated a total cost per cargo ton with a linear programming model designed to establish an after tax revenue of 8 percent above owner investment. This approach required very explicit assumptions on vessel sizes, time in port, port fees, taxes, rate of discount, fuel consumption, wages, capital, and other operating costs.

Heaver found significant economies of size in the use of large vessels. Perhaps the most interesting finding was that the cost of idle time in port per cargo ton is less for large ships than small ships, suggesting that port policies improving turnaround time for smaller vessels would accrue the greatest savings. Although no limit to vessel size economies was found, it was the author's belief that port maintenance costs would at some point offset any advantage to increasing vessel size.

A theory of optimum ship size was developed in a 1972 article by

P.M.H. Kendall (18). With the object of minimizing total transport costs, a series of cost curves were constructed for different sized vessels. The total sea transport costs were comprised of:

1) Ship costs
   a) capital costs
   b) operating costs

2) Terminal Costs
   a) port costs - dredging, berthing, locks, etc.
   b) Product handling costs
   c) Storage costs

Kendall's theory contains two factors not commonly included in vessel cost studies. Volume of trade at the port of origin was included since the larger the annual tonnage carried over a given route, the larger can be the ships to carry it economically. Because of high storage costs, the value of the product was included in the theory for optimum ship size.

A major premise of the theory is that economies of vessel size are not unlimited and that a proper balance between at-sea and terminal costs should be found to determine optimum vessle size.

The "engineering" cost estimation approach was again used in a 1977 study by R.O. Goss and C.D. Jones (10) to examine the costs of moving cargo in different sized dry bulk carriers. A required revenue per ton was calculated; defined as the long term price per ton covering all expenditures and yielding an adequate return on invested capital. The required revenue per ton was found by the net present value method and the use of various rates of discount ranging from 1% to 10%. Economies of size were found for vessels up to 80,000 deadweight tons without full consideration of terminal costs.

Statistical analysis of ocean freight rates has provided an alternative to the engineering method of cost estimation, as well as information on the determinants of ocean freight rates.

In his 1966 study, Zenon S. Zanetos (38), used ordinary least squares regression to model long term oil tankship rates. The model was based on spot market ocean freight rates, the number of layed up tankers, construction orders outstanding, charter duration, ship size, lead time between the charter and vessel delivery, an index of change in new orders, an index of change in the number of vessels in lay up, and an index of short term adjustment. An adaptive expectations formulation of the model showed that immediate long term charter rate expectations were not formed by current spot rates alone. Instead, some form of distributed lag seems to operate on long term rate expectations. Zanetos estimated an elasticity of long term rate expectations which was greater than one (elastic). Vessels scrapped were found to be independent of the conditions that generate orders for new vessels. Spot rates and vessels scrapped were negatively correlated, implying that normal replacements do not affect (new ship) orders in any significant way when rates are high.

Shipping costs for grain vessels chartered for U.S. grain exports between 1972 and 1976 were analyzed by Harrer (12) 1979, Harrer and Binkley (13) 1979, and Binkley and Harrer (3) 1981. An important assumption to all three of these works is that the tramp shipping market is highly competitive and therefore rates are unlikely to deviate from costs for long, given the possibility of new vessels entering the market. The determinants of ocean freight rates were hypothesized as distance, size of shipment, volume of trade, flag of registry, lay days, terms of shipping, season, and region of origin and destination. Input prices were not included in the formulation under the assumption that they are sufficiently invariant across routes as to have no perceptable impact on cross sectional differences. The ocean freight rates were indexed to reduce year to year variability and the shipment origins and destinations (over 1000) were grouped into 16 origin regions and 34 destination regions. With the exception of lay days, all of the hypothesized determinants were statistically significant using ordinary least squares regression. Some conclusions from these three works are:

1) The role of distance is declining in the formation of patterns in international trade.

2) Increasing volume of trade reduces ocean freight rates for grain.

3) Ocean freight rates on "flag of convenience" vessels are roughly equal to those available on other foreign flag vessels.

4) Economies of size exist for shipments up to 50,000 D.W.T., then become diseconomies for larger shipments.

5) The longer the at-sea voyage, the greater the economies of vessel size.

The highest coefficient of determination (R^2) achieved for these three works is less than .50, and no mention of testing for statistical problems is made. Yet, they provided an important step in econometric analysis of ocean freight rates for grain.

Statistical cost functions for dry bulk carriers were estimated by B. de Borger and W. Nonneman (8) in a 1981 study financed by the Ghent Port Authority. The authors analyzed 1979 ocean freight rates for coal, grain, and ore shipments from major export regions using linear regression. The level of ocean freight rates was expected to be determined by equilibrating forces of supply and demand, while the structure of freight rates should be governed by the cost structure of different types of producers.

On the hypothesis that short run variation in freight rates is due more to shifts in demand than supply, the authors tried to seperate the effects of short run excess supply from long term changes in capacity on freight rates. Variables for excess supply at the time of chartering and ocean freight capacity at the time of chartering were included in the model in addition to vessel size, voyage length and an indicator variable for various qualitative characteristics. The equation was estimated in a double log formulation to allow direct comparisons of elasticities. All of the variables were significant at the 5% level, and led to some interesting conclusions. One result was that periods of high excess supply coincide with periods of low total capacity. Apparently a significant number of high cost, marginal vessels will be taken out of service according to the level of excess supply. The total effect of a change from a slack market (low capacity) to a tight market (high capacity) was an increase in freight rates of 60% to 80% in 1979. A second finding was that the elasticity of supply for grain vessels (.1%) is greater than for the more specialized vessels in the coal and ore trades (.5%). This suggests that the common assumption of perfect inelasticity of short run supply of shipping should be reexamined, at least for the grain trade. In general, the results compared well with engineering costs functions, except for a consistently lower relative effect of distance on ocean freight rates.

CHAPTER III

TRAMP SHIPPING AND ECONOMIC THEORY

From the introduction of this thesis, many similarities of the economic theory of perfect competition to the tramp shipping market may be noted:

1) A large number of firms compete in a worldwide market.
2) The ocean transportation services offered are homogeneous between suppliers.
3) The technology, capital, and labor inputs required for operating a tramp ship are readily available to all potential entrants.
4) No regulation of the international tramp shipping market presently exists.
5) A firm may freely enter and exit the market, with the addition or loss of its' services having no perceptable influence on ocean freight rates.
6) Continuous information on charter agreements and rates concluded is available from a telex subscription service.

The most significant departure from the competitive model occurs through flag discrimination, where shippers give preference to vessels which are registered to a particular country. Although the number of countries practicing flag discrimination, including the United States, is ever growing, the tramp shipping market remains extremely competitive.

SUPPLY

The concept of supply of tramp shipping services can be divided into at least three interrelated dimensions: static, temporal and regional. A static definition might be the total deadweight tonnage of shipping available to produce transport services. Yet, a more realistic definition would recognize the inadequacy of this measure since a given quantity of tonnage is capable of producing various levels of shipping services. Finally, the total international supply of shipping services is rarely a focus of concern; rather, it is the supply available to a given region or trade route than interests cargo shippers, shipping firms and port managers alike. A quick examination of ocean freight rates between various equidistant ports usually indicates considerable interport variation, which in turn may indicate varying levels of the supply of shipping services.

Static Supply

While static measures of the supply of tramp shipping are most common, even these are not easily obtained. A 1978 tally by the U.S. Maritime Administration shows a total of 4,651 registered bulk carriers or 180,436,200 D.W.T. of carrying capacity, the majority of which is operated in the tramp shipping market. A more exact measure is difficult since ships move between the liner and tramp trades according to market conditions, are sold, have their names changed, are scrapped, or sink.

Intertemporal Supply

When the intertemporal elements of shipping supply such as intensity of utilization, ship operating speed, or the time in port required to load and/or unload (turnaround time) are considered, the length of the time period over which supply will be measured must also be defined. In the economic short run, some inputs are fixed in quantity; a shipping firm may expand or contract its output only by varying the amounts of other inputs (i.e., labor, fuel). Output may range from zero to the maximum permitted by the fixed input. In terms of the supply of shipping services, the short run is less than eighteen months, a minimum period required to construct new ships. As previously stated, the short run supply of shipping services may vary with the intensity of utilization of a fixed quantity of shipping tonnage. Tramp ship operators commonly speed up or slow down their vessels according to market conditions. In periods of high market rates, ships will increase normal service speed to increase operations with high revenues. In periods of low rates, ships will decrease speed to economize on fuel costs.

Port efficiency contributes to the supply of shipping services by decreasing vessel turnaround time. Those ports with modern cargo handling equipment, a sufficient number of berths, day and night shifts for longshoremen, drydocks, and adequate services are able to dispatch vessels much more quickly, thereby increasing available operating time.

Two additional factors which affect short run supply adjustments are the number of vessels on long term charters and the number of vessels laid-up. If a ship operator expects a decline in future ocean freight rates, he may try to obtain multiple voyage charters ahead of the current market rate, or offer his ship for a time charter to firms dealing in bulk commodities. In either case, the vessel is committed to a particular route at a locked in rate, and is unable to take advantage of any short run rate increases in another region.

When ship owners expect a prolonged period of low freight rates which will not cover the variable costs of operation, they may decide to lay up the vessel in order to minimize losses. The ship is decommissioned and the crew sent home until the market rate rises to a sufficient level to cover the costs of reactivating the ship, the variable costs of operation, and make at least some contribution towards fixed costs. The more ships that are in lay-up the greater the flexibility of short run supply, since ships are available.

The short run supply curve for shipping services is more elastic on the lower portion, because supply can be increased to some extent by more intensive utilization of existing ships, attracting ships from other trade routes, and the recommissioning of laid-up vessels. However, the increase in shipping services which can be achieved in the short run is often small in comparison to the magnitude of shifts in demand. For this reason, the upper section of the supply curve is extremely inelastic, since as additional short run capacity adjustments are exhaused, shippers pay higher and higher rates for an essentially fixed supply of tonnage. Once the supply has expanded as far as possible in the short run, shipping firms may earn quasi rents (rates above ATC) due to the scarcity of ships.

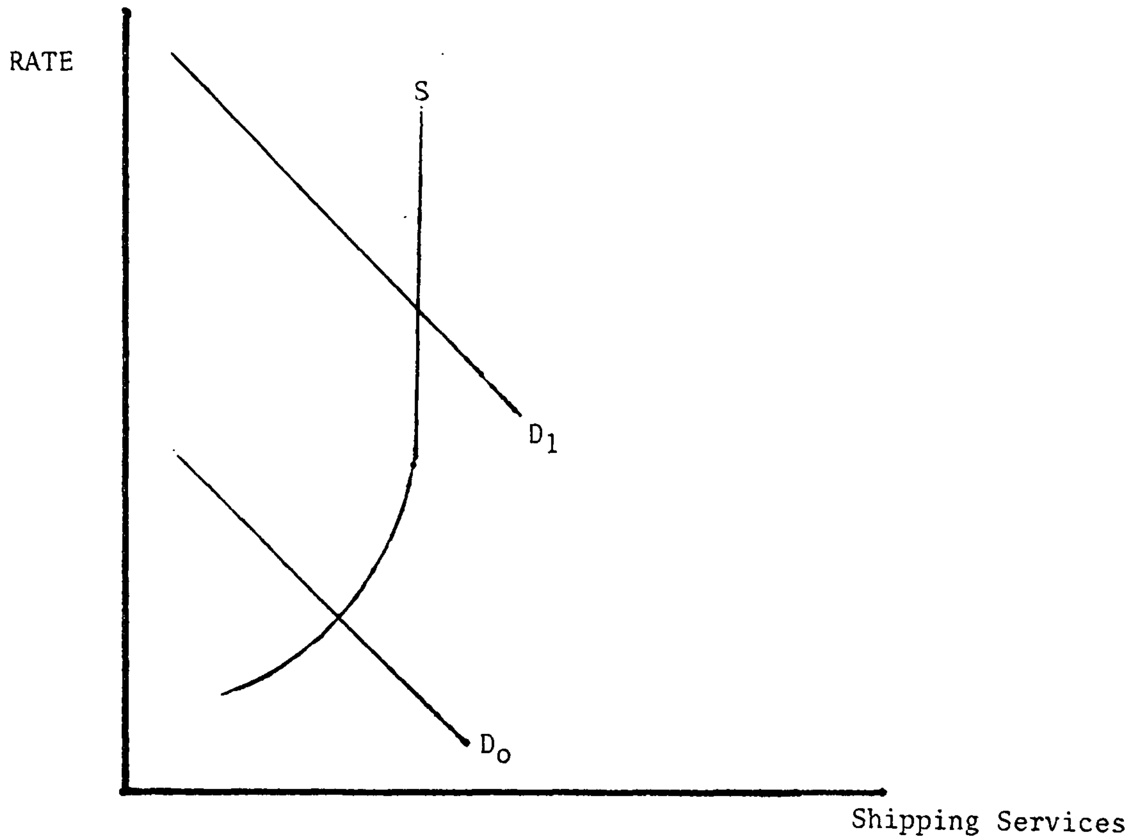

Figure 1. Short Run Supply of Shipping Services.

Rising costs of inputs can effectively reduce the supply of shipping produced at a given market rate. For instance, suppose the price of bunker fuel rises while the price of labor remains constant. Assuming labor and fuel are the only variable inputs for the production of shipping services (the quantity of ships is constant throughout), we can illustrate the effect of the rise in input price with the aid of figure 2. Pt.A is the initial level of production, and shows the various combinations of the two factors which will produce a certain level of shipping services. NF_1 is the initial isocost line, which depicts the various combinations of labor and fuel which could be obtained with a fixed expenditure. The rise of bunker fuel costs means that less fuel can be purchased with the fixed expenditure, so that the isocost line shifts inword to NF_2. The highest level of output (isoquant) that can be reached with this new isocost line is Q_2, reducing total output of shipping services. It is interesting to note the effect of the fuel price increase on the quantity of labor utilized. In this instance, the quantity of labor used to produce less shipping services actually increased to M from L. As less fuel was consumed in producing a given level of shipping services, the normal service speed of the vessels declined, requiring a greater amount of time and thus labor for each cargo unit transported. The effect of rising input prices on the perfectly competitive firms' output may also be demonstrated with the microeconomic model of unconstrained profit maximization as outlined by Henderson and Quandt (15).

$$\Pi = P_s f(X_1, X_2) - [P_1 X_1 + P_2 X_2 + b]$$

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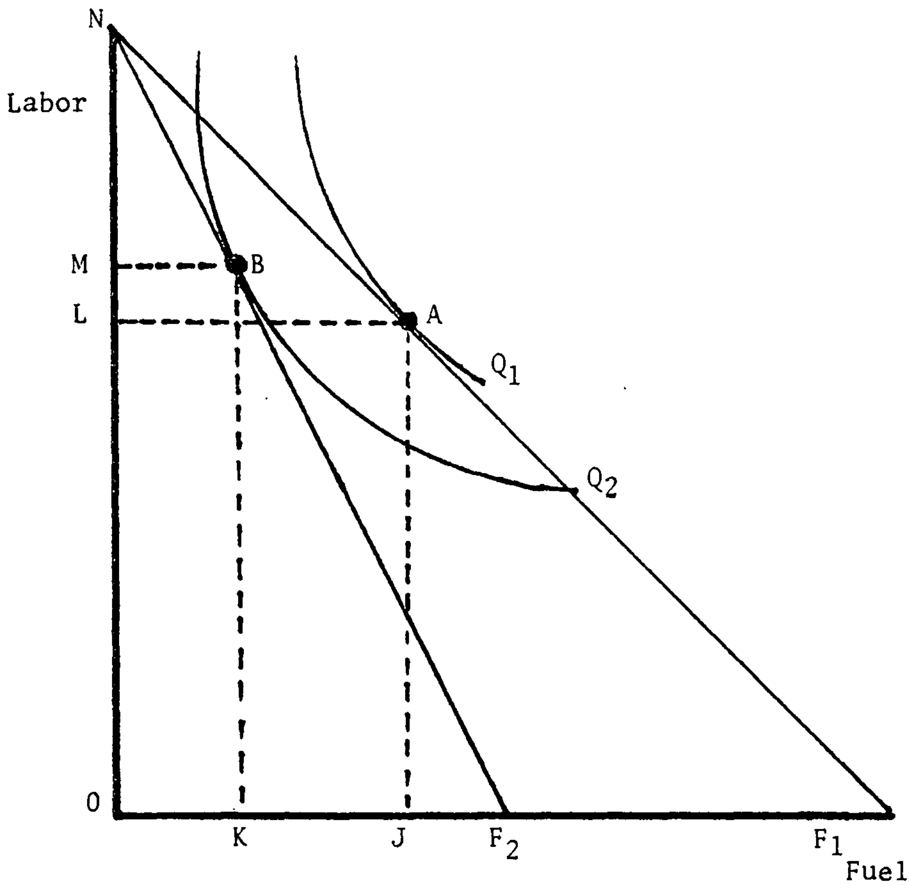


Figure 2. Rising input prices effect on quantity of shipping services produced.

P_s = price of shipping services X_1 = quantity of fuel

P_1 = price of fuel X_2 = quantity of labor

P_2 = price of labor   b = fixed cost

Q_s = quantity of shipping services = function of the two inputs.

Taking the first partial derivative:

(1) $\frac{\partial \Pi}{\partial X_1} = P_s \frac{\partial Q}{\partial X_1} - P_1 \stackrel{s}{=} 0 \rightarrow \frac{VMP_1}{P_1} = 1$

(2) $\frac{\partial \Pi}{\partial X_2} = P_s \frac{\partial Q}{\partial X_2} - P_2 \stackrel{s}{=} 0 \rightarrow \frac{VMP_2}{P_2} = 1$

(3) $\frac{VMP_1}{P_1} = \frac{VMP_2}{P_2} = 1$

SECOND ORDER CONDITIONS

(4) $\frac{\partial^2 \Pi}{\partial X_1^2} < 0 \quad \frac{\partial^2 \Pi}{\partial X_2^2} < 0$

$$\begin{vmatrix} \frac{\partial^2 \Pi}{\partial X_1^2} & \frac{\partial^2 \Pi}{\partial X_1 \partial X_2} \\ \frac{\partial^2 \Pi}{\partial X_2 \partial X_1} & \frac{\partial^2 \Pi}{\partial X_2^2} \end{vmatrix} > 0$$

If the above second order conditions hold, a profit maximum is assured when the ratios of the value of the marginal products (VMP) to their respective prices equal one. Assuming a 20% rise in the cost of fuel, the firm is thrown out of competitive equilibrium.

(5) $\frac{VMP_1}{1.2P_1} < \frac{VMP}{P_2} = 1$

In a perfectly competitive market, the individual firm cannot effect the market price, of either the output (P_s=V) or the inputs (P_1, P_2). However, it may vary the level of inputs in the production process and thereby change the marginal products of the inputs. The firm now has incentive to increase the marginal product of fuel (MP_1) until once again the conditions in equation 3 hold. This is done by reducing the quantity of fuel utilized, which will in turn reduce the output of shipping services.

According to Metaxas, the long run supply of tramp shipping depends on shipowners expectations about the future level of demand for tramp shipping services, potential profits, technological progress in vessel construction and operation and port development. In the economic long run, all inputs are variable in amount and the tramp shipping industry's output of services can be increased indefinitely. Although the durable "liberty ship" class of WW-II could be constructed in 14 days, modern ship construction generally requires much more time. Bulk carriers are usually launched from 18-36 months after they are ordered. Construction orders tend to be placed when market rates are high and ship operators are optimistic, which leads to most new ship deliveries being made at approximately the same time. Meanwhile, during the time elapsed between order and delivery, the market often has taken a downturn, with the sudden delivery of additional shipping capacity serving to aggravate the situation by providing even greater competition. The tendency to scrap ships in periods of low rates and order new ones in periods of high rates is known as the "shipbuilding cycle." Zannetos and O'Loughlin likened the shipbuilding cycle to the fluctuations in the supply of hogs experienced in agricultural markets. In both instances, there are a large number of competing "firms" operating independently and a substantial time lag between production decisions and the entry of the final product into the market. A slump in market prices would induce the "firms" to reduce production plans and the resultant decrease in supply would drive prices up again. "Firms" would then react by increasing production, causing another glut in the market after the appropriate gestation period. These supply induced oscilations in rates roughly resemble Ezekiel's (9) classic cobweb theorum. According to Zannetos (38), the rates in shipping are more complicated than the cobweb model since there is no definite production period and new shipping capacity enters the market continuously, peaking several years after a decline in rates. Therefore, new long run static equilibria are created continuously, providing a different point of reference for rate oscilations in each unit of time. Rate oscilations are contained by upper and lower boundaries, with the upper limit defined by the rate which will absorb all profit imputed to commodity production, and the lower limit by the rate which will cause marginal vessels to lay up rather than accept charters.

The shipbuilding cycles' effect on freight rates is partially dampened by the existence of a reserve of shipping in lay-up and improved market information. Lloyds of London publishes the amount of new tonnage on order worldwide, allowing investment decision makers to reasonably estimate the quantity of shipping capacity available in the market at a given time.

The Peak Problem

The capital intensive nature of the shipping industry combined with the erratic nature of the demand for shipping services subjects ocean transportation to the peak demand problem. As in the case of public utilities and mass transit, the quantity of services necessary to supply a given region is determined not by average demand, but by peak demand, causing underutilization of capital in periods of less than peak demand.

Lawrence has noted that the tonnage of conventional freighters, refrigerated, container and pallet vessels more than doubled between 1952 and 1972, apparently outpacing the demand for shipping services. However, except for very brief periods, the amount of tonnage in lay-up has been relatively small. This inconsistency is the result of several factors, including underutilization of ships. The fixed cost burden of modern ship operation is often proportionately larger than variable costs or out-of-pocket expense.

As previously mentioned, ships tend to be laid up when the rates received are lower than the variable costs of operation. Yet, depending on shipping market expectations, management may prefer to keep a ship in operation even if its earned revenues are not covering its variable costs. The expense associated with lay-up and recommissioning of a vessel is so great that laying up a vessel for less than a year is seldom considered. If management forsees an improvement in market conditions within a year, it is likely the vessel will continue to operate.

A second factor in underutilization is voyages "in ballast" (empty). During previous periods of industrial growth in the western world, large quantities of bulk materials were shipped from less developed countries to the industrialized nations. The limited markets for western goods in the less developed countires meant that many vessels leaving western developed nations were empty, or "in ballast." The rapid rise in U.S. grain exports and declining U.S. demand for natural fibers and petroleum products has reversed the direction of voyages in ballast. A large proportion of ships delivering cargoes to less developed countries now return empty to the U.S.

Regional Supply: Lower Columbia River Sea Ports

A variety of factors, economic and geographical, serve to make each port unique relative to others. The cargo mix shipped from ports within the same region is often different because of population density, accessability and facilities investment. However, regional ports usually have at least one export commodity class in common, for reasons of a shared comparitive advantage of their hinterlands. For the Lower Columbia River ports, the major commodity in common is grain. The Pacific Northwest is the largest production region in North America for soft white wheat, with approximately 85 percent being shipped overseas from the Lower Columbia River. In addition, red wheat and corn export shipments producted in the midwest are increasingly moved through Lower Columbia River terminals. From 1975 to 1979, red wheat exports through the ports of Portland, Vancouver, WA., Kalama, Longview and Astoria increased from 27,897,000 bushels to over 166,794,000 bushels. On the other hand, inbound, or import shipments are substantially lower than export shipments. In the Port of Portland, the tonnage of exports usually exceeds the tonnage of imports by about three and a half times. Two major reasons for this traffic imbalance are that the Lower Columbia lacks the population density to create major import demand, and it does not have mini-bridge rail connections to attract import cargoes as a transhipment point to U.S. inland metropolitan centers or the European continent.

This wide disparity between inbound and outbound cargoes has significant impact on the supply of tramp shipping to the region and ocean freight rates. Under optimal conditions, a tramp ship would discharge a cargo at the same port that it loads, producing revenue on both inbound and outbound voyages. Otherwise, the initial voyage to the Lower Columbia is "in ballast" (empty of cargo) and operators must charge a rate for export cargoes sufficiently high to cover the costs of the inbound voyage in ballast and the outbound voyage. It is possible that a tramp ship operator might achieve greater profits by avoiding the North Pacific entirely. For instance, a shipowner on the west coast of Ecuador could be faced with the possibility of steaming in ballast to Portland to take on an 18,000 ton cargo of grain at $26.54/ton destined for Yokahama. Alternatively, he could load a 16,000 ton cargo of sugar at $20.00/ton, destined for New Orleans, and pick up 20,000 tons of grain bound for Hakata at $23.50/ton. Although the distance from the Gulf of Japan is 4,787 miles greater than from Portland, involving Panama Canal transit costs and a lower freight rate, the shipowner is better off by choosing the second option.

The Port of Seattle, Washington is a major deep draft port, with excellent rail connections and minibridge service. Seattle, similar to Lower Columbia ports, also suffers from a substantial imbalance in inbound/outbound traffic. However, the imbalance is the opposite of the Lower Columbia, making Seattle an export deficit port. In 1977, the

Port of Seattle imported approximately 4,629,855 and exported 1,990,364 tons. The predominance of inbound cargo to Seattle and outbound cargo from Portland has created a circuitous pattern of call for many vessels serving the U.S. west coast. Frequently Seattle is the first port of call, and Portland is the last, with possible side trips to the San Francisco or Los Angeles Bay areas.

Although tramp vessels registered to foreign nations tend to follow this pattern of call, on west coast ports the Shipping Act of 1916 prohibits foreign carriers from participating in U.S. domestic trade. Foreign registered tramps are limited to discharging cargo originating from other countries and loading U.S. export cargo.

The order of call on west coast ports frustrates the development of both Columbia River and Puget Sound ports. Portland is impeded in increasing import traffic and Seattle is hindered in strengthening its exports. Locklin, Binkly and others have noted the importance of established trade routes in freight rate determination. If Portland were able to substantially increase its imports, there is little doubt that the supply of shipping to Lower Columbia ports would rise, and outbound ocean freight rates would decrease because of competition for cargoes.

Expected delays in ship arrivals and departures have a negative impact on the supply of shipping to a given port, since ship operators will include them into cost calculations when evaluating a potential voyage charter. A modern bulk carrier may cost several thousand dollars per day to idle, not including capital and opportunity costs. Also, tramp vessels often accept multiple voyage contracts, so that a delay in one port may set off a chain reaction of late arrivals to

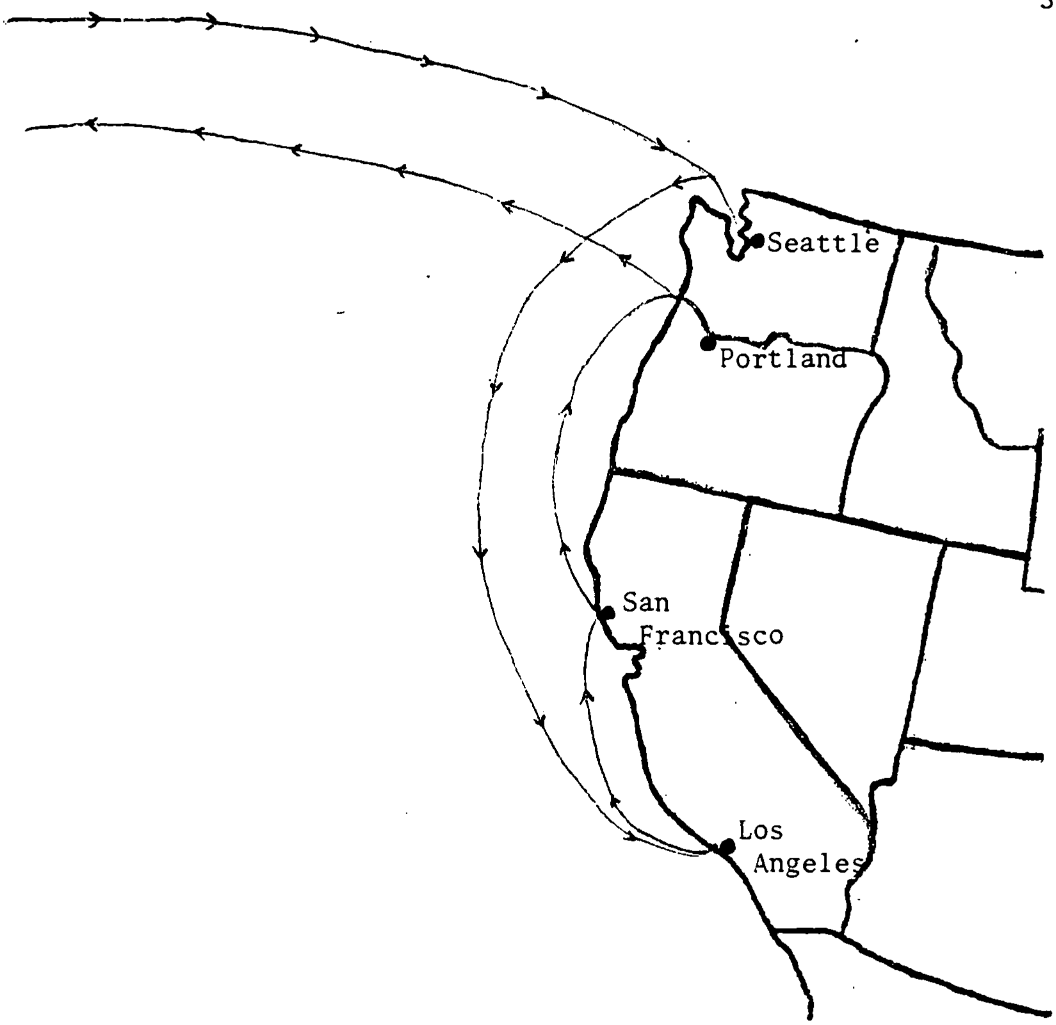


Figure 3. Pattern of Vessel Calls on West Coast Ports.

other ports of call. Several factors have contributed to delays for vessels calling on Columbia River ports.

Adverse winter weather conditions are not uncommon in the North Pacific, particularly between latitudes 50° and 60° N. Wave trains of different height, length, and frequency may be encountered, with some ridges building up to 50 feet from crest to trough. If there are persistently heavy headwinds and high seas, the shipmaster may take a less direct route to avoid a weather front, or reduce speed to prevent damage to the ships' engines and superstructure.

To reach Portland and Vancouver, Washington, ships must traverse over 100 miles of river channel at reduced speeds because of difficulty of navigation, traffic congestion, and the environmental impact of propeller wash. Some large vessels must stand off the rivers mouth awaiting high tide before entering the channel because of river depth requirements. Certain sections of the Columbia receive heavy silting, as near St. Helens and the mouth of the Toutle River. Vessels may run aground and hamper other river traffic. Although no further major eruptions of Mt. St. Helens are expected, hundreds of thousands of denuded acres pose a threat of erosion, flooding, and heavy silting down the Toutle River valley to meet the Columbia.

Labor unions have provided sporatic problems for grain exporters, with Portland Longshoremen demonstrating their political convictions by refusing to load vessels bound for Iran, and barge workers stopping operations over contract disputes. The lack of a night shift for Portland Longshoremen requires some vessels to either pay overtime for night loading or spend additional time in port, slowing turnaround time and increasing voyage expenses.

Columbia River channel depth poses a physical barrier to a growing percentage of tramp ships, effectively reducing the available supply of tramp shipping to Lower Columbia ports. From 1964 to 1974, the average size of dry bulk carriers placed in service grew from 20,000 to 55,000 D.W.T. . These large bulk carriers have average design drafts over 38 feet, and often exceed the 40 foot project depth maintained by the U.S. Army Corps of Engineers on the Columbia River. Although most tramp vessels are designed within "Panimax limits" (maximum size vessels to navigate the Panama Canal), the rise of westward overland grain flows to Asian markets increases opportunities to take advantage of the substantial size economies available in ocean shipping, passing by Panama Canal limitations.

Probably the biggest potential constraint on the supply of shipping to Lower Columbia River ports is the proposed waterway user charge supported by the Reagan Administration. Under this plan, all channel dredging and maintenance costs for each port would be fully recovered by implementing a surcharge on fuel. In fiscal year 1978, $8,503,000 was appropriated for the mouth of the Columbia River and Lower Columbia River channel maintenance by the U.S. Army Corps of Engineers. In a speech at the 1981 Future of Maritime Industries conference in Portland, Oregon, George Stoudt (29) of Coast Trading reported that a user charge of approximately 5 cents per bushel of grain could force relocation of the grain industry away from the Columbia River at a total capital cost of over 3/4 billion dollars. At the time of this writing, several alternative user charge proposals are in Congress, and the final outcome has yet to be determined. However, there is little doubt that a port specific user charge would lessen the attractiveness of Lower Columbia River ports to tramp shipping and the maritime industry as a whole.

DEMAND

The demand for tramp shipping, simply stated, depends on the volume of world trade. International grain trade likely began with the Phoenicians, merchant adventurers who plied the waters of the Mediterranean and Agean thousands of years before Christ. Ironically, a revolution in marine technology provided much of the impetus for growth in world trade. The reduction of shipping costs brought by the use of iron, steel, and steam opened new international markets and spurred tramp shipping activities. According to Couper, the first modern tramp vessels were introduced in the mid nineteenth century by British shipowners taking advantage of the repeal of the English corn laws. Most vessels were 1000-2000 D.W.T., and were occupied in the Western European trade, hauling coal to the continent and grain home. Cargo tonnage carried by tramp vessels grew by more than 660 percent between 1869 and 1914, and has shown other remarkable increases during World War I and World War II.

International agricultural trade has grown impressively in the 1970's, particularly for the U.S. The value of U.S. agricultural exports has risen from $8 billion in 1971 to over $38 billion in 1980, a figure extremely important to U.S. balance of payments. Agricultural trade is a major reason that the United States is the largest single employer of the world tramp shipping fleet. (22)

Before describing the demand for ocean transportation of grain on the Lower Columbia River, an examination of the theoretical determinents of transportation demand is appropriate.

Transportation Demand Theory

Using the familiar, if less than realistic, assumptions of a competitive market structure, homogeneous commodities, perfect knowledge and no barriers to trade, spacial price relationships between regions will differ by no more than the transfer costs. Otherwise, arbitrage will occur until the price differential is equal to transfer costs. In addition, price differences between any two regions which are less than transfer costs will preclude those two regions from engaging in mutual trade. Assuming that prices for a commodity, say wheat, do indeed differ by more than transporation costs between two regions, the following model of transportation demand can be developed.

If the supply and demand within the export region for wheat could be characterized by figure 4, an excess supply function is defined by that portion of the supply curve above the equilibrium price within the export region. This is the difference between quantity supplied and quantity demanded at every price above the regional market equilibrium price (P_E). At price P_E, more wheat is produced locally than can be consumed. This excess supply becomes available for trade in the world market.

Similarly, an excess demand function for the import region can be defined as the difference between the quantity demanded and the quantity

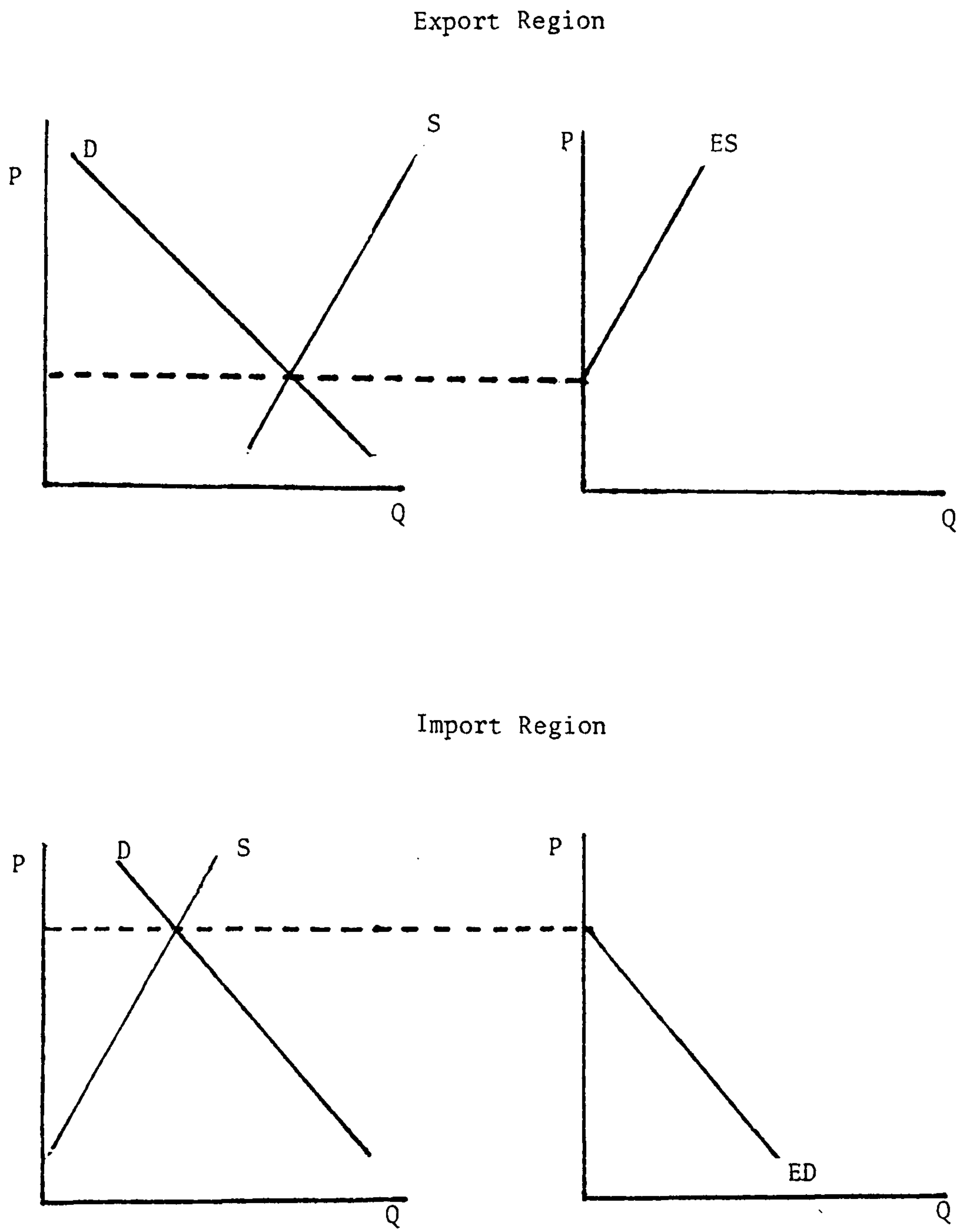


Figure 4. Excess Supply and Demand.

supplied at every price below the regional equilibrium price (P_I). At price P_I, a market for imported wheat will exist.

Proceeding to figure 5, if free trade could be carried on between the two regions without transportation costs, a price of P_M would result in the world market with OQ_M tons being traded. The price of wheat in the exporting region would rise to P_M and in the importing region it would decline to P_M.

Many theoretical models of international trade would conclude at this point, completely ignoring the impact of marketing costs as a determinent of the feasibility of trade. However, substantial marketing costs are involved in trading wheat internationally, the largest being ocean transportation. For the purpose of simplification, it will be assumed that ocean transportation is the only significant marketing cost. If no trade occurred between the two regions, the amount of capital available to meet transportation costs would be the difference between the two regional equilibrium wheat prices (P_E-P_I). As stated above, even if transportation costs were equal to zero, the maximum amount of wheat to be transported would be OQ_M. These two extremes mark the intercepts of the demand curve for shipping services. The supply curve for shipping services, assuming pure competition in the shipping markets, represents the cost of shipping various quantities of wheat between the exporting and importing regions. The equilibrium price and quantity in the ocean shipping market will determine the quantity of wheat that can be economically traded by the two regions. The import price will be P_I', and the export price will be P_E'. In summary, the introduction of transportation costs as determined in the

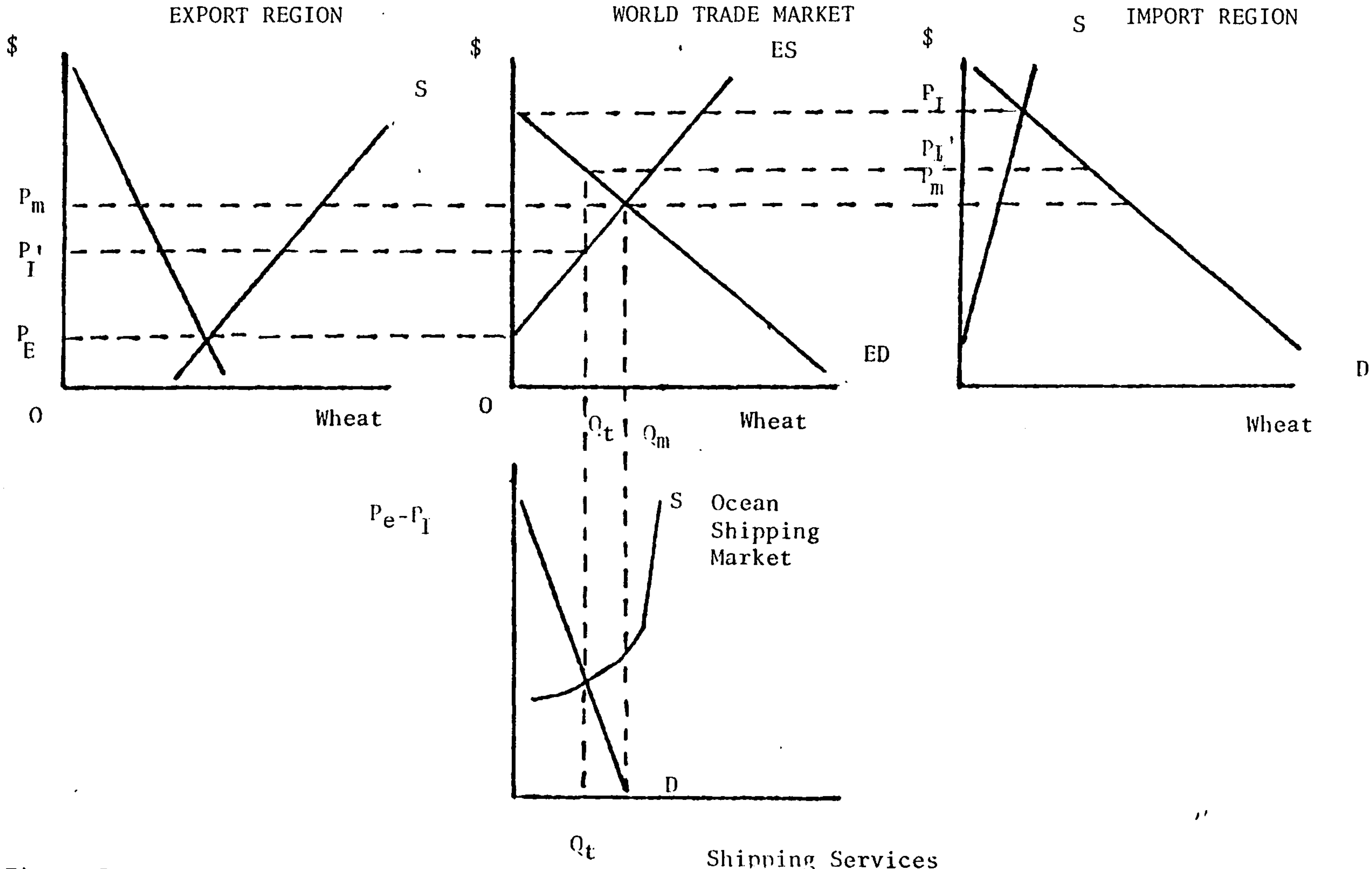


Figure 5: Interregional Trade Model.

ocean shipping market resulted in the quantity of wheat traded declining by $Q_M - Q_T$, the export region price declining by $P_E' - P_M$. By varying the equilibrium price of ocean shipping, the quantity of wheat that can be economically traded changes, as well as the equilibrium prices of wheat in the exporting and importing regions.

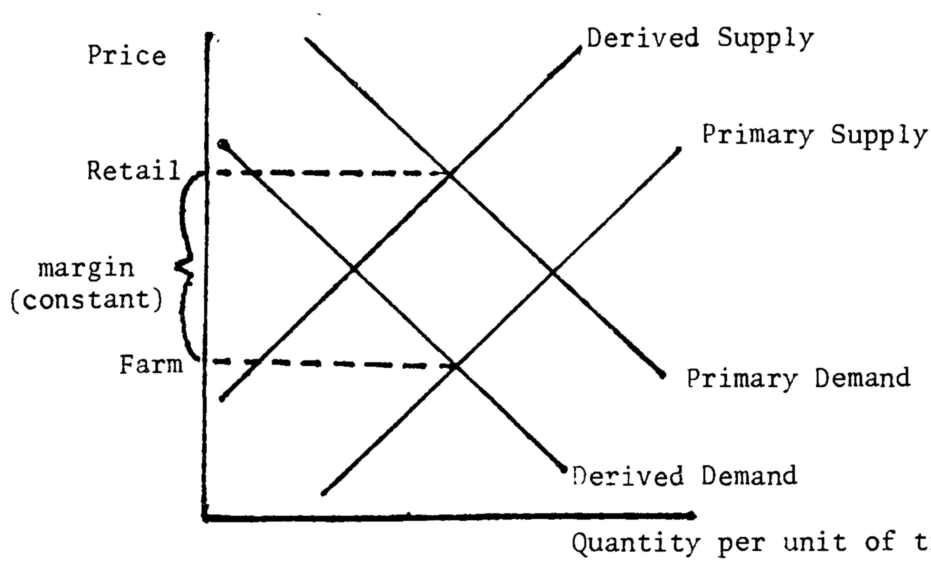
The demand for ocean transportation of grain is a derived demand; that is, it is ultimately derived from the primary demand for grain at the point of consumption in a foreign market. Ocean transportation is one of many inputs which are used to produce final grain products such as bread, noodles, crackers, cooking oil, pastries and livestock feed at the importing region. Derived demand differs from primary demand by marketing and/or processing charges per unit of product. These charges are known as marketing margins.

If a single marketing margin were defined as the collection of all services taking place between grain production in the U.S. and final consumption in the importing country, and the per unit price of those services were constant over different quantities exported, these demand functions would resemble figure 6a. The derived demand is the demand for grain at the farm level, and the primary demand is in a sense a joint demand for all inputs of the final product at the point of consumption. Analagously, the quantity supplied at the farm level (primary supply) often differs from the quantity of final product or derived supply at the consumption point because of value added through processing and transportation. The difference between the primary and derived demand curves is the marketing margin, which is constant in case (a).

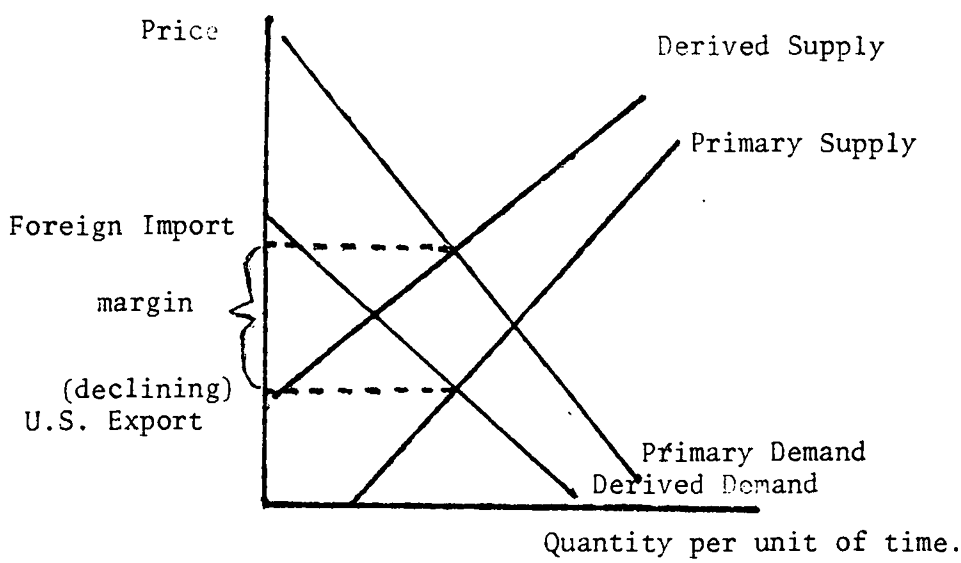
Marketing margins may be defined between intermediate points where the product is purchased by wholesalers or processers. At least six distinct marketing margins can be defined for export grains: margins between farm and track price, track price and export price, export price and import price, import price and resale price, resale price and miller's price, miller's price and retail price. The margin between export price and import price represents the cost of ocean shipping. In figure 6b, an intermediate marketing margin is illustrated for the difference between export and import prices. This marketing margin declines with quantity traded per unit of time because of the economies of scale available in ocean shipping of grain. The narrowing margin suggests that the L.R. supply curve for this aspect of marketing services is negatively sloped over some portion of the function.

Changes in marketing margins occur because of shifts in the primary or derived supply and demand functions. The use of new inputs or the adoption of new services can cause a shift in the primary demand curve, since the product definition has changed at the next level. However, the nature of basic transportation services for dry bulk commodities changes very little over time, focusing this analysis on changes in derived demand and supply. If the cost of providing an existing set of services changes, both the derived demand and derived supply relations shift from their previous positions. An increase in the margin resulting from a rise in input prices will shift the derived demand schedule downward and dervied supply schedule upward. If the margin has been defined as the difference between the import price and the farm price, the import price increases while the price received by

(a)



(a) Constant marketing margin.



(b) Declining marketing margin representing Economies of scale in Ocean Transportation.

Figure 6.

farmers declines. The magnitude of these price changes depend on the relative slopes of the demand and supply curves. Previous research suggests that the supply curve is more price inelastic than the demand curve at the farm level. As noted in figure 7, a partial equilibrium analysis shows most of the incidence of an increased margin falling on the farm price. A rise in ocean freight rates for grains, all other things being equal, is likely to have a greater negative impact on U.S. farmers than on foreign importers of U.S. grains.

The Hypothesized Determinants of Ocean Grain Freight Rates From Lower Columbia River Ports

The competitive nature of the tramp shipping market suggests that, in the long run, economic rents will be driven to zero and rates will equal average total cost. While it may be true enough that rates will move toward this competitive equilibrium in the long run, short-run ocean freight rates may differ substantially from average cost.

Probably the largest single factor in the divergency of short-run rates from costs is the tendency toward a continual regional excess demand for, or excess supply of, tramp tonnage. This problem is aggravated by the cyclical character of ship building. Orders for new ship construction are usually placed when rates are high. Ship building takes at least 12 to 18 months, and often the bulk of the new buildings will begin operation at approximately the same time. Meanwhile, rates may have fallen as a result of waning demand so that the increased competition from the new entrants will drive rates even lower.

In prolonged periods of weak demand and low rates, ships will de-

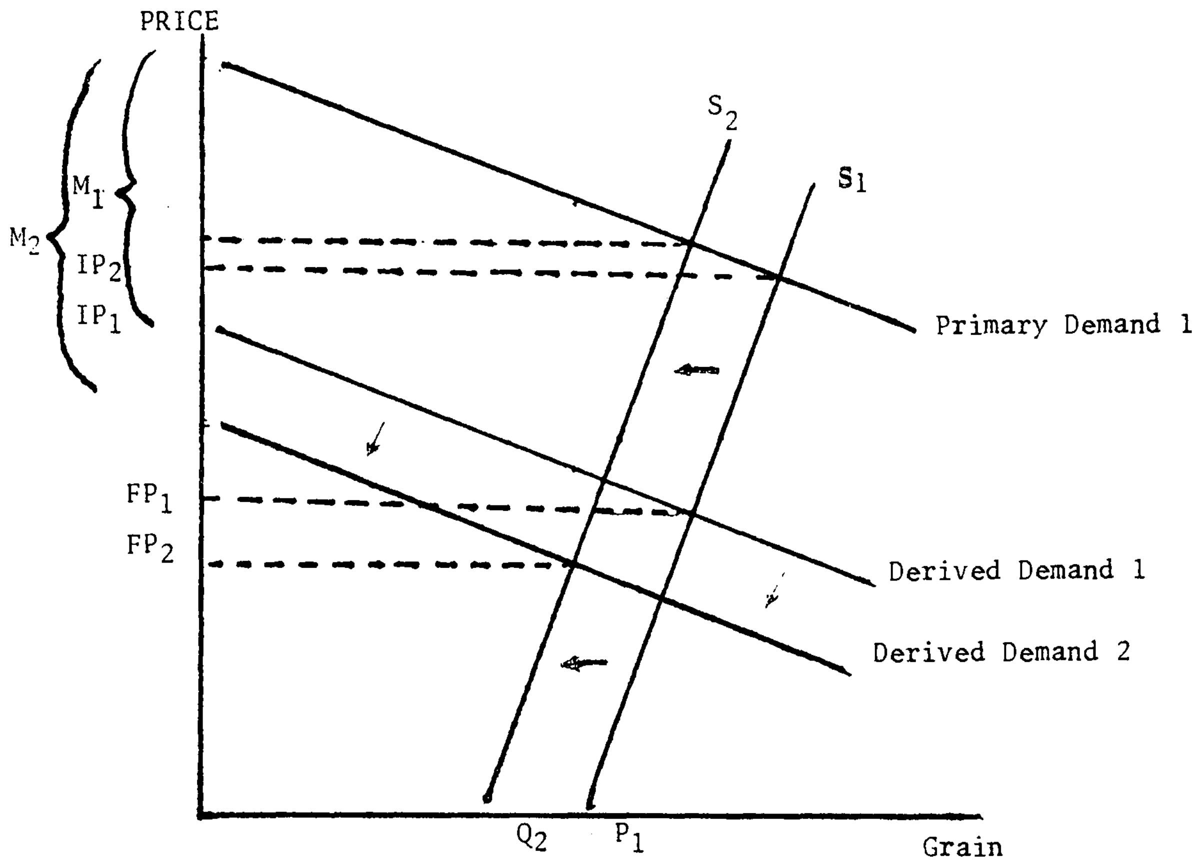


Figure 7. Incidence of increased marketing margins caused by rising ocean freight rates.

where:

FP = Farm Price
IP = International Price
M = Marketing Margin
DD = Derived Demand
PD = Primary Demand
S = Supply
Q = Quantity

crease speed to conserve fuel, and may undertake repairs and maintenance which had been put off when rates were higher. Some tonnage will leave the immediate market in search of higher rates on other trade routes. Tramp operators may cancel orders for new ship construction and either lay up or scrap their least efficient ships. Those ships which remain in the trade will accept any charter which pays a rate sufficiently high to cover variable costs and make some contribution toward fixed costs, in this way minimizing their losses.

If a sudden increase in aggregate demand for shipping were to occur, the lengthy construction process would mean that the supply of tonnage would remain relatively fixed in the short run, leading to a rapid increase in rates, most likely to a level above average total cost. It is the impact of changing magnitude of demand for tramp tonnage on rates that has led Metaxas and others to hypothesize that short-run ocean freight rates are primarily demand determined.

In keeping with this concept, the model developed for ocean freight rates for grain exported from Lower Columbia River ports includes both a measure of regional demand for tramp shipping and cost-of-service information. It is the inclusion of this demand component, as well as qualitative information on other factors influencing rates, which delineates the model from a pure cost function. Cost factors, which are included in the function, are what Cufley (6) calls "voyage expenses" (bunker fuel, loading, discharge), as opposed to "running costs" (wages, stores, deck and engine room supplies, provisions, insurance). The model was originally hypothesized as:

Rate per cargo ton = f(DIST, TON, LD, DWT, AGE, DTH, P, T. FUEL, F, EX S)

where:

DIST = distance to destination port

TON = shipment size in long tons

LD = lay days

DWT = ship size in deadweight tons

AGE = age of the ship

DTH = maximum depth at destination port

P = size of the port

T = terms of shipping

FUEL = bunker fuel price in dollars per barrel

F = flag of registry

EX = U.S. west coast grain exports

S = Quarter of the year

Distance

The distance of shipment is frequently the base for rate determination in shipment of commercial goods and is representative of the degree of variable costs to be incurred by the transportation operator. Bressler and King (4) have noted three common relationships between distance and rates (see Figure 8). The first (Function 1) is the continuous, positively-sloped, linear function. The second (Function 2) is the positively sloped, discontinuous step function where all rates within a given zone are equal. This type of freight rate system is often utilized by railroads. The third (Function 3) is the continuous, curvilinear function where freight charges increase at a decreasing rate with distance. This type of function often occurs when there are high fixed costs, as in ocean shipping, and was the hypothesized relationship for the analysis presented here. It is assumed that shippers wish to take the shortest possible route to their destination, since grain has low per unit value and transportation costs make up a larger proportion of the landed price than many goods of higher unit value.

Although the impact of distance has, until recently, decreased as a factor in ocean shipping with the introduction of improved propulsion systems and ship design, it is expected that this trend is reversing, due to rapidly rising bunker fuel prices.

Shipment Size

It is generally recognized that ocean shipping benefits from economies of size. The existence of economies of size have not been the subject of debate in recent literature; rather, it is the extent to which these economies occur. Harrer and Binkley used size of shipment as a proxy variable for vessel size to determine the optimal size grain shipment and the range of size economies. Although size of shipment and vessel size are probably well correlated in aggregate, grain shipments occasionally move in small consignments as part-cargoes. In these instances, shipment size has little to do with the size of the tramp vessel.

During rate negotiations, an agent for the cargo shipper may try to convince the shipowner a lower rate is in order since the marginal cost of transporting the small consignment with another cargo is very

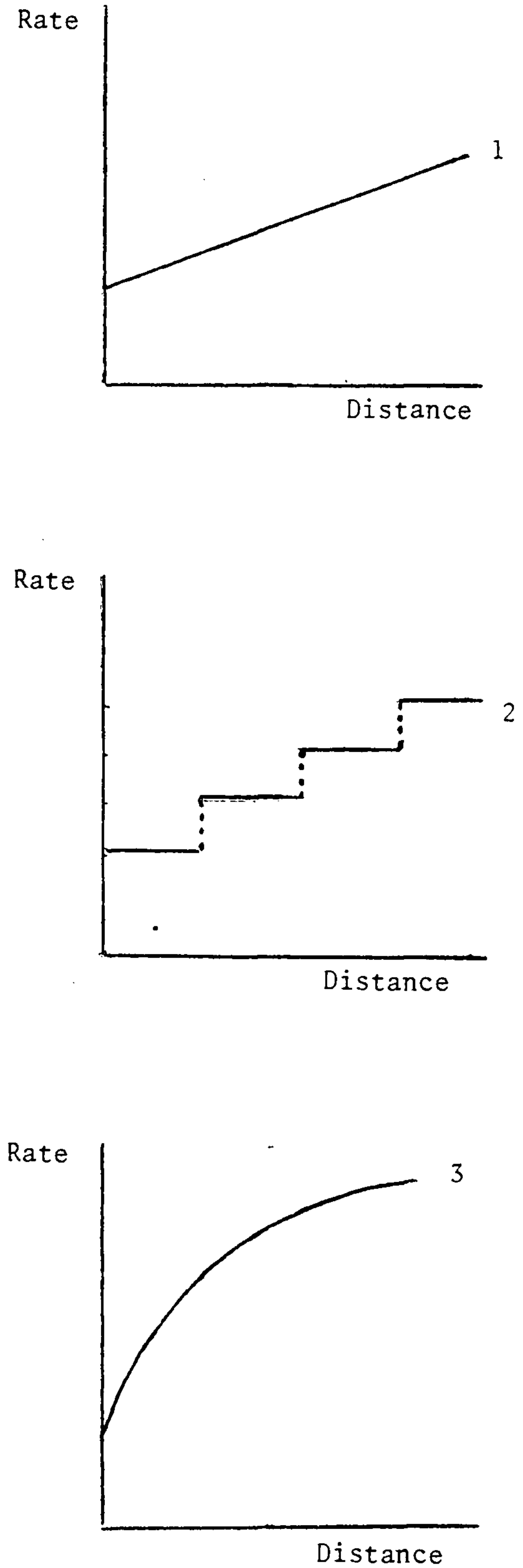


Figure 8. Alternative rate-distance relationships.

low. Conversely, a shipowner may ask for more than the market rate because the handling costs for a small consignment would make up a high proportion of the earned revenue. To determine whether shipment size or size of the vessel has greater impact on freight rates, a variable measuring vessel size was included.

Vessel Size

The cargo-carrying capacity of a ship is measured by its dead-weight tonnage (DWT), the difference between the displacement light and the displacement loaded in tons of 2,240 pounds. The average size of bulk carriers has been growing rapidly, with a phenominal increase in the 1960's. From 1964 to 1968, the percentage of bulk carriers in the world fleet over 10,000 DWT nearly doubled.

Economies of scale in ship design can be demonstrated by examining hull resistance and cargo carrying capacity of different size ships. A rule of thumb states that resistance increases with the square of hull dimensions, while cargo carrying capacity increases with the cube. Table 1 illustrates how large increases in cargo carrying capacity can be achieved with relatively small increases in hull resistance.

By increasing vessel size from the small liner to the large tanker, cargo carrying capacity increases 80 times, while hull resistance increases only 15 times. This allows for a lower proportion of fuel consumption per ton of cargo carried.

However, the economies to be gained from increasing ship size apparently are not unlimited. Goss and Jones (10) found economies of size for dry bulk carriers up to 80,000 DWT. Harrer and Binkley's

Table 1.

INCREASES IN SHIP RESISTANCE AND CAPACITY

	Submerged Hull Square	Resistance Index	Cargo Carrying Capacity	Capacity Index
Small Liner	528 sq. ft.	1	2,500 tons	1
Large Liner	1,404 sq. ft.	2.7	10,000 tons	4
Dry Bulk	3,995 sq. ft.	7.6	60,000 tons	24
Large Tanker	7,824 sq. ft.	14.8	200,000 tons	80

Source: Marine Engineering Log. 1966-1968 issues.

study stated that grain shipments over 50,000 tons are subject to higher freight rates than smaller shipments. Several factors may contribute to limit size economies. Insurance costs rise significantly with vessel size, as well as maintenance costs. The expenditure required to maintain a vessel of 100 feet overall length is approximately five times that required to maintain a vessel of 50 feet overall length. Once a vessel reaches a certain displacement, it becomes necessary to introduce twin screws, which can add greatly to engine room and fuel consumption costs.

Another limitation extremely large bulk carriers face is that, to effectively utilize them, they must carry consignments that are much larger than those customarily ahndled. Existing grain storage and handling facilities at many import marine terminals may be strained to the point of gross inefficiencies, leading importers to prefer smaller, more frequent shipments.

Draft, or the distance between a ship's waterline and the bottom of the hull, provides the most important constraint to ship size. The largest of the bulk carriers cannot call on many of the world's ports because of insufficient depth. Ship designers are attempting to circumvent this problem by building bulk carriers as wide as they can, consistent with good sea-going qualities.

Gripaios (11) points out that there can be significant advantages to using smaller ships. When port facilities are limited, small vessels may be able to load closer to the point of origin and discharge closer to the point of final destination, saving on transhipment costs.

For short voyages, the time spent in port loading and unloading becomes more important (terminal costs become the major portion of voyage expense). In many cases large vessels and small vessels will load and discharge the same number of tons per hour. Since total daily operating costs of smaller ships are less than those of larger ships, smaller ships may have an advantage in this respect.

Finally, flexibility is an important aspect to tramp operations. Ships will often leave geographical market for another on the prospect of more cargoes or higher rates, making the ability to transit the Panama and Suez Canals highly desirable.

The smaller Panama Canal dimensions limit ship size to roughly 55,000 DWT.

Port Depth

The Lower Columbia River provides a natural harbor with excellent shelter, and has been a major grain export terminal since the 1830s. Because of turbulence while crossing the Columbia River bar, the U.S. Army Corps of Engineers currently maintains the mouth of the river to a depth of 48 feet, while the lower river channel is maintained to a depth of 40 feet.

A study of Oregon ports, by Ogden Beeman and Associates, and Manalytics, Inc. (1), found that, in 1977, nearly 85 percent of the grain vessel trips on the Lower Columbia River were made by vessels of less than 30,000 DWT, with average design drafts of 33.4 feet or less. The channel depth provides a practical limit of approximately 50,000 DWT, so that it appears vessel operators are not pushing the Columbia River channel limits to obtain economies of size. The above mentioned

Table 2.

PHYSICAL LIMITS OF THE PANAMA AND SUEZ CANALS

	Beam	Draught	Length
Panama Canal	104 ft.	36-38.5 ft.	835 ft.
Suez Canal	128 ft.	40 ft.	900 ft.

study concluded that current channel depths do not provide a constraint to waterborne commerce. Rather, it is the ports of the grain importing countries that are likely to constrain the size of the vessel to be employed. Within the sample, 92 percent of the destination ports of Lower Columbia grain export shipments had depths of less than 40 feet. Grain shipments to some less developed countries require ships of under 15,000 DWT. If larger vessels are used, they must either limit their draft by taking on less than a full cargo, or they must anchor offshore at their port of destination and be unloaded by lighters or barges, a time-consuming and costly process. To examine the influence of port depth on transportation costs, the greatest useable depth alongside the pier at the destination prot was included as a variable.

Port Size

A matter of great importance to the tramp ship operator is the liklehood of obtaining another cargo at the same port where his chartered voyage is completed. If he is unable to locate a cargo, he must leave "in ballast" (empty), and steam to a port where cargo is available, incurring additional crew, fuel, and capital costs without further compensation. It is reasonable, therefore, to assume that the size of the charter destination port is one indicator of the likelihood of finding another cargo. Larger, more developed ports tend to be located on major trade routes and deal in greater varieties and volumes of cargo than smaller ports. They also are more likely to have fast, modern equipment to unload and load the vessel, thereby decreasing turnaround time and minimizing port fees and longshoremen labor costs.

A tramp ship operator who expects to incur additional expenses of increased port time and/or a voyage "in ballast" by calling on a small port will naturally attempt to pass them on to the charterer. When the market allows, he is likely to demand a premium for such a voyage. Accordingly, an indicator variable for port size was constructed, using a classification by the U.S. Defense Mapping Agency.

Charter Terms

An important point of negotiation between a ship operator and charterer is to determine which of the two will pay for the loading and unloading of the cargo. Three basic arrangements are called "free-in-and-out", "free discharge", and "gross terms". A contract specifying "free-in-and-out" means that the charterer is responsible for loading and unloading. "Free discharge" contracts require the ship operator to pay for the loading, and the charterer for the unloading. Both loading and unloading are paid for by the ship operator under "gross terms." The rate per ton negotiated will depend on the degree to which the ship operator assumes loading and unloading costs. Nearly all Lower Columbia River shipment are by free-in-and-out or free-discharge terms. The rate for a charter with "free-in-and-out" terms is expected to be lower than an identical charter with "free discharge" terms.

Lay Days

Lane Kendall (17) has noted that the term, "lay days", is used in two different contexts. It is used to denote the dates specified in the charter contract for delivery of the ship, and to denote the number of days allowed in port for loading and unloading. Not surprisingly, this has led to some confusion in the literature. It is the first interpretation that will be used in this model. The majority of Lower Columbia River grain export sales are concluded on a free-on-board (FOB) basis. If a vessel does not arrive at the export elevator within the contracted time period, the importer must pay the exporter for additional storage and a penalty charge of the prime lending rate plus 2 percent on the dollar value. In turn, the chartered vessel operator, in some cases, must pay the charterer or importer a previously agreed upon penalty for delivering his vessel late. Therefore, it is to the ship operator's advantage to negotiate as many lay days as possible to avoid the possible penalty. If the charterer specifies a very short lay day period, the ship operators may require a higher rate as a risk premium.

Ship Age

The age of a vessel can affect costs and ultimately freight rates in several ways. However, there is some disagreement in the literature about age having a positive or negative impact on rates. O'Loughlin and Metaxas have noted that it is the smaller, older ships which are the first to lay-up in a period of low freight rates because of their higher costs of operation. Gripaios (11) agrees, stating that, "newer ships are cheaper to operate because they are more fuel efficient, require less maintenance and repair, are larger, and are more likely to be designed to a specific trade." Heaver (14) believes that the size of crew, and thus labor costs, are lower for new ships since they are more highly automated. On the other hand, while treating the topic of capital costs and depreciation, L. Kendall asserts that the sooner a ship's value is written off, the more quickly the owner is able to compete for cargoes in the bad (low rate) years. This implies that older ships, having lower capital costs, would be more cost efficient to operate in periods of low rates. As previously mentioned, there has been a substantial increase in the standard size of bulk carriers over the last 20 years. If on-average, newer ships enjoy the lower fixed costs per deadweight ton accorded to large vessels, as well as lower variable costs of operation, it is expected that rates vary positively with ship age.

Price of Fuel

The cost of bunker fuel looms large in the expense accounts of any tramp ship operator. A July 15, 1979 Presidential Report to Congress on U.S. competitiveness in world agricultural trade stated that, "energy costs, particularly for ocean carriers, now constitute the single largest percentage increase of all components of increased transport costs." Costs of bunker fuel rose 60 to 100 percent in the first 9 months of 1979, even though basic crude oil prices showed relatively little change over that period. Darhanian and Gaibler (7) have noted that many charters' agreements now include a rate escalation clause for increasing bunker fuel costs. Contrary to Binkley's (3) assumption, shipping input prices may vary substantially within the same port region. As described by L. Kendall, the price of bunkers in a port of shipment origin will determine the amount of cargo a vessel operator will take on, and his voyage plan. If bunker fuel is relatively cheap, he will trade off some cargo for an increased load of fuel, or, if fuel is expensive, he will take on more cargo and less fuel, planning to stop at a port with cheaper fuel at some point during the voyage. If no "cheap fuel" port is in the proximity of his voyage route, he will likely try to obtain a higher rate of compensation.

An influence on rates, more subtle than the direct passing-on of rising fuel costs, is the way vessel operators have adjusted operations. Bes (2) has noted that bunker fuel consumption varies with the cube of speed. Vessel operators have found significant savings in fuel costs can be achieved by lowering speed, which, in turn, lowers the number of boyages tramp ships can make in a given time period. This effective reduction in the supply of shipping services may exert some influence to raise ocean freight rates.

Flag of the Vessel

The demand for s shipping service supplied by a particular foreign flag is, in the absence of national restriction or preference, infinitely elastic. An unpublished M.S. thesis by Harrer (12) found that there was not significant difference between rates charged by foreign flag ships, supporting the premise of homogeneity of service in a competitive tramp shipping market. However, the United States operates a complex system of cargo preference and shipping subsidies which, in effect, create a separate market for U.S. flag shipping services.

Section 901 of the Merchant Marine Act of 1936 requires that 50 percent of U.S. government cargoes move on U.S. flagships. USDA-AID grain shipments under PL-480 are subject to this 50 percent requirement so that a comparatively larger percentage of wheat shipments from the Pacific Northwest move by U.S. flagship. Legislation in practice requires that ships operating under the United States flag be built domestically and manned by citizen crews, creating a large cost differential between U.S. and foreign flagships. Kilgour (19) has stated that the rates for government-sponsored cargoes lifted by U.S. flag tramps are perhaps twice those of foreign flagships.

Grain Exports

A measure of the supply of tramp shipping services would be the total tonnage operating at any given time, requiring continuous information on the tonnage of ships newly constructed, the tonnage of ships laid up, and the tonnage of ships scrapped. Unfortunately, this kind of information about tramp shipping is not readily available, but an indicator of the equilibrium quantity of tramp shipping services demanded is available. Grain is one of the largest commodities in tonnage transported by the tramp shipping industry. With the inclusion of U.S. west coast grain exports, the influence of fluctuations in demand for international transportation of grain on freight rates should be tracked. It would be expected that an increase in grain export tonnage or, equivalently, an increase in the quantity of shipping services demanded, would result in a rise in freight rates.

Season

Even though improved storage facilities have done much to even out seasonal variation in world grain shipments, a seasonal trend still exists in grain export volumes and ocean freight rates. O'Loughlin (26) examined world ocean freight rates from 1950-1965 and found that peak rates tend to occur in the last quarter of the year when grain export shipments in the Northern Hemisphere are heaviest. Binkley and Harrer's (3) model based on U.S. export shipments provided similar results, with a seasonal low in ocean freight rates the first quarter of the year and a seasonal high occurring in the final quarter corresponding with peak export volumes.

Seasonality in commodities other than grain may have great impact on the freight rates available to grain shippers. Couper (5) describes how timber, petroleum, and coal movements are greatest in the summer and fall, coinciding with the height of Northern Hemisphere agricultural shipments. To some extent these commodities compete for carriage for a relatively inflexible supply of world tramp shipping capacity.

Both the U.S. west coast and the Lower Columbia River exhibit a seasonality trend in grain exports. Although ice does not plague the Columbia as in the St. Lawrence Seaway and the Baltic, winter storms in the North Pacific do occasionally slow or halt shipping activities. Summer grain harvests in recent years have overflowed river elevators and led to piling grain on the open ground. In addition, the U.S. Army Corps of Engineers introduces a unique form of seasonality to Columbia River ports. Maintenance and repairs on the river's lock system occurs every July, closing various segments of the upper river to traffic throughout the month.

The effect of the lock closures on wheat exports is substantial. A yearly low occurs in July, with average monthly volume down by 22-63% for these three years. To the extent that individual port conditions affect ocean freight rates, a third quarter low would be expected in rates for grain shipments from the Columbia. As in the case of world ocean freights, a fourth quarter high is predicted.

Table 3.

WHEAT INSPECTED FOR EXPORT AT COLUMBIA RIVER PORTS

(IN 1000 Bushels)

	1975	1976	1977
JANUARY	28049	26730	17996
FEBRUARY	15539	25977	19614
MARCH	15055	23858	20819
APRIL	18397	17006	20010
MAY	20903	17640	21453
JUNE	10645	15049	14427
JULY	8906	7198	13773
AUGUST	18888	26540	15168
SEPTEMBER	15341	27625	18873
OCTOBER	19394	17505	13841
NOVEMBER	22901	19817	16461
DECEMBER	24024	10988	19482

Table 4. Summary of Hypothesized Signs for Quantitative Variables.

1)	Ho: $\beta_{DIST} > 0$	vs.	Ha: $\beta_{DIST} \leq 0$
2)	Ho: $\beta_{TON} < 0$	vs.	Ha: $\beta_{TON} \geq 0$
3)	Ho: $\beta_{LD} < 0$	vs.	Ha: $\beta_{LD} \geq 0$
4)	Ho: $\beta_{DWT} < 0$	vs.	Ha: $\beta_{DWT} \geq 0$
5)	Ho: $\beta_{AGE} > 0$	vs.	Ha: $\beta_{AGE} \leq 0$
6)	Ho: $\beta_{DTH} < 0$	vs.	Ha: $\beta_{DTH} \geq 0$
7)	Ho: $\beta_{FUEL} > 0$	vs.	Ha: $\beta_{FUEL} \leq 0$
8)	Ho: $\beta_{EX} > 0$	vs.	Ha: $EX \leq 0$

CHAPTER IV

THE DATA AND THE ECONOMETRIC MODEL

Data

Neither the grain industry or the tramp shipping industry are known for seeking public attention. Thus the process of collecting detailed information about individual grain shipments was time consuming and required identification of information sources not commonly used by agricultural economists.

Information on grain charters reported on a weekly basis from 1978 through 1980 was obtained from Maritime Research, Inc. The freight rate per long ton, ship name, destination, commodity, shipment size, lay days, shipping terms, ship registry, and region of origin are reported for individual voyage charters.

All shipments listed as originating from regions other than "U.S. North Pacific" were deleted. Since the U.S. North Pacific encompasses Oregon, Washington, and Canada, additional information was necessary. Each charter was cross-checked with the records of Portland, Oregon district of the U.S. Customs Service to confirm dates and shipments from the Columbia River.

Shipments on Japanese flag vessels were eliminated from the sample since they operate in a market distinct from the international tramp shipping market. The Japanese government practices flag discrimination and heavily subsidizes a Japanese Corsortium of six shipping companies.

According to S.A. Lawrence (22), over 70% of Japanese cargoes move on Japanese ships. In a private telephone conversation, Mr. Takagi (30), manager of Toshoko Grain, stated that ocean freight rates for Japanese owned grain shipments on Japanese flag vessels are consistently lower than those available in the open market.

All shipments where the vessels name was listed as "steamer" (actual vessel to be determined) were not included in the sample because verification of the port of origin was not possible. This was not viewed with concern since vessels listed as "steamer" comprised a very small percentage of the reported shipments, and were usually Japanese flag carriers.

Bagged grain shipments were removed from the sample because of different loading requirements and increased stowage factors.

A final modification of the sample size relates to the method used for estimation of the models parameters. Ordinary Least Squares was belived appropriate since Zannetos (38) and Binkley and Harrar (3) found no major problems with its use and simultaneity does not appear to be a factor.

More than one grain charter was recorded for most weeks between January 1978 and January 1981. To avoid problems with autocorrelation[1/] only the first reported charter for each week was retained in the sample.

Calculation of distances was completed with the aid of <u>Distances Between Ports</u> (33), a U.S. Defense Mapping Agency publication. It

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1/ See Intilligator, Michael, Econometric Models, Techniques and Applications, 1978, Prentice-Hall, Inc., Edgewood Cliffs, N.J. p. 66.

was assumed that great circle routes would be used to minimize distance, realizing that some deviation would occur to avoid weather fronts, canal tolls, or loadline limits.

Ship size and ship age were obtained from Lloyd's Shipping Index (1981), and two U.S. Department of Commerce publications, Bulk Carriers in the World Fleet (35), and Vessel Inventory Report (36). While various sizes of ships were well represented in the data sample, the majority were under ten years of age. This may reflect a trend for ships to be designed specifically for the Asian grain trade.

Weekly prices for intermediate grade bunker fuel in Seattle, Washington, are reported by Platts Bunkerwire of New York. Seattle, Washington prices were used as a proxy for the unavailable Portland, Oregon prices, since the markets are more closely related than other West Coast ports. Their proximity in location and the pattern of call on West Coast ports means that many ships have the option of refueling in either Portland or Seattle. A large price differential between these ports would drastically reduce sales in the higher priced of the two, and introduce the possiblity of cross-hauling bunker fuel.

Nearly all grain export shipments are inspected and recorded by the United States Department of Agriculture. Total volume shipped is reported by port in the national edition of "Grain Market News," published by the Agricultural Marketing Service, U.S. Department of Agriculture.

The maximum depth at a cargo pier of the destination port and a rating of port size were found in the World Port Index (1980).

Qualitative information (port size, shipping terms, flag of registry, and season) was incorporated into the model by constructing indicator variables. A rating of port size as small, medium and large is provided by the World Port Index based on several applicable factors including total area, facilities and wharf space. The small and medium categories were combined for the port size variable.

No indexing procedure to account for inflation was used for the lack of an appropriate index. While ocean freight rates are listed in U.S. dollars per long ton, the international character of the market means that shipping services may be paid for in numerous currencies. The values of some of these currencies are pegged to a vehicle currency like the U.S. dollar, while others float freely and have their value determined in the international money market. It is not uncommon for charter agreements to be made up to a year in advance, lacking in a rate oblivious domestic inflation or the fate of the dollar in the international money market.

Nearly all Columbia River grain shipments are Free-on-Board, where the importer is responsible for ocean transporation. To use a U.S. price index for ocean freight rates paid to foreign nationals in foreign currencies for shipping services whose major inputs are purchased in foreign countries would likely introduce extraneous variation.

Econometric Model

The model was estimated on the basis of 112 observations of single voyage charters originating from the Columbia River. During some weeks, including Christmas, no grain charters were reported. This might result in some bias of the coefficients for very short run analysis, but

Table 5. Summary of Data Description.

1. Ocean freight rates are listed in nominal U.S. dollars per long ton of cargo.

2. All shipments were verified as originating from the Lower Columbia River ports of Portland, Oregon, Astoria, Oregon, Vancouver, Washington, Kalama, Washington, and Longview, Washington.

3. The following types of shipments were excluded from the sample:

   a) Japanese flag carriers.

   b) Shipments with vessel name listed as "steamer."

   c) Bagged grain shipments.

4. Only the first reported and verified grain charter for each week was used for the sample.

5. All distances were calculated using great circle or shortest distance routes.

6. Seattle, Washington bunker fuel prices in U.S. dollar per barrel were used as a proxy for Lower Columbia River bunker fuel prices.

7. Ordinary least squares was used to estimate the model, with indicator variables accounting for qualitive effects.

but the missing weeks are nonconsecutive and should not be a problem as long as only those coefficients with mostly short run influence are interpreted over the short run.

The variables for ship size (DWT) and size of shipment (TON) were included in the model, recognizing a high degree of correlation between the two. This was done with the goal of determining which has a greater impact on ocean freight rates. Similarly, the terms distance (DIST) and distance squared (DIS2) are highly correlated, but were included in the model to examine the functional nature of their impact on ocean freight rates.

<u>Equation One</u>

RATE =		6.749 DIST	-	.287 DIS2	-	.568TON	-	.306 LD
std. error:		(1.836)		(.123)		(.158)		(.181)
t-statistic:		3.68		-2.32		-3.59		-1.69
	+	.148DWT	+	.123 AGE	+	.047 DTH	+	1.957 FUEL
		(.114)		(.126)		(.099)		(.149)
		1.29		.97		.47		13.05
	-	.022 EX	+	47.51 F	+	2.259 P	+	1.902 T
		(.007)		(3.045)		(1.541)		(1.527)
		-2.97		15.70		1.46		1.25
	-	2.139 S_2	-	3.805 S3	-	4.101 S4	-	17.151
		(1.777)		(1.750)		(1.697)		(8.449)
		-1.20		-2.17		-2.42		-2.03

R-Squared = .909 F-Statistic (15,96) = 64.01

where:

DIST = Distance of shipment in 1000's of miles
DIS2 = Square of the distance
TON = Shipment size in 1000's of long tons
FUEL = Price of bunker-C fuel in dollars per barrel
EX = West coast U.S. grain exports in 1000's of long tons
DWT = Vessel size in 1000's of deadweight tons
LD = Number of lay days
AGE = Age of the vessel in years

DTH = Destination port depth alongside the cargo pier
F = Indicator variable for U.S. flagships
P = Indicator variable for small sized destination ports
T = Indicator variable for free discharge terms
S2 = Indicator variable for July through September shipments
S3 = Indicator variable for October through December shipments
S4 = Indicator variable for January through March shipments

The high standard errors and low t-statistics on several of the variables (AGE, DTH, P, T) suggest the possible existence of multicollinearity in equation one. Multicollinearity is the result of two or more of the independent variables being correlated, and leads to unbiased but inefficient estimators. With the presence of this correlation, the coefficient of any independent variable depends on which other independent variables are included in the model, and may represent only a portion of its true affect on the dependent variable. The symptom of large standard errors may result in some or all variables being unduly rejected on the basis of t-tests. A three stage Farrar-Glauber test for multicollinearity on equation one indicated the existence of the problem (Appendix I). Intrilligator (16) has noted that in the absence of additional data or other a priori information, multicollinearity may be diminished by dropping explanitory variables from the model. As previously mentioned, a high degree of correlation was expected between shipment size (TON) and size of the vessel (DWT), since they convey very similar information.

Additional regressions were run, including log-log and linear transformations of the model. To examine the effects of multicollinearity on equation one, all variables were kept in the model with the exception of either vessel size or size of shipment. Vessel size became statistically significant with the exclusion of size of shipment, but greater explanitory power and a higher t-statistic was obtained with the retention of size of shipment and deletion of vessel size. There are at least two possibilities for why vessel size exhibits a relatively smaller impact on ocean freight rates than shipment size. If the market is extremely competitive, the most efficient vessels will tend to be the long run price setters for ocean freight services. In the short run, vessel size may have a lesser influence on individual rate negotiations then"the going market rate". Secondly, the existence of "part cargo" shipments (less than a shipload) in the sample may serve to obscure the impact of vessel size on ocean freight rates since potential economies of size are not obtained with underutilization of the ship.

Equation Two

Equation two is essentially a reduced form of equation one with changes in the statistical significance of two variables. The deletion of vessel size from the model led to port size gaining statistical significance and terms of shipping losing significance at the .95 level. A Farrar-Glauber test indicates a reduced degree of multicollinearity (Appendix A).

RATE =	6.576 DIST	- .280 DIS2	-.362 TON	+ 1.843 FUEL
standard error:	(1.788)	(.121)	(.067)	(.139)
t-statistic	-5.43	-2.33	-5.43	13.26
	-.021 EX	+ 50.517 F	+ 2.157 P	- 1.337S2
	(.007)	(2.631)	(1.317)	(1.718)
	-2.99	19.24	1.64	-.778

-3.133S3	- 3.412 S4	- 16.75
(1.709)	(1.648)	(6.763)
-1.83	-2.07	-2.48

R-Squared = .903 F-Statistic (10,101) = 94.37

An examination of graphs of error terms against lagged error terms, the endogenous variable, and the individual exogenous variables show no indication of autocorrelation, contemporaneous correlation, or heteroskedasticity.

A Goldfeld-Quandt test for heteroskedasticy was applied to equation two and the null hypothesis of heteroskedasticy was rejected (Appendix II).

Interpretation

The problem of multicollinearity is common to models containing indicator variables, and will often inflate the standard error the the coefficients so that few of them are significantly different from zero when a t-test is applied. It is theoretically inappropriated to make any strict interpretation of the separate influences of exogeneous variables in multicollinear models. However, Kmenta (20) states that "the meaningful distinction is not between the presence or absence of multicollinearity, but between its various degrees." Equation two does not suffer from large standard errors and insignificant t-values, so that some inferences of the model will be made.

Four of the hypothesized variables were not statistically significant at the .95 level. This lack of statistical significance should not be interpreted as determining the variable is unimportant in the formation of ocean freight rates.

The failure of "lay days" to enter the model might be explained by a tendency for an unnecessarily large number of lay days to be specified in the charter agreement. It is not uncommon for as many as 30 days leeway to be allowed for the date of vessel delivery, posing little inconvenience or risk to the vessel operator.

The comparative newness of the tramp ships carrying cargoes of grain from the Columbia River may be the reason why the coefficient of AGE was not significantly different from zero. Approximately 70 percent of the sampled calls were by grain vessels under ten years of age, which may have provided too little variation to be statistically significant. Still, the fact that so many vessels are new would lead one to believe that ship age must be important to efficiency of operation.

As previously described, port depth is a major limitation on economies of size in shipping and would be expected to affect rates. Yet, when both the export and import terminals are of similar depth, the impact of port depth on rates is likely to be obscured. The average cargo pier depth at ports of destination is 33.3 feet, providing a relatively small decrease from the maximum draft available on the Columbia River. Since 85 percent of the grain ship calls on the Columbia had design drafts of 33.5 feet or less, it appears that economies of size in grain ships have not been fully exploited in this trade route. Perhaps this is a partial explanation of why the variable DTH was statistically insignificant.

Shipping terms are very important to any rate negotiation, and the absence of statistical significance is puzzling. In several of the model formulations tried, the variable T was marginally significant, which suggest the possibility of a multicollinear relationship distorting the test for significance.

The remaining seven variables were statistically significant at the .95 level. Distance, as expected, was very important in rate determination. The model indicates that ship operators charge $6.29 ($6.57 - $.28 DIST) for the first 1,000 miles they haul grain from the Lower Columbia River. Prior to the late 1970's, distance as a factor in ocean freight rates was thought to be declining through more efficient vessel design. The phenominal increases in bunker fuel prices from 1977-1980 may have reversed this trend. Harrar (12) estimated the rate charged for shipping increases by approximately $1.13 to $1.42 for every thousand nautical miles of ocean voyage using time series data on grain shipments from U.S. ports between 1972-1976.

A distance squared term DIS2) was included in the model to determine the functional relationship of distance to ocean freight rates. Many trade models assume transportation costs are a linear function of distance, which would lead to a lack of statistical significance for the distance squared term. The negative sign on DIS2 and significance at the .975 level supports the hypothesis that freight charges increase with distance at a decreasing rate (Figure 1). Solving for the first derivative of the distance parabola equation set equal to zero yields the point where maximum charges for distance occur.

$$\frac{\partial RATE}{\partial DIST} = 6.576 - 2(.280)DIST = 0$$

$$DIST = 11.743$$

According to the above function, the portion of ocean freight rates from Columbia River ports attributable to distance reaches its maximum at 11,743 miles, which is approximately halfway around the world. This result has intuitive appeal, since destinations of greater distance could be more easily reached by travelling in the opposite direction.

The existence of economies of size in ocean shipping is supported by the negative sign on the coefficient of shipment size (TON). On average, the rate received by tramp ships will be reduced by approximately 36 cents/ton for every additional 1,000 tons of grain shipped, all other factors being held constant.

The model indicates that bunker fuel costs are very important in rate making, as would be expected in a competitive market. A one dollar per barrel increase in the price of bunker fuel leads to $1.84 per ton increase in ocean freight rates. While efforts are being made to reduce vessel fuel consumption through satellite navigation, improved weather information, slower operating speeds, better propulsion and ship designs, bunker fuel prices appear to have a substantial and sustained effect on ocean freight rates.

The negative impact of west coast grain exports on rates from Lower Columbia ports was unexpected. A 1000 ton increase in weekly U.S. west coast grain exports results in a 2 cent per ton decline in ocean freight rates. In 1980, weekly west coast grain exports ranged from 250,400 tons to 688,248 tons, providing a potential fluctuation of $8.76 per ton based on this variable. One possible explanation is that increasing grain exports from the U.S. west coast draws tramp vessels out of the Gulf of Mexico and other trade routes, leading to increased rate competition in the North Pacific.

U.S. flagships operating out of the Columbia River appear to have a very large rate differential with foreign vessels. In the sampled shipments, American flagships received about $50.62 per ton more than foreign flagships would for similar voyages. This figure is consistent with Kilgour's assessment that subsidized U.S. flagships receive approximately twice the rate paid to foreign vessels in the international market. In April of 1980, four U.S. flagships were chartered for over $100 per ton to carry cargoes of grain to Bangledesh from the Columbia River. Yet, even with seemingly exhorbitant rates, the U.S. dry bulk shipping is still on the decline. In 1980, the U.S. dry bulk fleet consisted of only 18 vessels, 12 of which were over 30 years old. A normal lifespan for a dry bulk carrier is approximately 20-25 years. Legislation restricting U.S. flagships to citizen crews, domestically built ships, and repairs in domestic shipyards has made even subsidized operation under the U.S. flag unattractive to most U.S. shipowners. Instead, the majority of U.S. owned tonnage is registered under so called "flags-of-convenience". Countries such as Panama, Greece, Singapore, and Liberia encourage foreign owned vessels to register under their flag through financial incentives. For example, a vessel may be registered under the Liberian flag within 48 hours of application; there is no income tax, no resident ownership or corporate meeting requirements, and the U.S. dollar is the national currency. Over 30% of Liberian registered tonnage is U.S. owned, and Liberia is the world's leading maritime nation for total deadweight tonnage.

Since many U.S. Department of Agriculture and Agency for International Development grain shipments under PL-480 go to distant, less developed countries with limited port facilities, part of the U.S. flag rate differential may be the result of higher terminal costs. The remainder is the result of the different cost structure imposed by U.S. maritime policy.

Voyage charters with large destination ports cost shippers about $2.16 per ton less than equivalent voyages going to smaller ports. As previously mentioned, larger ports are more likely to have outbound cargoes, modern equipment for unloading and loading, machinery and parts for repairs, drydock facilities, and medical care.

The indicator variables for season at shipment provided some interesting and unexpected results. Ocean freight rates available for 1978-1980 grain shipments from the Columbia do not follow the world market trend of an annual peak in the last quarter of the year. Fourth quarter shipments (October through December) achieve a rate lower than April through June by an average of $3.13 per ton. Grain shipments from January through March achieve rates approximately $3.41 per ton less than April through June shipments.

The t-statistic for the coefficient of third quarter shipments was not significant even at the .80 level, so that there may be little or no difference between rates obtained in the second and third quarters of the year. As in the Binkley and Harrar analysis, the lowest rates tend to occur in the first quarter. One conclusion from this is that peaks in ocean freight rates for grain do not necessarily coincide with peaks in export volumes.

Although the constant term does not explain any particular influence, it is noteworthy. The fact that the model utilized for this analysis is not a pure cost function precludes any interpretation of the constant as fixed cost, as in Harrer and Binkley. A strict interpretation of the constant term as an intercept would require extrapolation beyond the relevant range of data. Therefore, the negative sign on the constant term in no way contradicts economic theory.

Because of the wide variability of ocean freight rates, a elasticity calculated at the mean may allow a more useful comparison of the quantitative variables. The elasticity represents the percentage change in freight rates given a one percent change in the explanatory variable (Appendix III).

Distance appears to have a greater impact on Columbia River shipments than in the deBorger and Nonneman analysis for major world export regions (.60 vs. .38). The previously mentioned partial shift of grain export flows towards the Columbia River may testify to growing importance of distance in ocean freight rates for this port area.

Although Harrer did not include elasticities in his analysis, it was possible to calculate an elasticity of the mean for size of shipment from the data presented on 1976 Far East shipments originating from North Pacific Ports (Appendix III). The elasticity for size of shipment in table four indicates greater discounts for volume on the Columbia River than the -.04 elasticity for the North Pacific region based on Harrer's model.

Bunker fuel has not been included in previous statistical

Table 6. Elasticities At The Mean.

Distance	=	.60
Size of shipment	=	-.26
Bunker fuel price	=	.99
W.C. grain exports	=	-.24

analyses of ocean freight rates, yet it appears to have the greatest impact of all the variables. A one percent rise in the price of bunker fuel leads to a one percent rise in freight rates. To the extent that bunker fuel prices vary consistently between ports, this difference is likely to be reflected in port specific freight rates. In addition, the imposition of fuel based waterway user charges may be a suboptimal method of recovering waterway maintenance costs. Any such charge will be fully referred through higher port specific freight rates, affecting the competitive position of Lower Columbia River ports.

The elasticity for west coast grain exports indicates a one percent rise in grain shipments leads to about a quarter of a percent decrease in Columbia River grain freight rates. This variable was designed to measure equilibrium demand, but may alternatively be interpreted as reflecting volume of trade. P.M.H. Kendall hypothesized increased volume of trade reduced freight rates, which was subsequently confirmed in the Binkley and Harrer analysis. The negative impact of volume of trade on ocean freight rates may be greater than the positive influence of rising demand for Columbia River ports. This in turn has implications for the elasticity of supply for tramp tonnage.

CHAPTER V

SUMMARY AND CONCLUSIONS

The introduction to this thesis provides a brief description of the tramp shipping market and the growing importance of the Lower Columbia River as a grain export corridor to Asia. Developments in both the international tramp shipping market and domestic surface transportation modes appear to be the cause for a switch in grain export flows away from traditional U.S. Gulf and Great Lakes corridors. Although ocean transportation currently makes up as much as 20% of the landed price of grain in an importing country, no previous analysis of port specific ocean freight rates have been completed.

To assist in the development of the model, a summary of theory relevant to tramp shipping and the impact of ocean freight rates on grain export volumes and prices was presented. Included in the hypothesized determinants of ocean freight rates was an important input price (bunker fuel), under the assumption that the supply of shipping to a specific port may be more elastic than in the shipping market as a whole.

Ocean freight rate data for 112 single voyage charters originating from the Lower Columbia River was developed by comparing North Pacific ocean freight fixtures with U.S. Customs Service records, and additional data sources for newly hypothesized variables were identified. Ordinary least squares regression was used to estimate the model which explained approximately 90% of the variation in grain freight rates from the Lower Columbia River. Seven of the twelve hypothesized variables were significant at the .05 percent level, leading to a number of inferences.

The freight rate differential for U.S. flagships is more than four times that found in the Binkley and Harrer analysis, yet is in keeping with Kilgour's finding that U.S. flagships charge roughly twice the rates of foreign flag vessels. This provides further evidence that U.S. flagships essentially operate in a market seperate from the international tramp shipping market and probably have little impact on international grain transportation as a whole.

Ship owners appear to receive a premium on grain cargoes destined for smaller ports, which tend to be off major trade routes, and have fewer modern port facilities.

Seasonality is still a factor in Columbia River export shipments, with a yearly low in rates occurring from January through March and yearly high from April through June. While the yearly low coincides with that found in the O'Loughlin and Harrer studies for world ocean freight rates, the Columbia River yearly high does not.

Because of the wide range of fluctuation in ocean freight rates, elasticities at the mean were calculated for the quantitative variables. The elasticity for distance (.60) was greater than the distance elasticity calculated by de Borger and Nonneman (.38) for major world export regions.

Similarly, the elasticity for size of shipment (-.26) was greater than the elasticity calculated on the basis of Harrer's model (-.04) of 1972-1976 ocean freight rates for U.S. grain export regions.

The last two variables, bunker fuel prices and west coast grain exports, have important implications for the economic theory of shipping. It has been standard practice in past economic analyses to assume the short run supply of shipping is highly inelastic (8, 13, 25, 26). Yet, the large and significant impact of short run bunker fuel prices on ocean freight rates for the Columbia River indicates short run supply is sensitive to changes in input prices. To the extent that ocean freight rates are determined by costs, the greater the expected elasticity for short run supply of shipping.

The negative impact of increasing grain exports on ocean freight rates provides further evidence that the short run supply of shipping to the Columbia River is not inelastic. If it were inelastic, increasing grain exports would exert a strong upward influence on ocean freight rates, not a negative influence as shown by the data. Jorgan Snitker (28), owner of Tradeship Chartering Inc., has characterized the Pacific ocean as being in a continual state of over supply of tramp shipping tonnage. The swift mobility of this tonnage between trades may explain the apparent elasticity of short run supply. The short run supply of shipping available to any given port is probably more elastic than short run supply available to a given region. Likewise, regional short run supply is more elastic than short run supply available to the world as a whole. Future analyses should take into account the geographic range of their data sample before making assumptions about the supply of shipping.

The estimated coefficients and elasticities for distance, size of shipment, U.S. flagships, and season of the shipment indicate that the determinants of ocean freight rates for an individual port or port area may be structurally different from those estimated from broad regional or world data.

The results of this thesis imply that domestic public policy at both the regional and national levels is capable of influencing international ocean freight rates. Regional port development policy designed to improve facilities may contribute to the reduction of ocean freight rates for imported cargoes and thus reduce prices to consumers. If these improvements allow expansion of grain exports, the increased volume of trade impace on freight rates should reduce the landed price of U.S. grain exports to foreign importers.

To the extent possible, shipping grain out the the Lower Columbia from January through March should enable F.O.B. importers to obtain lower ocean freight rates. Care would have to be taken that additional storage costs did not counter balance any savings achieved. This would also reduce the landed price of grain at the importing country, and improve the competitive position of the Pacific Northwest with other export regions.

At the national level, charges designed to recover waterway maintenance costs should not be based on shipping input prices such as bunker fuel. The calculated elasticity for fuel of .99 shows that such a charge would be fully referred in the form of higherport specific ocean freight rates, with the possibility of causing major shifts in existing trade flows. Instead, some form of fixed cost based user charge appears more desirable, since it would be spread evenly throughout a tramp shipping firm's operations and is not likely to result in changes in the competitive position of individual ports.

The relatively limited amount of economic analysis in the area of commercial shipping leaves many avenues of inquiry open. The decline of oil imports to the industrialized nations has caused a substantial number of modern oil tankers to be unemployed. Many of these are entering the grain trade and may have a significant impact on international grain transportation.

The grain importing patterns of may nations are tied to their foreign currency reserves. It is possible that tramp shipping may be partially affected by the operations of international money markets.

In 1981, ships entering the Persian Gulf received war risk premiums of $25.00-$30.00 per cargo ton because of the Iran-Iraq conflict. World political events such as wars, reconstruction, and the closing of the Suez Canal have caused wide variation in ocean freight rates.

A study of port specific ocean freight rates does not provide an adequate test of the impact of port depth on freight rates, since any size economies would be controlled by the depth at the port of origin.

An analysis of the short run elasticity of supply of shipping for individual ports and port regions would be useful in understanding ocean freight rates.

Finally, this thesis provides strong evidence that the structure of international ocean freight rates for grain may vary across export origins. An estimation of port specific rate functions for ports in the Puget Sound, U.S. Gulf, Great Lakes, Canada and Australia would make possible a comparison of the intensity of impact of freight rate determinants, and lead to the prediction of trade flows to export markets.

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APPENDIX I

Farrar-Glauber Test for Multicollinearity

I. Chi-Square Test for the Presence and Severity of Multicollinearity.

Ho: the samples X's are orthogonal

Ha: the sampled X's are not orthogonal

$$^{*}\chi^2 = -[n-1-1/6(2K+5)] \cdot \log \begin{bmatrix} \text{Value of the} \\ \text{standardized} \\ \text{determinant} \end{bmatrix}$$

where:

χ^2 = Value of chi-squared computed from the sample

n = size of the sample

K = number of explanatory variables

Equation One

$^{*}\chi^2 = 956.49$ $\qquad$ $^2(.05;100) = 124.34$

therefore reject Ho: the X's are orthogonal

Equation Two

$^{*}\chi^2 = 611.894$ $\qquad$ $\chi^2(.05;100) = 124.34$

therefore reject Ho: the X's are orthogonal.

II. F-test for Location of Multicollinearity.

Ho: $R^2_{x_i \cdot x_1 x_2 \ldots x_R} = 0$

Ha: $R^2_{x_i . x_1 x_2 \ldots x_R} \neq 0$

$$F^* = \frac{(R^2_{x_i . x_1 x_2 \ldots x_R})\ (K-1)}{(1 - R^2_{x_i . x_1 x_2 \ldots x_R})\ /\ (n-k)}$$

where:

n = size of the sample

k = number of explanatory variables

<u>Equation One</u>

R-Squared for Independent Variables Regressed on Others.

DIST(.984)	DIS2(.985)	TON(.861)	LD(.180)	DWT(.852)
AGE (.216)	DTH(.481)	FUEL(.553)	EX(.589)	F (.392)
P (.438)	T (.434)	S2(.425)	S3(.395)	S4(.415)

*F-Statistics (13,87)

F (14,87) = 1.79

DIST(444.7)	DIS2(451.7)	TON(43.1)	LD(1.52)
DWT (39.91)	AGE(1.9)	DTH(6.48)	FUEL(8.57)
EX(9.95)	F (4.47)	P (5.4)	T (5.8)
S2(5.19)	S3(4.53)	S4(4.92)	

R-Squared for Independent Variables Regressed on Others

DIST(.983)	DIS2(.984)	TON(.210)	FUEL(.474)	EX(.503)
F (.177)	P (.221)	S2(.382)	S3(.359)	S4(.374)

*F-Statistics (9,102)

F (9, 107) = 1.97

DIST(681.9)	DIS2(695.0)	TON(3.01)	FUEL(10.21)
EX(11.45)	F (2.44)	P (3.22)	S2(7.0)
S3(6.34)	S4(6.76)		

III. Test for Pattern of Multicollinearity

Ho: $r_{x_i x_j . x_1 x_2 \ldots x_R} = 0$

Ha: $r_{x_i x_j . x_1 x_2 \ldots x_R} \neq 0$

$$t^* = \frac{\left(r_{x_i x_j . x_1 x_2 \ldots x_R}\right)\sqrt{n-k}}{\sqrt{1-r^2_{x_i x_j . x_1 x_2 \ldots x_R}}}$$

Equation One

$t(.05,97) = 1.65$

Ho: $r_{x_i . x_1 x_2 \ldots x_R} = 0$ is rejected for:

DIST:DIS2

$r_{x1x2} = .987$

$t = 62.4$

EX:FUEL

$r_{xix2} = .674$

$t = 8.99$

Equation Two

$t(05,102) = 1.65$

DIST:DIS2

$r_{x1x2} = .99$

$t = 70.97$

$r_{x1x2} = .663$

$t = 8.95$

APPENDIX II

Goldfeld-Quandt Test for Homoskedasticity

Goldfeld - Quandt Test

Equation Two

$$F^{*}_{T_a - K_1 T_b \, 1 \, k} = \frac{(\hat{e}'\hat{e})_a / (Ta - K)}{(\hat{e}\hat{e})_b / (tb - K)}$$

where:

$\hat{e}$ = error term
T = sample size
K = number of explanatory variables

Without a priori information on the error variance, the full sample was divided in half to form sample a and sample b.

Ho: $\sigma_a^2 = \sigma_b^2$ vs. Ha: $\sigma_b^2 \neq \sigma_b^2$

$$F^{*} = \frac{406.595 / (56 - 10)}{406.59 / (56 - 10)} = 1.00$$

$$F(.05;\ 9,\ 46) = 2.09$$

If $F^{*} \leq$ 2.09, reject Ha

If $F^{*} >$ 2.09, reject Ho

1 < 2.09, therefore reject Ha

APPENDIX III

Elasticity at the Mean for shipment size from Harrer's Model of 1972-1976 U.S. Grain Exports.

Elasticity at the Mean: Shipment Size

$$\frac{\partial \text{ RATE}}{\partial \text{ TON}} \cdot \frac{\overline{\text{TON}}}{\overline{\text{RATE}}}$$

where:

∂ = partial derivative

$\overline{\text{TON}}$ = mean of ton

$\overline{\text{RATE}}$ = mean of rate

1976

Origin: U.S. North Pacific

Destination: Southeast Asia

Mean Shipment = 12,000 Mean Rate = 39.73

Coefficient of shipment size = .0001303 in equation two.

$$-.0001303 \left[\frac{12000}{39.73}\right] = -.0393$$

Source: Harrer, B. "Ocean Freight Rates and Agricultural Trade." M.S. Thesis, Purdue University, 1979.

APPENDIX IV

Equation One Elasticities of the Mean

Equation One Elasticities at the Mean

Distance	.61
Size of Shipment	-.41
Bunker fuel price	1.04
W.C. grain exports	-.25

APPENDIX V

Data Used in Estimation of the Model

LEGEND

Variable		Column
RATE	Ocean freight rate in U.S. dollars per long ton of cargo.	1
TON	Shipment size in long tons (2,200 lbs.)	2
LD	Days specified for ships arrival at the point of loading.	3
DWT	Ship size in deadweight tons (loaded vessel displacement minus empty vessel displacement).	4
AGE	Age of the ship.	5
DIST	Distance in nautical miles to destination port.	6
DTH	Maximum depth alongside cargo pier at destination port.	7
P	Port size as classified by U.S. Defense Mapping Agency.	8
T	Charter terms for payment of loading and unloading.	9
FUEL	Bunker fuel price in U.S. dollars per barrel.	10
F	U.S. flagships.	11
EX	U.S. west coast grain exports in long tons.	12
S1	First quarter shipments (Jan. - March)	13
S2	Second quarter shipments (April - June)	14
S3	Third quarter shipments (July - Sept.)	15
S4	Fourth quarter shipments (Oct. - Dec.)	16

1400	20000	11	22582	6	5699	28	1030	0	0	0	0	0	262700	1	1
2600	17500	17	19030	3	10024	33	1025	0	0	0	0	0	294080	1	1
1525	25000	11	27910	13	6023	38	1020	0	0	0	0	0	294080	0	0
1375	15000	11	16400	10	4679	13	1015	0	0	0	0	0	294080	1	1
1515	25000	11	27480	7	6023	38	1010	0	0	0	0	0	188860	0	0
1375	15000	13	16103	9	4464	38	1010	0	0	0	0	0	188860	1	0
2547	9642	12	27944	11	7415	33	1000	0	0	0	0	1	188860	0	0
1733	49705	17	74832	11	10024	33	1000	0	0	0	0	0	276567	1	1
1385	18516	11	19674	7	5699	28	990	0	0	0	0	0	340963	1	1
1880	4921	11	5662	2	3868	38	980	0	0	0	0	1	276567	0	1
2750	16000	11	22653	7	11058	28	970	0	0	0	0	0	276567	0	1
2700	14500	16	19500	17	11058	28	970	0	1	0	0	0	276567	0	1
2725	16000	15	20209	15	11058	28	970	0	1	0	0	0	269331	0	1
2750	17000	16	26646	7	11058	28	1000	0	1	0	0	0	315762	0	1
1450	21000	12	23059	1	4464	38	1035	0	1	0	0	0	251442	1	0
1225	23500	10	26400	15	5699	28	1060	0	1	0	0	0	340963	0	1
2050	12300	8	15909	6	5653	38	1085	0	1	0	0	0	340963	0	0
1400	14000	21	15493	14	4910	33	1110	0	1	0	0	0	357950	0	1
1425	22000	16	23059	1	4464	38	1120	0	1	0	0	0	306432	1	0
1420	30000	11	31972	4	5699	28	1120	0	1	0	0	0	357950	1	1
1500	17000	15	18066	8	4464	38	1110	0	0	1	0	0	271784	1	0
1425	27559	11	29242	17	5699	28	1115	0	0	1	0	0	271784	1	1
1717	23622	8	28317	1	10024	33	1100	0	0	1	0	0	166333	1	1
1759	65898	6	99999	3	10024	33	1090	0	0	1	0	0	156752	1	1
2400	29000	12	31035	13	11006	23	1085	0	0	1	0	0	413362	0	1
3178	4921	11	22630	9	8659	33	1060	1	0	1	0	1	413362	1	1
2450	25000	19	27493	9	11006	23	1040	0	0	1	0	0	158841	0	1
1675	23500	11	25800	15	4464	38	1040	0	0	1	0	0	413362	1	0
2965	45000	8	57405	2	11028	33	1035	0	0	1	0	0	173278	0	1
1500	38000	11	51374	11	4464	38	1045	0	0	0	1	0	129261	1	0
1346	19685	7	28762	5	2699	28	1070	0	0	0	1	0	283613	1	1
6762	14764	16	22564	9	6023	38	1065	1	0	0	1	0	334184	1	0
2100	44000	11	54270	3	11014	33	1065	0	0	0	1	0	129261	1	1
1740	22000	11	23059	1	4464	38	1080	0	0	0	1	0	300468	1	0
1660	28000	11	30300	15	5699	28	1090	0	0	0	1	0	300468	1	1
2175	29528	9	32381	8	10024	33	1090	0	0	0	1	0	308375	1	1
1800	15000	11	16006	9	4679	13	1090	0	0	0	1	0	300468	1	1
1780	23000	17	24760	1	5699	28	1120	0	0	0	1	0	163347	1	1
2000	26000	16	51091	8	7415	33	1120	0	0	0	1	0	163347	1	0
2100	25000	16	27900	8	6023	38	1125	0	0	0	1	0	201614	0	0
2250	16000	11	20483	14	7828	28	1157	0	0	0	0	0	201614	0	0
1750	25000	11	27518	12	4464	38	1173	0	0	0	0	0	221043	1	0
1850	20000	10	21721	21	5418	38	1189	0	0	0	0	0	313810	0	1
6095	7874	12	1415	17	7415	33	1190	1	0	0	0	1	285963	1	0
1560	18500	10	19965	16	5699	28	1232	0	0	0	0	0	316095	1	1
2215	31004	8	15964	8	10024	33	1275	0	0	0	0	0	466411	1	1
2300	13287	13	15285	17	7142	33	1437	0	0	0	0	0	311678	0	0
2300	14000	9	15095	2	4753	38	1518	0	0	0	0	0	311678	0	1
3900	15000	16	19613	9	11058	28	1600	0	0	0	0	0	246657	0	1
2070	21500	11	23059	2	5699	28	1660	0	1	0	0	0	351098	1	1
2750	25000	11	28689	12	11028	33	1680	0	1	0	0	0	342361	0	1
3000	36000	11	45282	10	11028	33	1700	0	1	0	0	0	318918	0	1
2400	24606	11	28806	3	6023	38	1725	0	1	0	0	0	370562	0	0
2135	15400	16	16534	4	4679	13	1750	0	1	0	0	0	285772	1	1
2650	18000	12	19506	7	7142	33	1650	0	1	0	0	0	521629	0	0
1990	17142	31	19000	4	4323	63	1825	0	1	0	0	0	328993	1	1

2700	25000	15	28771	9	6023	38	1825	0	1	0	0	0	342928	0	0
3600	23000	16	27036	2	6023	38	1940	0	1	0	0	0	285772	0	0
1750	38000	15	41399	12	4323	53	1993	0	1	0	0	0	478296	0	0
9622	17224	11	22564	11	8659	33	2046	1	0	1	0	0	245035	1	1
3100	23000	11	24144	3	4464	38	2100	0	0	1	0	0	285772	1	0
3710	25000	14	29202	7	6023	38	2100	0	0	1	0	0	328993	0	0
3601	7677	11	16328	13	4679	13	2350	0	0	1	0	1	563255	1	1
2900	25000	16	26811	1	4464	38	2350	0	0	1	0	0	324484	1	0
3575	25000	11	27900	9	6023	38	2070	0	0	1	0	0	414886	0	0
5550	15000	8	20446	9	11058	28	2175	0	0	1	0	0	414886	0	1
2900	25000	16	26811	1	4464	38	2200	0	0	1	0	0	368431	1	0
3850	23500	11	26200	2	7142	33	2110	0	0	1	0	0	386927	0	0
3088	25000	16	26811	1	5699	28	2120	0	0	0	1	0	336552	1	1
3250	15400	14	16534	4	4464	38	2110	0	0	0	1	0	435845	1	0
3474	8312	11	22564	11	7415	33	2110	1	0	0	1	1	435845	1	0
3400	16240	17	18216	2	4679	13	2090	0	0	0	1	0	291125	1	1
4750	25000	11	33311	7	10045	38	2225	0	0	0	1	0	504563	0	0
3450	24000	16	24760	2	5699	28	2265	0	0	0	1	0	476486	1	1
3420	23000	15	23700	3	4464	38	2400	0	0	0	0	0	358707	1	0
3533	15500	19	17000	10	4679	13	2380	0	0	0	0	0	436640	1	1
4250	29000	15	35250	2	8659	33	2350	0	0	0	0	0	476486	0	1
6000	13500	9	15070	12	11058	28	2400	0	0	0	0	0	285813	0	1
6000	20000	14	27536	2	11058	28	2380	0	0	0	0	0	358707	0	1
6325	25800	11	29600	7	10045	38	2350	1	0	0	0	0	370044	1	0
3385	21500	14	23700	3	4464	38	2350	0	0	0	0	0	347062	1	0
3450	23000	16	23700	3	4464	38	2350	0	0	0	0	0	289921	1	0
1950	51000	15	66157	4	4323	53	2350	0	0	0	0	0	285813	0	0
4700	30000	10	36496	17	8659	33	2340	0	0	0	0	0	333777	1	1
3590	24000	16	24760	3	5699	28	2300	0	0	0	0	0	257725	1	1
13035	12000	11	13532	17	8659	33	2130	1	1	0	0	0	425802	1	1
5100	24000	9	25900	3	8659	33	2060	0	1	0	0	0	435244	0	1
3530	17000	16	18113	18	4679	13	2030	0	1	0	0	0	435244	1	1
4800	14000	11	27700	3	7415	33	1975	0	1	0	0	0	435244	1	0
3435	21500	15	23700	3	4464	38	1960	0	1	0	0	0	250400	1	0
3435	24000	16	25049	14	5699	28	1960	0	1	0	0	0	468756	1	1
3344	10400	16	23700	3	4464	38	1940	0	1	0	0	0	457035	1	0
4400	25000	15	25700	9	8659	33	1950	0	1	0	0	0	457035	0	1
4400	18500	10	20000	7	8659	33	1945	0	1	0	0	0	457035	0	1
5000	25000	14	26300	17	9046	33	1940	0	0	1	0	0	423909	0	1
2000	27000	8	29200	11	2340	43	1930	0	0	1	0	0	401883	0	1
1650	50000	6	58506	12	4323	53	2025	0	0	1	0	0	439873	0	0
2400	20000	8	24700	12	2699	28	2300	0	0	1	0	0	485733	0	1
3450	25000	15	28500	2	6023	38	2400	0	0	1	0	0	485733	0	0
4300	25000	11	26702	4	11421	33	2400	0	0	1	0	0	528211	0	1
1760	20000	11	23101	2	2699	28	2300	0	0	1	0	0	531281	0	1
3600	20000	14	22300	8	8106	33	2300	0	0	1	0	0	495477	0	0
3200	25000	11	33600	13	6023	38	2300	0	0	1	0	0	495477	0	0
3625	20000	11	27564	14	8106	33	2300	0	0	0	1	0	688848	0	0
3300	35000	16	37765	7	10045	38	2365	0	0	0	1	0	688846	0	0
3235	40000	12	51999	6	10045	36	2375	0	0	0	1	0	521685	0	0
3100	25000	11	28312	10	6023	38	2385	0	0	0	1	0	653024	0	0
1800	27000	9	27600	15	4323	53	2450	0	0	0	1	0	585680	0	0
3000	30000	17	30300	10	5145	33	2750	0	0	0	1	0	539645	1	0
5600	21500	15	22106	14	10978	33	2750	0	0	0	1	0	483929	0	1
2950	8000	6	10000	6	3868	38	2750	0	0	0	1	1	559786	0	1
3275	33000	19	36200	1	5418	38	2725	0	0	0	1	0	427075	0	1