AN EXAMINATION OF THE FACTORS AFFECTING INTERNATIONAL CONTAINER TRAFFIC

By

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We accept this thesis as conforming to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

October 1985

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Date  October 15, 1985
ABSTRACT

The objective of this study is to examine the factors affecting international container traffic, with special reference to the Port of Vancouver. In order to achieve this objective, a number of topics are examined. First, background information about West Coast container ports and trade flows and patterns of economic activity are provided. This is followed by an examination of the transportation system concept and by a presentation of important characteristics of current container ports. Then, the economics of container vessel size are discussed. The present institutional frameworks in Canada and in the United States are examined, followed by an examination of current trends of shipping services that may have an impact on container movements through the West Coast. Some of the factors that are relevant to shipping lines when assessing different route configurations are identified and a computer model is used to evaluate the attractiveness of two different configurations involving ports in the Pacific Northwest. The sensitivity of route choice to different parameters is examined. Finally, general conclusions are presented. It is suggested that the development of sophisticated intermodal services in the United States may have an important impact in the routing of Canadian cargo through American ports; the trend towards an increase in vessel size is also a factor that favours the concentration of services through the United States.
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I. INTRODUCTION

The development of containerization has been closely followed by the development of the concept of the through movement of goods, frequently using two or more transportation modes. Over the years, transportation modes have been adapting themselves for a more efficient handling of containers. An overview of the developments reveals that they are associated with significant implications for the future of ports.

OVERVIEW OF CONTAINER TRANSPORTATION DEVELOPMENTS

During the last few years, containerization has experienced important changes throughout North America. Some of the changes are associated with technological advances, like the increase in vessel size and the development of double stack trains for inland distribution. Other changes are related to modifications of the regulatory environment. This is specially important in the United States, where new Shipping, Trucking and Railway acts have been passed.

A brief overview of the trend towards larger container vessels starts with the "first generation" of containerships that emerged in the late 1950's. They averaged 750 20-foot equivalent units (hereafter, just referred to as TEUs), and they were mainly wartime tonnage converted to container-carrying configurations. In the mid 1960's,
Sea-Land acquired container carrying vessels specially suitable for the North Atlantic trade. This move set the beginning of the "second generation" of container vessels, with capacities that averaged 1,500 TEUs. A "third generation" followed with capacities of as much as 3,000 TEUs. In 1984, United States Lines started the deployment of the world's largest containerships. The ships, which can be referred to as "fourth generation" vessels, can carry a total of 4,482 TEUs. (1)

The economic feasibility of increasing ship carrying capacity is based on the fundamental advantages of the "economies of size", i.e. ship costs per unit of carrying capacity decrease with increasing ship size for a given ship type. This is true for virtually all categories of vessel cost, such as capital cost, power plant, fuel consumption and crew cost. It is a function of the more than proportional increase in cargo carrying capacity in relation to the external dimensions of the ship. However, the relative importance of capital cost increases with vessel size so that full utilization of large capital intensive vessels is essential. (2) One of the implications of the deployment of larger vessels is the tendency towards a reduction in the number of ports of call, increasing the use of inland distribution and feeder services. Therefore, there is uncertainty about the future role of the Port of Vancouver in the West Coast container trade.
Another element that is representative of current changes in containerization is the development of double stack container trains. They can also take advantage of "economies of size", resulting in important inland cost reductions. These trains are currently connecting several West Coast ports in the United States with inland centres. No similar systems have been developed in Canada through the Port of Vancouver. This is another factor that may affect the attractiveness of the Port of Vancouver for handling containers.

In terms of changes in the regulatory environment, new legislation in the United States has important implications in the characteristics of liner shipping services. New transportation acts have generated a very competitive environment that relies heavily on market forces. This allows operators to compete in a more aggressively manner in the United States than in Canada. For example, door-to-door freights and confidential contracts are now allowed in the United States. The existence of this new environment is another element that affects the competitive position of the Port of Vancouver.
It appears that the Port of Vancouver is experiencing a re-definition of its competitive position as a container port. An examination of the potential effects of the changing conditions is needed.

OBJECTIVE AND OUTLINE

The objective of this study is to examine the effect of various factors on the flow of container traffic, with special reference to the Port of Vancouver. In order to achieve this objective, a number of subjects have to be investigated.

It is appropriate to provide background information to compare the Port of Vancouver with other container ports on the West Coast of North America. In order to do so, traffic volumes and representative features, related mainly to port infrastructure, are presented. It is also useful to identify characteristics of international trade and patterns of economic activity within North America that may affect patterns of cargo flow. All these subjects are presented in Chapter two.

It is necessary to consider the attractiveness of a port within the "transportation system concept", that is the flow of cargo from origin to destination. This has to be accompanied by an examination of the main features that
characterize current container ports. The examination has to be related not only to physical considerations but also to institutional characteristics of ports such as ownership, corporate structure and administration. All these topics are examined in Chapter three.

The characteristics of "transportation systems" are affected greatly by changes that take place in the shipping industry. Therefore, it is appropriate to examine the structure of shipping costs and the economics of vessel size. It is, also, useful to provide statistics about current changes in container vessel size. These subjects are addressed in Chapter four.

The characteristics of "transportation systems" are affected, also, by the prevailing institutional framework. The effects of institutional changes on container traffic through West Coast ports are considered in Chapter five. That chapter also describes current trends in transportation services related to West Coast container traffic.

The examination of "transportation systems" has to consider both inland and ocean costs. When a shipping line is assessing the attractiveness of alternate routes, inland and ocean costs are important parameters that affect the final routing decision. Furthermore, there are a number of elements such as cargo volumes and marketing factors that are
important in the decision process. Therefore, it is appropriate to identify these elements and to establish a quantitative framework in which to evaluate the economics of alternate routes. The attractiveness of the Port of Vancouver to shipping lines can be examined using this quantitative framework. Alternative route configurations involving single and multiple port of call options, with and without direct service through ports in the Pacific Northwest are examined in Chapter six.

Finally, the implications of the quantitative and qualitative findings are drawn together in Chapter seven. Conclusions are presented on the impact of container shipping developments on the prospects for container traffic through the Port of Vancouver.
REFERENCES


2. T. Heaver, Liner Conferences Issues with Special References to Freight Rates (TP 3904; Transport Canada, 1982), p. 34.
II. WEST COAST CONTAINER PORTS AND FLOWS

This chapter provides background information about West Coast container ports. The chapter starts with a comparison of container volumes and some relevant features of the major container ports on the West Coast. Container volumes are then related to trade flows and patterns of economic activity. Finally, the current movement of containers between Canada and the U.S. is described.

Some statistics are not available for both Canada and the U.S.. For example, the description of minibridge services refers only to U.S. trade. Acknowledging this limitation, the presentation of the relevant data is intended to provide background information from which some conclusions may be drawn about future prospects of container movements through the Port of Vancouver.

CONTAINER PORTS ON THE WEST COAST

This section compares the container throughput and some relevant features of the major container ports on the West Coast (excluding Alaska and Mexico). A map showing the location of the ports is shown in Figure 2.1. Geographically, they can be grouped in three zones: North Zone, including Fraser Port, Vancouver, Seattle, Tacoma, Longview and Portland; Central Zone, formed by Richmond, San Francisco,
FIGURE 2.1

CONTAINER PORTS ALONG THE WEST COAST OF CANADA AND THE U.S.

1982 MOVEMENTS

KEY

○ 250,000 TEUs +
▲ 100,000 TEUs +
□ 25,000 TEUs +
△ 10,000 TEUs -

INCLUDING INBOUND AND OUTBOUND, LOADED AND EMPTY UNITS

Stockton, Oakland and Alameda; and South Zone, including Los Angeles, Long Beach and San Diego. Figure 2.2 shows the 1982 container throughput for the major eight ports, which represent 98.6% of the total movement of inbound and outbound containers on the West Coast. Considering the three zones previously identified, the South Zone has the largest throughput with 38.5% of the total number of TEUs, followed by the North and Central Zones with 33.3% and 26.8% respectively. In terms of container balance, most ports show a larger proportion of loaded outbound than inbound containers. A list by decreasing ratio of inbound to outbound containers indicates that Tacoma has the largest ratio, which is equal to 1:3.5; San Francisco follows with a ratio of 1:2.1; then, Oakland shows a ratio of 1:1.5, followed by Vancouver and Seattle with ratios of 1:1.2 and 1:1.1 respectively. The Port of Los Angeles shows a larger proportion of loaded inbound than outbound containers, with a ratio of 1:0.8. Figures available for the ports of Portland and Long Beach do not disaggregate loaded and empty container, therefore equivalent statistics are not presented.

Individually, the Port of Vancouver is in sixth position among the container ports on the West Coast, measured in terms of the total number of TEUs that are handled. Oakland is the leading port with 820,000 TEUs, accounting for 24.1% of the total. It is followed by Seattle, Long Beach and Los Angeles, all of them handling over 500,000 TEUs. Tacoma and
FIGURE 2.2

CONTAINERISED CARGO STATISTICS, 1982

<table>
<thead>
<tr>
<th>PORT</th>
<th>INBOUND</th>
<th>OUTBOUND</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LOAD</td>
<td>EMPT</td>
<td>TONN</td>
</tr>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
<td>(c)</td>
</tr>
<tr>
<td>VANCOUV.</td>
<td>42</td>
<td>14</td>
<td>411</td>
</tr>
<tr>
<td>SEATTLE</td>
<td>287</td>
<td>140</td>
<td>1765</td>
</tr>
<tr>
<td>TACOMA</td>
<td>23</td>
<td>23</td>
<td>314</td>
</tr>
<tr>
<td>PORTLAND</td>
<td>27(g)</td>
<td>(h)</td>
<td>126</td>
</tr>
<tr>
<td>SAN FRAN.</td>
<td>27</td>
<td>7</td>
<td>431</td>
</tr>
<tr>
<td>OAKLAND</td>
<td>257</td>
<td>127</td>
<td>4173</td>
</tr>
<tr>
<td>LOS ANG.</td>
<td>256</td>
<td>62</td>
<td>(i)</td>
</tr>
<tr>
<td>LONG BEA.</td>
<td>394(g)</td>
<td>(h)</td>
<td>(i)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3349</td>
<td>98.6</td>
<td></td>
</tr>
</tbody>
</table>

NOTES: (a) = Total loaded TEUs * 1000
         (b) = Total empty TEUs * 1000
         (c) = Total tonnes * 1000, excluding tare weight
         (d) = Total loaded + empty TEUs * 1000
         (e) = Percentage of TEUs with respect to "TOTAL"
         (f) = Total tonnes * 1000
         (g) = Loaded + empties
         (h) = Included in figure for loaded
         (i) = Figure not available.

Source: Containerisation International Yearbook 1984
Vancouver are next, with 135,000 and 115,000 TEUs respectively.

The relative importance of the ports could be modified if other measures of trade activities were used. For example, the use of trade value would decrease the relative importance of Pacific Northwest ports. Another factor that could modify the relative importance of the ports is the use of more recent statistics. In past years, there have been redefinitions and inaugurations of services involving some of the largest shipping lines that serve the ports on the West Coast. Three remarkable examples of changes in services are: First, the new transpacific service offered by Maersk Lines through Tacoma; this is estimated to represent a total of 60,000 TEUs per year. (1) Second, Sea-Land's move from Seattle to Tacoma; In 1982 Sea-Land recorded 70,441 containers handled through Seattle. (2) Third, the re-establishment by the Evergreen Line of its transpacific service through the Port of Seattle; this is expected to represent 75,000 TEUs per year. (3)

It is useful to make summary comparisons of the major container ports on the West Coast. Some problems arise when trying to identify appropriate features that can be compared among ports. For example, using the number of vessels or shipping companies that have offered direct calls in a certain period of time, does not consider differences in
vessel size. Acknowledging the limitations implicit on any comparison, Figure 2.3 summarizes certain features that have been chosen to illustrate some of the characteristics of the major container ports on the West Coast. They are: number of container terminals; total berth length; number of container cranes; minimum depths; number of major railways serving the port; and whether the ports have dedicated terminals for the use of some shipping lines. The ports of Vancouver, Tacoma and San Francisco have the smallest number of container terminals. They also show the smallest number of container cranes, with about one third of the total number of cranes placed at the ports of Seattle, Oakland, Los Angeles and Long Beach.

The ports of Vancouver and Tacoma also have the smallest total berth length. In terms of minimum depths, the ports of Seattle, Oakland and Los Angeles have terminals that are only 35 feet deep, whereas Vancouver, Tacoma and Long Beach have minimum depths of 40 feet and over. Three major railways serve all ports, except for Vancouver, Seattle and Tacoma that are only served by two. Vancouver, Portland and San Francisco are the only major ports that do not have dedicated terminals for the exclusive use of some shipping lines.
## FIGURE 2.3

### FEATURES OF WEST COAST CONTAINER PORTS

<table>
<thead>
<tr>
<th>PORT</th>
<th>CONTAIN. TERMINAL</th>
<th>BERTH LENGTH (FEET)</th>
<th>CONTAIN. CRANES</th>
<th>MINIMUM DEPTH (FEET)</th>
<th>MAJOR RAILWAYS</th>
<th>DEDICATED TERMINALS TO LINES</th>
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<tr>
<td>VANCOUV.</td>
<td>2</td>
<td>2540</td>
<td>3(a)</td>
<td>40</td>
<td>2</td>
<td>NO</td>
</tr>
<tr>
<td>SEATTLE</td>
<td>5</td>
<td>12530</td>
<td>17</td>
<td>35</td>
<td>2</td>
<td>YES</td>
</tr>
<tr>
<td>TACOMA</td>
<td>2</td>
<td>2150</td>
<td>4(b)</td>
<td>45</td>
<td>2</td>
<td>YES</td>
</tr>
<tr>
<td>PORTLAND</td>
<td>5</td>
<td>5430</td>
<td>8</td>
<td>40</td>
<td>3</td>
<td>NO</td>
</tr>
<tr>
<td>SAN FRAN.</td>
<td>2</td>
<td>7040</td>
<td>6</td>
<td>38</td>
<td>3</td>
<td>NO</td>
</tr>
<tr>
<td>OAKLAND</td>
<td>8</td>
<td>13310</td>
<td>18</td>
<td>35</td>
<td>3</td>
<td>YES</td>
</tr>
<tr>
<td>LOS ANG.</td>
<td>7</td>
<td>8900</td>
<td>15</td>
<td>35</td>
<td>3</td>
<td>YES</td>
</tr>
<tr>
<td>LONG BEA.</td>
<td>7</td>
<td>10950</td>
<td>19</td>
<td>40</td>
<td>3</td>
<td>YES</td>
</tr>
</tbody>
</table>

**NOTES:**
(a) It excludes 2 container cranes installed in 1983
(b) It excludes Sea-Land facilities built after 1983.

TRADE FLOWS AND PATTERNS OF ECONOMIC ACTIVITY

It is appropriate to present now, some data on trade flows and patterns of economic activity significant to the future prospects of container movements through the Port of Vancouver.

Major trading partners through the U.S. West Coast are Pacific Rim countries. Out of the total liner trade in 1984, 85% of the outbound tonnage and 79% of the inbound tonnage were with Pacific Rim countries. (4) In the U.S., trade growth with Pacific Rim countries has been accompanied by an impressive increase in minibridge services. These services are defined as a combined ocean/rail movement of cargo on a single bill of lading, offered by ocean carriers from a foreign port to one port of destination through an intermediate port or the reverse. In 1977, 20.8% of the liner imports to the East Coast were moved via minibridge through West Coast ports. Since then, the proportion of minibridge cargo has grown steadily. In 1984, 30.0% of the movements destined to the East Coast were moved under minibridge services. (5) These statistics show the suitability of U.S. western ports to operate minibridge services in the trade with countries in the Pacific Rim. Equivalent statistics have not been found to illustrate the performance of western Canadian ports.
Current population and industrial shifts towards southern and western regions in the U.S. do not favour ports in the Pacific Northwest. The shift to the "sun belt" states can be illustrated by comparing a few statistics. (6) While population between 1970 and 1980 grew at rates of 4.1 % and 0.2 % in midwestern and northeastern states respectively, growth figures for western and southern states were 25.7 % and 19.9 %. A similar shift is shown by statistics on industry activity. Between 1970 and 1981, the number of jobs in midwestern and northeastern states decreased 3.4 % and 4.0 % respectively, whereas western and southern states showed increases of 32.0 % and 18.0 %. Among West Coast ports, those in southern California have the largest population base. While they have a total population of 12 millions living at a very short distance, the population base of ports in northern California is 5.2 millions. The combined figure for Seattle, Tacoma, Everett and Metropolitan Vancouver, B.C. is only 3.6 millions. (7), (8)

Currently, regions close to the ports of Seattle and Vancouver attract 25 % to 30 % of the inbound containers that move through those ports. All the rest is moved to eastern destinations. (9) A faster growth of U.S. southern and western states for whom ports in California are at shorter distances, may favour the use of southern ports as major access points to and from continental markets. From this point of view, should the utilization of a reduced number of
ports, or "load centre" concept succeed, the Port of Vancouver is undoubtedly at a disadvantage with respect to other West Coast ports.

According to 1982 statistics presented in Figure 2.2, the ratio of containers handled through the Port of Vancouver with respect to the top 7 U.S. ports is approximately 1 to 28. This is a much smaller proportion than the population ratio of the two countries, which is almost 1 to 10. When considering regional population distributions, Pacific and Mountain regions in the U.S. account for 18.6% of its total continental population, (10) whereas the equivalent four western Canadian provinces represent 29.1% of the total population. (11) Thus, it appears that the Port of Vancouver handles fewer containers than might be expected on the basis of population distribution. There are a number of factors that may explain the level of container flows through western ports in both countries. Regional economic activity, imbalance of certain trades, suitability of certain goods to be containerized, adequate development of port facilities and inland infrastructure, and different consumption habits may be just some of them. Another one which is especially relevant to this study relates to the movement of Canadian import and export cargo through U.S. ports. According to 1984 statistics, (12) only 3,367 U.S. TEUs moved via western Canadian ports, whereas 79,597 Canadian TEUs were handled by ports in western U.S. Measured in monetary terms, four
countries in the Pacific Rim - Japan, Hong Kong, Taiwan and South Korea - account for 79% of the Canadian imported cargo and 78% of the Canadian exported cargo that is moved through western U.S. ports. (13) A discussion of one of the main causes of the routing of Canadian cargo through the U.S. is presented in the section of Chapter 5 that examines the "container clause".
REFERENCES


12. Task Group, p. 20.
III. COMPETITION AMONG PORTS

Not many years ago, the definition of a seaport as "a protected place where ships can load, unload, and ride at anchor" (1) was probably adequate. Today, containerization has brought into the port scene a number of changes that limit the value of that sort of definition. Containerization has contributed, among other aspects, to the development of complex multiorganizational inter-relations. Port authorities, terminal operators, ocean and land carriers, labor organizations and a variety of entities that provide support services are among the institutions that give shape to modern container ports.

This chapter explains the concept of a port in its broadest sense. The first part shows that the attractiveness of container ports is affected by the characteristics of the transportation systems that are available, and that rather than narrowly focusing on competition among ports, it is appropriate to focus on competition among transportation systems. The second part of this chapter describes some of the features that characterize current container ports.

THE TRANSPORTATION SYSTEM CONCEPT

When examining port competition, several hierarchical levels can be distinguished, with competition occurring
simultaneously at every level. (2) Those levels include competition among: seaports and other forms of ports, such as airports; port ranges, where each range is composed of a number of port areas situated along the same coast and with more or less common potential hinterland; port areas in a certain port range; and terminals in a certain port area.

Port administrators have their own perceptions regarding their major port competitors. Richard Ford (3) indicates that Seattle's major competition is Southern California, mainly because the Port of Seattle major market is in the interior of the U.S., which can be served almost equally from California than from the Pacific Northwest. Richard Dale Smith (4) points out that Tacoma's biggest competitors are ports in the South and East Coast. For the Port of Vancouver, the ports of Seattle and Tacoma that divert approximately half of the Canadian cargo (5) are its major competitors. In order to describe the scope of the different levels of competition, it is appropriate to introduce now the transportation system concept.

One of the relevant characteristics of containerization is that it has allowed a fast development of multimodal transportation. Today, a basic system of international container movements can be illustrated as shown in Figure 3.1. Its characteristics are as follows:(6)
FIGURE 3.1

BASIC SYSTEM OF INTERNATIONAL CONTAINER MOVEMENTS

1. Containers are picked up at shipper premises and moved by truck to inland depots located in or close to major urban areas.

2. Containers are moved to seaports by road or rail vehicles.

3. Containers are transferred to vessels for an ocean journey.

4. Containers are transported between ports.

5. Transfer to road or rail vehicles is carried out at port of destination.

6. Containers are distributed by truck or rail to inland depots located in or close to major urban areas.

7. Containers are delivered by truck to consignees.

There are, of course, many variations of the system that has been described. For example, when a landbridge mode is used, containers are transferred from a ship to rail and then to another ship for carriage to the final port of destination. This description decomposes the transportation process in a number of steps. In practice, there will be several alternatives to perform each step. Any combination of these alternatives to move cargo from origin to destination generates a different "transportation system". Shippers and
consignees are facing a number of alternate transportation systems for moving their cargo. Thus, port competition is related to the different transportation systems available to shippers and consignees. In each of the hierarchical levels of competition that have been previously indicated, competition takes place among transportation systems. Seaports that can provide attractive transportation systems in terms of cost and quality of service, will be at a comparative advantage with respect to those who offer less efficient alternatives. Each one of the elements in the transportation chain - ports, shipping lines, land modes,... - is contributing to the performance of the transportation system. The relative success of each one of the entities that give shape to a transportation system is affected by their ability to create a system that is preferred by shippers and consignees.

FEATURES OF CONTAINER PORTS

Some of the features that characterize current container ports are presented next. Because of the orientation of this study, the description is focused mainly on West Coast ports, from where a number of examples have been taken.
OWNERSHIP

Most ports around the world are controlled, in some way, by public sector port authorities. All major container ports in the West Coast are included in this category. Professor Richard Goss (7) cites four reasons why a public sector port authority is needed. First, ports may be considered as public goods, or services which are unlikely to be provided sufficiently or at all by the private sector. Second, the legal regime on property rights is generally different between land and water. To acquire property rights on water is usually a complex situation and requires the intervention of public entities. Third, in the development of ports and port facilities there is a need for community planning; the placing of port structures and facilities needs to be systematically considered, both in relation to each other and to such other factors as a nearby city. The fourth reason is the desirability of public ownership to maintain efficiency, taking into account the impact of ports in the economic stability of the regions where they are located.

CORPORATE STRUCTURE AND ADMINISTRATION

Two extreme styles of corporate structure can be identified. One which is based on a centralized national direction, and another which has an autonomous local direction. Until recently, major port authorities in Canada
were under a centralized control. Today, major Canadian ports including the Port of Vancouver have been awarded greater autonomy. In contrast, most ports in the U.S. including those in the West Coast, can be grouped as being under a strong autonomous local direction. For example, most ports in the U.S. Pacific Northwest are special districts created by the state legislature, where decisions are taken by elected representatives of those districts. To present a detailed discussion of the advantages of the two systems is beyond the scope of this study. However, it should be noted that the ability of a port to respond to changes in the competitive environment is going to be affected by the characteristics of its corporate structure.

An administrative aspect that may have an impact on the interest of shipping lines in the use of a port, is the availability of dedicated terminals to lines. For example, an important feature in ports such as Seattle, Tacoma, Oakland and Long Beach is the availability of terminals for the exclusive use of lines such as Sea Land, APL, and U.S. Lines. Other ports like Vancouver and San Francisco do not have sites that are for the exclusive use of a line. (8) Calls of shipping lines operating without an exclusive site will be subject to site availability, making it difficult to sustain reliable schedules and increasing the probability that vessels will be kept laying idle and unproductive.
PARTICIPATION IN PORT OPERATIONS

Two extremes can be also identified in terms of the level of port authority involvement in port operations. At one extreme, there are those ports acting primarily as landlords in the sense that even though they own and construct their facilities, they lease them out to private sector firms. The Port of Long Beach can be mentioned in this group. (9) At the other extreme, there are those ports where port authorities are responsible for everything which occurs in its area. An intermediate situation is represented by the Port of Seattle, where most terminals are not run by the Port Authority; however, the Port Authority is heavily involved in the operations of a consolidated centre. (10) A full discussion of the advantages and disadvantages of terminal operations by the port authority is beyond the scope of this study, but it should be noted that the relationship between port authorities, terminal operators and shipping lines may be important to the development of efficient transportation systems.

CARGO HANDLING INFRASTRUCTURE

The evolution of containerization has included the development of much highly specialized container handling equipment. Such equipment can be found in ports, as well as on board of vessels, inland depots, manufacturer warehouses,
etc. Gantry cranes, straddle carriers, side loaders and many other pieces of equipment are commonly found in port areas.

Terminal operators try to provide a combination of cargo handling equipment that produces a fast flow of cargo. The cargo handling equipment selected must be compatible with the terminal area available, the TEU throughput and the equipment and operating philosophies of the carriers and terminal operators. Congestion and low productivity when moving containers are characteristics that make ports unattractive. The ability of a port to provide an efficient cargo handling infrastructure is going to have an impact on the efficiency of the transportation systems that are developed.

CONNECTIONS TO INLAND CENTRES

One of the benefits of containerization is that it allows the development of efficient intermodal transportation. Surface modes, especially rail and truck, play an important role in the distribution process. Distance between ports and inland centres is a determinant of the mode that presents the larger cost advantages. A study by the CTC (11) shows that in the U.S. and for a given type of service, rail offers a cost advantage over trucking for distances in excess of 500 miles.

To enhance their competitive position, it is important that seaports have adequate links to and from inland centres.
where cargo is originated or required. An example of the development of port infrastructure in line with improving connections to inland centres, is the recent construction of a multi-million Container Transfer Facility with participation of the ports of Los Angeles and Long Beach. This project will bring railheads 20 miles closer to the harbor, and is expected to improve the competitive position of the two ports. (12)

SPECIAL SERVICES

Some of the services that are provided at container ports may be a source of competitive advantage. Services may be beneficial not only to shippers and consignees, but to shipping lines. They will enhance the quality of the transportation systems that are provided. Some of them are: Consolidation centres that handle LCL (less than truck load) shipments for containerization, foreign trade zones that allow the delay in the payment of duties until the cargo leaves the zone, adequate warehousing facilities, computarized systems that provide shippers with information on the status of their cargo, and the availability of shipyards and of cheap fuel for bunkering vessels.
GEOGRAPHIC LOCATION

The geographic location of a port may have an important impact on the inventory costs of shippers and consignees that move their cargo through that port. Inventory costs are an important component of the total logistics costs. A survey in the U.S. shows that total inventory costs (before taxes) ranges from 14% to 35% of the full manufactured cost. (13) To reduce inventory costs, some companies use a "just in time" delivery system. For time-sensitive goods, ports located close to the originating centres may be at an advantageous position. Richard Ford, executive director of the Port of Seattle (14) claims that one of the significant advantages of the Port is that it has the shortest route into the major transpacific areas when compared with other container ports in the West Coast. Location is also related to the distance from ports to population centres. Being close to them may attract ocean services and also to offer the possibility for backhaul with cargo from inland centres to the seaport. Ports in California have a large captive market, while those in the Pacific Northwest are more limited in this respect.

PHYSICAL CHARACTERISTICS

Constraints on the limits to expand port facilities may affect the competitive position of a port. Richard Ford
indicates that one of the reasons given for Sea-Land's move from Seattle to Tacoma in 1985 was land accessibility. (15) Land becomes important when shipping lines are planning their long-term needs for space. The relative importance of this factor may change in the future if technological changes reduce the land requirements for handling containers.

The possibility of access by vessels with large draft may be also a factor in a port's competitive position. U.S.Lines, APL, ACL, and Barber Blue Sea are a few examples of lines that have recently deployed ships with a draft greater than the traditional 30 feet. (16) Ports that are only capable to accommodate ships with a conventional draft will be jeopardized in attracting new vessels.

The level of protection to inclement weather conditions may be also a factor in a port's competitive position. It is advantageous for a port to provide vessels with an environment where this factor is not a constraint to the quality and continuity of the ship's operations.

LABOR AGREEMENTS AND PRODUCTIVITY

The characteristics of labor agreements at specific ports also has an impact on the attractiveness of the ports for shipping lines. An example of this is the "container clause" that applies to certain containers moved through the Port of
Vancouver. The clause applies to inbound and outbound containers. It means, for example, that inbound cargo will be destuffed at the dock if it is consigned to the Lower Mainland for a public warehouse or for a consignee who is not the beneficial owner of all the contents. This clause is one of the significant factors that explains the movement of Canadian import and export cargo through the ports of Seattle and Tacoma. Containers can be moved intact from or to off-dock locations in Vancouver by routing them through both American ports. (17)

Productivity of the labor force may also vary from port to port. This can be due to factors such as the existence of different incentive regimes, the quality of training programs, and many other features. Other things being equal, those ports with the highest productivity will be preferred.

PRICING

Port charges include a number of items, some of them absorbed by shipping lines, and others paid by shippers and consignees. Actual port charges are primarily a function of the pricing policy of the port authority, vessel size, length of the stay in port and type of cargo being handled. Ports may improve their competitive position by offering attractive tariffs to their users. For example, it has been suggested that the Vancouver Port Corporation could use port charges as
part of its competitive strategy. The Globe and Mail reported that "lower container handling charges are in the wind at the Port of Vancouver as part of a strategy to recapture container cargo now lost to the U.S. port of Seattle." (18)

But port charges are only a fraction of the total transportation costs. Robert Kaye, marketing director of the Port of Halifax, indicates that "ports account for only one percent of transportation costs". (19) Within a shipper logistics framework, what is relevant is the overall price of moving cargo through a given port, including not only port charges, but the cost of inland distribution. Erik Tofsrud, former general manager of the Port of Vancouver, recognizes the importance of inland costs and recommended "monitoring rail rates in Western Canada in order to press for reduced charges". (20)

REGULATORY ENVIRONMENT

Services that may be provided by transportation companies serving a port area are affected by the characteristics of the prevailing regulatory environment. Deregulation of the U.S. liner shipping industry under the Shipping Act of 1984 allowing intermodal through rates, and the exemption in the U.S. of rail intermodal service from economic regulation have enabled new service developments in that country. It is important that shipping lines are now able to offer through
Deregulation in the U.S. has allowed shipping lines to quote door-to-door rates. This new deregulated scheme has changed the competitive relationship between ports. Traditionally, rates for liner services to and from U.S. ports were the same on a route for any given type of cargo. The rates were "equalized" between ports. The shipper used to be wholly responsible for the costs of inland transport. Therefore, by choosing to ship via the nearest port, a shipper's total transport costs tended to be minimized.

W. Gregory Halpin, chairman of the American Association of Port Authorities, points out that "under the traditional system, the old port sales emphasis was focused at the shipper. If a port sold the shipper, it got the cargo. Now the shipper says he doesn't care about the port. The steamship line can handle his cargo anywhere it wants to, as long as the cargo reaches the destination on time and at the agreed upon price". (22) As a general conclusion, regulations applicable to certain regions/countries may limit the capability of their ports to provide transportation systems that are favoured by shippers and consignees.
REFERENCES


10. "Q and A with R. Ford."


14. "Q and A with R. Ford."

15. Ibid., p. 24.


19. Ibid.


IV. ECONOMICS OF CONTAINER VESSEL SIZE

The economics of international container systems is influenced greatly by the economics of ship size because of the effects of ship economics on the choice of ports served. Therefore, it is necessary to examine the economics of container ship size as a factor that will influence the attractiveness of the Port of Vancouver. It is done in three parts: The chapter begins with a brief description of the developments of containerization to about 1980. It then describes the structure of liner shipping costs and the factors that work for and against increasing vessel size. The chapter ends with an examination of the current changes in the size of container carrying vessels.

DEVELOPMENTS IN CONTAINERIZATION

The gestation and developments of containerization have been extensively covered in the literature. Henry S. Marcus in his book 'Ship Replacement in the Containerization Era' (Lexington Books, 1974) presents a comprehensive study of the subject. Here it is appropriate to mention only a few highlights that took place in the process of containerization.

The container itself is an old concept; it was in use on a railway in Britain in 1830, only five years after the opening
of the first public railway. (1) However, it was only in the early 1950's when the "container revolution" began. In 1951, Eric Rath's T.M.T. took a converted truck trailer body, whose wheels had been removed, as deck cargo from Florida to Puerto Rico. As demand grew, further conversion of truck bodies took place. (2) In 1956, Sea-Land (Malcolm McLean) started its containership service between New York and Puerto Rico, following experimental shipments the previous year from Houston and New York. Matson followed shortly with its U.S. West Coast-Hawaii service. But it is only since 1966 that the growth of container service has been explosive. (3) During the decade of the '70s, containerization grew at an average annual rate of 18.5%. (4) Figure 4.1 shows statistics for world-wide containerised throughputs for that period. They indicate that total throughput increased from 47 million tons. in 1970 to 256 million tons. in 1980. However, only a 5% growth for the decade 1980-1990 is indicated, implying a total throughput of 410 million tons. by 1990. This reduction in the rate of growth is supported by several surveys (5) that have indicated that the rate is going to be lower in this decade. Figure 4.2 supports this projected reduction by showing how the growth rate dropped consistently between 1976 and 1981. The Figure shows a reduction in the rate of growth of worldwide container traffic from 20% per year in 1976 to 9% per year in 1981. The growth rate for the container traffic of developing nations dropped from 44% in 1976 to 18% in 1981.
FIGURE 4.1

CONTAINERISED TRAFFIC GROWTH AT PORTS WORLD-WIDE
1970-1980

NOTES: (a) = Estimated
(b) = Projected.

FIGURE 4.2

CHANGES IN ANNUAL GROWTH RATE OF CONTAINER TRAFFIC BY COUNTRY GROUPINGS
(TEUs x 1000)

NOTES: A = All developing nations
B = World.

The rapid development of containerization followed the significant escalation in port labor costs. Shipowners' costs were rising and their profits were being substantially reduced. (6) In 1960, MacMillan and Westfall examined the operators of U.S. companies using conventional break bulk methods of cargo handling and showed that direct labor accounted for 50% to 60% of the total cost of sea transport. (7) Moreover, productivity at the ports was generally low and the equipment for handling cargoes was relatively inefficient. (8) Slow turnaround time was causing poor utilization of the vessels that were spending a large proportion of the time in port rather than at sea. Conventional general cargo ships could be spending two-thirds or more of their time in port. (9) On the land side, inland transit from ports involved a repetition of the expensive and slow loading and unloading process. (10) One French consultant in the early '60s analysing cargo movements between U.S. Midwest and Europe, advised that the average commodity was handled no fewer than 26 times between source and ultimate destination. (11)

Containerization provided an opportunity to reduce the cost of frequent handlings but it also enabled dramatic changes in several areas of the transportation chain. Before containerization, an economic constraint to the growth of ship size was that with slow cargo handling, the high cost of ship time in port offset the advantages of size economies at
sea. (12) Improvements in cargo handling methods removed this constraint on size. Today, specialized vessels with fast cargo handling capabilities have emerged. Cellular, semi-container, roll-on roll-off (Ro-Ro) and Lash vessels are some of the types that have been developed. The advantages of using any of these types is a function of variables such as route and port characteristics, labor costs, and cargo mix.

Figure 4.3 shows the composition of the world container carrying fleet and its size distribution in 1980. The three vessel categories - fully cellular, Ro-Ro and semi-cellular - are represented by about the same number of ships. Only 43 vessels have a capacity of 2000 TEUs and over, which corresponds to 1.8% of the total number of vessels.

Ports, railways and trucking companies have also evolved, adapting themselves to offer a more efficient door-to-door service. In North America, the use of "piggy-back" systems (the carriage of road trailers on railway flats) and the recent deployment of double-stack container railcars are some examples of the coordination among different modes in order to offer a more efficient through service.

Advantages are to be gained from a through container transport system, and it is now generally accepted that a standardized method of transportation of cargo can offer
FIGURE 4.3

COMPOSITION OF THE WORLD CONTAINER FLEET, 1980

<table>
<thead>
<tr>
<th>TEU SIZE RANGE</th>
<th>NUMBER OF FULLY-CELLULAR (a)</th>
<th>NUMBER OF ROLL-ON/ROLL-OFF (b)</th>
<th>NUMBER OF SEMI-CONTAINER (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>below 250</td>
<td>172</td>
<td>409</td>
<td>261</td>
</tr>
<tr>
<td>250-499</td>
<td>141</td>
<td>186</td>
<td>325</td>
</tr>
<tr>
<td>500-749</td>
<td>86</td>
<td>52</td>
<td>130</td>
</tr>
<tr>
<td>750-999</td>
<td>94</td>
<td>65</td>
<td>67</td>
</tr>
<tr>
<td>1000-1249</td>
<td>112</td>
<td>25</td>
<td>8</td>
</tr>
<tr>
<td>1250-1499</td>
<td>72</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>1500-1749</td>
<td>69</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>1750-1999</td>
<td>41</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>2000-2249</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2250-2499</td>
<td>13</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2500-2749</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2750-2999</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3000 and over</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTALS</td>
<td>830</td>
<td>770</td>
<td>808</td>
</tr>
</tbody>
</table>

NOTES: (a) = Ships equipped with cell-guides in all holds to facilitate container handling by lift-on/lift-off (LO/LO) methods
(b) = Ships designed with horizontal means of access for wheeled and other mobile cargo
(c) = General cargo vessels possessing a capability for carrying containers.

definite economic gains. (13) Among the advantages claimed for container systems are that faster turnaround and transit time allow a greater number of ship voyages per year. An example that illustrates the dramatic effect of these two factors is found in the trade between the U.K. and Australia. (14) "Traditionally, some 110 conventional ships carried the bulk of the liner trade between these two countries, with each vessel achieving 2.2 round voyages per year. After containerization, 9 cellular ships making 5.5 round voyages each per year lifted the same volume of cargo. Similar figures have been experienced in other ocean trades." Other advantages of container systems include the reduction in handling costs over the whole transport chain, the economies of scale that can be obtained by using larger vessels, the need for fewer berths and a reduction on pilferage and damage of the cargo. (15)

However, the success of containerization can not be generalized to all trades. The absence of large and balanced-trade volumes, the existence of government policies to promote the use of cheap labor, and the lack of cargo compatibility for containers, are barriers to container penetration in some trades. (16) In order to overcome these barriers, some changes have taken place in the shipping industry: route amalgamations and round-the-world services have reduced the problem of container imbalances, as well as generated routes with acceptable traffic volumes;
restrictions on cargo compatibility have been solved, at least partially, by the development of "special" container types. They include, for example, half heights, tanks, refrigerated and open top containers. These special container types accounted in 1980 for 15% of the 2.5 million TEUs in the world. (17)

Since the early days of containerization, container trades have been concentrated in a few routes. Figure 4.4 shows a comparison of the structure of the container throughput in 1970 and 1980. Western Europe shows the largest share in both years, but its contribution dropped during that period from 44% to 33%. North America's share also dropped from 35% to 21%, and the most remarkable increase corresponds to the Far East, with a change from 9% to 22%. In 1980, these three regions accounted for 76% of the total container throughput in the world. It is appropriate to indicate that because of the geographic location of West Coast ports with respect to countries in the Far East, the dramatic increase of container traffic to and from such countries becomes important to potential traffic through the West Coast.

A detailed breakdown of the TEU capacity provided in 1980 is shown in Figure 4.5. Container capacity provided between North America and the Far East exceeded that between North America and Europe. In total in 1980, over 14 million TEU capacity was provided by ocean carriers. Figure 4.5 shows a
FIGURE 4.4

STRUCTURE OF TRADE AND GROWTH BY REGION

<table>
<thead>
<tr>
<th>REGION</th>
<th>THROUGHPUT (IN MILLION TONS)</th>
<th>1970</th>
<th>%</th>
<th>1980</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>WESTERN EUROPE</td>
<td></td>
<td>20.9</td>
<td>44</td>
<td>84.2</td>
<td>33</td>
</tr>
<tr>
<td>FAR EAST</td>
<td></td>
<td>4.1</td>
<td>9</td>
<td>57.0</td>
<td>22</td>
</tr>
<tr>
<td>NORTH AMERICA</td>
<td></td>
<td>16.5</td>
<td>35</td>
<td>52.7</td>
<td>21</td>
</tr>
<tr>
<td>AFRICA</td>
<td></td>
<td>0.1</td>
<td>(a)</td>
<td>13.1</td>
<td>5</td>
</tr>
<tr>
<td>OCEANIA</td>
<td></td>
<td>2.8</td>
<td>6</td>
<td>11.8</td>
<td>5</td>
</tr>
<tr>
<td>NEAR &amp; MIDDLE EAST</td>
<td></td>
<td>0.1</td>
<td>(a)</td>
<td>12.5</td>
<td>5</td>
</tr>
<tr>
<td>SOUTH &amp; S.E. ASIA</td>
<td></td>
<td>(a)</td>
<td>(a)</td>
<td>11.3</td>
<td>4</td>
</tr>
<tr>
<td>SOUTH AMERICA</td>
<td></td>
<td>2.8</td>
<td>6</td>
<td>11.1</td>
<td>4</td>
</tr>
<tr>
<td>EASTERN EUROPE</td>
<td></td>
<td>(a)</td>
<td>(a)</td>
<td>1.8</td>
<td>1</td>
</tr>
</tbody>
</table>

NOTES: (a) = insignificant throughput.

FIGURE 4.5

STRUCTURE OF CONTAINER CAPACITY BY REGION AND VESSEL TYPE, 1980

<table>
<thead>
<tr>
<th>REGION</th>
<th>CAPACITY (in thousands of TEUs)</th>
<th>FULLY CELLULAR</th>
<th>ROLL-ON/ROLL-OFF</th>
<th>SEMI CONTAINER</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. AMERICA-F.EAST</td>
<td></td>
<td>2486</td>
<td>118</td>
<td>335</td>
<td>2939</td>
</tr>
<tr>
<td>EUROPE-N.AMERICA</td>
<td></td>
<td>1838</td>
<td>423</td>
<td>451</td>
<td>2712</td>
</tr>
<tr>
<td>EUROPE-F.EAST</td>
<td></td>
<td>1284</td>
<td>33</td>
<td>88</td>
<td>1405</td>
</tr>
<tr>
<td>EUROPE-MIDDLE EAST</td>
<td></td>
<td>418</td>
<td>656</td>
<td>177</td>
<td>1251</td>
</tr>
<tr>
<td>N. AMERICA-CARIBBEAN AND HAWAII</td>
<td></td>
<td>624</td>
<td>471</td>
<td>18</td>
<td>1113</td>
</tr>
<tr>
<td>ALL OTHERS</td>
<td></td>
<td>2088</td>
<td>1373</td>
<td>1401</td>
<td>4862</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>8738</td>
<td>3074</td>
<td>2470</td>
<td>14282</td>
</tr>
</tbody>
</table>

breakdown of this capacity by type of vessel. Fully cellular capacity accounts for 61 %, RO-ROs for 22 % and semi container vessels for 17 %.

THE STRUCTURE OF SHIPPING COSTS

In shipping management, the traditional unit of account has been the voyage. Profitability and losses are usually stated on a daily as well as round-trip basis. Although a consistent terminology is not used to break down ships' total cost, the most commonly used categories of costs are, capital, operating and voyage costs. Capital cost relates to the costs incurred by a shipowner with respect to vessel acquisition. Container costs may also be included in this category. Operating costs are usually broken down into five items: administration; insurance; repairs and maintenance; manning; and lube oil, stores and supplies. Voyage costs include fuel and port expenses as well as canal and waterway costs.

A representative example of the structure of total fully built-up costs is shown in Figure 4.6 for a 1000 TEU fully cellular vessel. The data corresponds to a sample of newbuildings in 1981. (18) Capital costs represent the largest single item, accounting for 59 % of the total cost. Voyage and operating costs follow, with 21 % and 20 % respectively. Within operating costs, manning is the largest
### FIGURE 4.6

**STRUCTURE OF TOTAL FULLY BUILD-UP COSTS, 1000 TEU FULLY CELLULAR VESSEL**

<table>
<thead>
<tr>
<th>COST ITEM</th>
<th>CONTRIBUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CAPITAL</strong></td>
<td>59 %</td>
</tr>
<tr>
<td><strong>OPERATING</strong></td>
<td>20 %</td>
</tr>
<tr>
<td>MANNING</td>
<td>9.0 %</td>
</tr>
<tr>
<td>LUBE OIL, STORES, SUPPLIES</td>
<td>2.4 %</td>
</tr>
<tr>
<td>REPAIRS AND MAINTENANCE</td>
<td>3.4 %</td>
</tr>
<tr>
<td>INSURANCE</td>
<td>3.2 %</td>
</tr>
<tr>
<td>ADMINISTRATION</td>
<td>2.0 %</td>
</tr>
<tr>
<td><strong>VOYAGE</strong></td>
<td>21 %</td>
</tr>
<tr>
<td>FUEL</td>
<td>19.3 %</td>
</tr>
<tr>
<td>PORT</td>
<td>1.7 %</td>
</tr>
<tr>
<td>CANAL/WATERWAYS</td>
<td>0 %</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>100 %</td>
</tr>
</tbody>
</table>

single item with almost half of the total. The other four items share the rest almost equally. In voyage costs, fuel accounts for almost 92% of this component, and port expenses constitutes the remaining 8%. Container cost has not been included in the capital cost, and canal and waterway crossings have not been considered in the operating costs.

The share of individual items may vary from one vessel to another. Even if the same type of vessel is considered, factors like the use of flag of registry, government subsidies to the price of fuel, slow steaming conditions or fluctuations in the market demand for vessels may be responsible for significant variations. The relative weight of the cost factors also differs among vessels of different size. This aspect is examined in more detail in the following section.

SOME IMPLICATIONS OF INCREASING VESSEL SIZE

One of the characteristics of ships is that they can exploit what is known as "the cube law". The law states that while the surface area varies with the square of a dimension, the volume varies with its cube. Accepting that shipping costs are closely related to the surface area of the vessel while revenues are related to its volume, it is possible to conclude that 'the bigger the vessel the better'. (19) Costs per unit of capacity decrease for virtually all categories of
vessel cost, such as capital cost, power plant, fuel consumption and crew costs. (20) An example of the economies of scale on capital costs for a family of cellular containerships is presented in Figure 4.7. The shape of the curves indicate that at different design speeds, capital cost increases in a less than proportional manner with respect to increases in vessel size. Unit cost at sea is also affected by the speed of the vessel. Working from empirically observed data it is possible to construct a family of curves (one for each ship size) showing the relationship between cost per ton/mile at sea and operating speed. (21) Figure 4.8 shows the shape of these curves. For a given speed, unit costs have an inverse relationship with ship size and the optimal (i.e. cost minimizing) speed is higher the larger the ship size.

One of the extensive studies on the impact of ship size is the work by S. Gilman, "Ship Choice in the Container Age". (22) Figure 4.9 is extracted from that study and shows the inverse relationship between ship size (TEUs) and cost 'at sea' (per 000 TEU miles) at various speeds. The effect of ship size and speed as well as the relative impact of several cost components are now reproduced from some of the Gilman's conclusions. Cost figures are for the beginning of 1980 and for ships built in Europe and crewed with seamen paid at U.K. rates. Cost of containers as well as canal and waterway crossings are not included in the calculations. The former is independent of vessel size and because of the economies of
FIGURE 4.7

CAPITAL COSTS FOR CELLULAR CONTAINERSHIPS

DIFFERENT CURVES REPRESENT VESSELS WITH DIFFERENT DESIGN SPEEDS

FIGURE 4.8

COSTS PER TON/MILE AT SEA

FIGURE 4.9

ECONOMIES OF SIZE AT VARIOUS SPEEDS
FOR CELLULAR CONTAINERSHIPS

DIFFERENT CURVES REPRESENT VESSELS WITH DIFFERENT DESIGN SPEEDS

Source: S. Gilman, Ship Choice in the Container Age (Marine Transport Centre, University of Liverpool, 1980), p. 47.
ship size it should account for a greater proportion of total costs as ship size increases. The latter is usually a direct function of the net register tonnage (or cargo carrying capacity) of the vessel. Consequently, it should be represented by higher costs as ship size increases, and to account for a greater proportion of the total costs in larger vessels. The study states that:

"...there are substantial economies of size at sea which follow the shape of a negative exponential, i.e. with cost savings diminishing progressively as ship size increases, and at 19, 21 and 23 knots size economies are all of roughly the same magnitude. For diesel engined ships each of the major groups of costs moves in the same direction,... Fuel costs and capital costs (which for these purposes may be taken to include the costs of insurance and maintenance), are of the same order at slow speeds, but as speed increases fuel costs tend to dominate,... Economies in fuel consumption are particularly important up to about 1500 TEUs after which they tend to dwindle away,... For example, for ships of 21 knots there is a saving of 9.3 pounds per '000 TEU miles as size increases from 600 to 1500 TEUs but of only 1.3 pounds as it increases further to 3000 TEUs. ... Capital costs behave in a regular way and also show the eventual diminution of returns to size. Crew costs are quite important among the smaller ships where they may account for as much as 14% of the total costs, but they decline in proportion to increases in
capacity, whether obtained by greater size or by greater speed and account for only 6% of the total for a 3000 TEU ship at 19 knots."

There are, however, some factors that limit the possibility to take advantage of the economies of size. Limiting factors can be physical barriers such as canal crossings and port drafts, and limitations in the demand for vessel space because there is, in general, no reason to operate a ship larger than the cargo it is intended to carry.

Another factor that works against the increase in vessel size is represented by the diseconomies of scale while a vessel is in port. At any given handling rate, large ships are more expensive in service-time cost than smaller ships. (23) The total cost per TEU while a vessel is in port is a function of two factors. One is the daily cost in port. This item increases with vessel size, (24) with capital cost representing the largest proportion. A study shows that it accounts for 69% of a 600 TEU ship and for 84% of a 3000 TEU ship. (25) The second factor that affects the total cost is the time the vessel spends in port. This has several components: (26) First, access, including waiting time for tides, lock and/or channel transit, berthing and de-berthing, etc; second, waiting time to commence cargo handling, either queuing or waiting for labor and equipment or the beginning of shifts; and finally, cargo handling time itself which is a
function of the average cargo handling rate. A commonly held view is that ship turnaround time increases with increases in ship size. However, studies that have been undertaken in this area show no evidence that any of the components of time in port has a strong relationship with ship size. (27), (28) Rather, they indicate that given a number of TEUs to be handled, ship turnaround time remains relatively constant over a wide range of ship sizes. This implies that diseconomies of size apply to ship costs in port. As ship size increases, port costs also increase, but in a less than proportional manner. Thus, because of ship turnaround time remains unchanged, the cost per handled TEU will be higher as ship size increases. This is shown in Figure 4.10, where curves represent the cost per handled TEU at two different handling rates for various ship sizes.

The total cost per TEU attributable to the ocean leg in the transportation chain is the sum of vessel costs at sea and in port. The result, as shown in Figure 4.11, is a "U shaped" curve with a minimum corresponding to the least-cost-ship size. Any optimization has to specify, however, the route and ship characteristic applicable to the trade. There is no single ship size that is optimal for all types of ships and for all routes. (29) Routes which provide vessels with a high proportion of sea days to port days are favourable to large vessels. (30) The same is valid to routes with high handling performance in port. (31) In both cases,
FIGURE 4.10

SHIP COSTS PER TEU IN PORT, AT DIFFERENT HANDLING RATES

Source: S. Gilman, Ship Choice in the Container Age (Marine Transport Centre, University of Liverpool, 1980), p. 53.
FIGURE 4.11

RELATIONSHIP BETWEEN SEA AND PORT COSTS WITH RESPECT TO VESSEL SIZE

COST/TEU

TOTAL COST/TEU

DISECONOMIES OF SCALE IN PORT

ECONOMIES OF SCALE AT SEA

SHIP SIZE

MINIMUM COST/TEU
the small proportion of port days to sea days allows a better utilization of the economies of scale of larger ships. Economies of size are also affected by the length of the route. For any vessel size, the impact of economies of size increases in longer routes. Consequently, long trade routes have larger vessels than short trade routes. (32) Shorter routes present substantial diseconomies of size because of the greater proportion of time in port that is involved. Therefore, large vessels operating in shorter routes are affected in greater proportion than smaller ones.

CURRENT CHANGES IN THE SIZE OF CONTAINER CARRYING VESSELS

The previous section presented some general relationships of the economies of vessel size. In practice, there has been a marked tendency to take advantages of these economies. In 1968, only 3 fully cellular ships with a capacity of over 1000 TEUs were in service. By 1980, over 300 fully cellular containerships were included in that group. (33) The average TEU capacity of fully cellular vessels in 1980 was 859 TEUs, whereas the average size of the fully cellular ships on order by the end of 1982 was about 1600 TEUs. (34) Due to the high correlation \( R^2 = .95 \) between the TEU capacity of a fully cellular vessel and her deadweight, (35) it is also reasonable to measure the increase in vessel size by showing the average deadweight (DWT) of containerships on order in different years. In 1979, the average was 12,870 DWT; in
1982, the figure had increased to 15,956 DWT; and in December 1984, the average indicated 17,362 DWT. (36) Another example of the increase in vessel size is found when examining the average deadweight tonnage of all liner vessels calling at the Canadian West Coast. The average deadweight increased from 19,000 DWT to 23,000 DWT between 1977 and 1981. In 1977, 60% of these vessels had some container capacity and averaged 610 TEUs. By 1981, 88% of the vessels had some container capacity and the average was 880 TEUs per vessel. (37)

Fully cellular ships represent the largest component of the world container fleet, accounting for 55% of the total TEU capacity in 1980. Fully cellular ships on order by the end of 1982 represented 64% of the total TEU slots ordered. Ro-Ro vessels accounted for 21% of the total TEU capacity in 1980. This group also showed a tendency towards an increase in size. The average Ro-Ro size was 386 TEUs in 1980, whereas the average size on order by the end of 1982 was 877 TEUs. Semi-containerships accounted for 24% of the total TEU capacity in 1980. They do not show such an impressive tendency towards the increase in size. The average size was 391 TEUs in 1980, and the average size on order by the end of 1982 was 496 TEUs. (38) An examination of the implications of current trends towards the deployment of larger vessels and the implications for the Port of Vancouver are included in Chapter seven.
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20. T. Heaver, Liner Conferences Issues with Special References to Freight Rates (TP 3904E; Transport Canada, October, 1982), p. 34.


22. S. Gilman, Ship Choice.


26. Ibid.


30. T. Heaver.


32. T. Heaver.


V. INSTITUTIONAL FRAMEWORKS AND CONTAINER SERVICES

The evolution of transportation systems is customer driven. In a competitive environment, shipping lines, ports and land modes are constantly considering new services that may be attractive to shippers and consignees. Services that emerge are affected by the prevailing institutional frameworks. One of the purposes of this chapter is to describe some of the institutional aspects applicable to the West Coast. Consideration is given to the regulatory environment of the different transportation modes in U.S. and in Canada. The controversial "container clause" for the Port of Vancouver is also described, as it has an important impact on the attractiveness of routing containers through the Port of Vancouver. A second purpose of this chapter is to examine current trends of shipping services that may have an impact on container movements through the West Coast.

INSTITUTIONAL FRAMEWORKS

When examining the development of transportation services through the West Coast, it is necessary to identify the characteristics and the main differences between the regulatory environment existing in the U.S. and in Canada. In doing so, it is appropriate to examine the general regulations that apply to all major transportation modes involved in cargo movements.
In general, U.S. legislation relies more heavily on market forces than its Canadian counterpart. At the time of writing this section, a number of proposed reforms to the Canadian transport legislation are being considered. If the proposed legislation is approved, a less regulated environment with greater reliance on market forces is expected to prevail. This could have a considerable impact on all modes of transportation. However, as new legislation has not yet been introduced, the following references to the Canadian regulatory environment is based exclusively on current legislation.

MARINE LEGISLATION

One of the relevant aspects included in the marine legislation refers to the treatment of "liner conferences". They are cartel-like associations of firms that provide liner services. The term liner services is used generically to describe scheduled shipping services between one or more ports in two regions for less than shipload quantities of cargo. (1) In many trades, members of conferences represent a very large proportion of the liner shipping capacity on a route. Such is the case with the "Transpacific Westbound Rate Agreement", (TWRA) that holds roughly 76 % of the overall westbound transpacific trade capacity from Canada and the United States. (2) In Western Canada, 15 out of the 21 lines
that were giving direct service in 1983 were conference members. (3) Some of the characteristics of the marine legislation in the U.S. and in Canada are described next. They are mostly based on a study performed by Ports Canada. (4)

In the U.S., a new Shipping Act came into effect in 1984. The Act gives the liner industry, including carriers and terminal operators, antitrust immunity to arrange collective rate making and other cooperative activities. The Act designates the Federal Maritime Commission (FMC) as the entity responsible for monitoring the practices of commercial parties and foreign governments in respect to their regulations over ocean transportation. The FMC has the sole responsibility for determining if an injunction is required. It has also the power to suspend tariffs of foreign carriers serving the U.S. in retaliation for any foreign interference with U.S. flag vessel operations. Suspensions may occur, for example, as a response to the application of the UNCTAD code in respect to promoting the carriage of goods by nationally registered ships. Shipping conference members have the right to take independent action and to quote rates on door-to-door services. Rates must be negotiated individually between ocean and land carriers. The Act prohibits closed conferences as well as new loyalty or patronage contracts (those by which a shipper obtains lower rates by submitting all or a fixed portion of his cargo to the carrier or conference).
In Canada, conference legislation is based on the Shipping Conferences Exemption Act which came into effect in 1979. It exempts certain practices of liner conferences from the provisions of the Combines Investigation Act. The Shipping Act does not require the right of independent action as its equivalent in the U.S. does, nor grant anti-trust immunity to agreements among marine terminal operators and between these operators and ocean common carriers. It allows conferences to set rates for Canadian destinations even if they do not call at Canadian ports. It accepts closed conferences, and conference members are allowed to carry out patronage contracts with a maximum of 15% rate differential between contract and non-contract rates. After two extensions, the expiring date of the Act has been set as of March 31, 1986.

RAIL LEGISLATION

An examination of the rail legislation is relevant to the study in the sense that railways are important elements for the inland distribution of containers. A Transport Canada study (5) indicates that in the intra-provincial markets, rail enjoys a clear advantage over private trucking only for shipments heavier than 45 tonnes, for shipment distances greater than 500 Km. and for commodities in the crude materials grouping. In the extra-provincial movements, length of hauls tend to be longer than those that exist in the
intra-provincial markets. Thus, rail's cost advantage becomes apparent in and above the 18 to 45 tonnes category. Some of the characteristics of the rail legislation in the U.S. and in Canada are described next. They are mostly based on a study performed by Ports Canada. (6)

In the U.S., a new Rail Act known as the Staggers Rail Act came into effect in 1980. Prior to that date, the railroad industry functioned under a high degree of government regulation. The new act emphasizes adequacy of rail carrier revenues and the elimination of non-compensatory rates. It encourages intramodal and intermodal competition. All transportation in rail "piggyback" equipment (trailers and containers on flat cars) is exempted from any regulatory involvement of the Interstate Commerce Commission (ICC). The ICC is the body that under previous legislation used to exercise a strong regulatory role. The new act has transformed the functions of the ICC largely to a monitoring role. The ICC does not now approve rate changes, and notice of change of a filed rate can be as short as three days. The new Act states that rates and conditions can be negotiated and must be filed with the ICC, but that they are no longer a matter of public record. Contract rates under confidential terms are permitted but collective rates are forbidden.

In Canada, rail regulation is based on the principles of the National Transportation Act (NTA) enacted in 1967. The
Act seeks to encourage intermodal competition with railways as one competing mode. With respect to rates, it focuses on the interests of the users of the system, but rates do have to be compensatory. Only tariff rates can be charged, which should be applied equally to all users. Contract rates are allowed but they have to be public. Collective and joint rates are also accepted. The Act does not allow confidential contracts to be negotiated by Canadian railways for international traffic.

TRUCKING LEGISLATION

There is an intensive use of trucking in intermodal transportation. Commencing in 1935, the trucking industry in the U.S. became regulated, but never to the degree of the American railroads. Over the years, trucking became a significant competitor to the railroads, but particularly in the eastern U.S. where distances between cities are usually less than in the western part of the country. (7) In 1980, the U.S. Motor Carrier Act deregulated the trucking industry. As in the railway and shipping acts, it allows the confidential negotiation of rates and terms for services. Relaxation of entry controls has facilitated Canadian truckers obtaining U.S. operating authority.

In Canada, the 1954 Motor Vehicle Act is still in force and allows provinces to regulate trucking. As a result, there
are different regulations over for-hire trucking. Some
provinces require filing and approval of trucking rates and
have the power to prescribe rates. Operating authorities,
depending on province of issue, may have stipulations
covering commodities, areas of operation, routes, pick up and
delivery points, allowable operating weight, shipment size,
named shippers and equipment requirements. (8)

THE "CONTAINER CLAUSE"

Within the examination of the institutional frameworks it
is appropriate to consider the implication of the "container
clause" in the routing of cargo through the Port of
Vancouver. The controversial clause is the 26.05 of the
International Longshoremen's and Warehousemen's (ILWU)
agreement. Its main section reads as follows: (9)

"Any container which is destined for, or comes from, any
person who is not the owner of the cargo in, or to be placed
in, such container, who consolidates or receives consolidated
cargo which comes from or is destined to any point within the
Vancouver Local Area, ... shall be packed or unpacked, as
the case may be, on the dock by persons employed under the
terms and conditions of this Agreement."

The clause means, for example, that inbound containers
will be destuffed at the dock if they are consigned to the
Lower Mainland for a public warehouse or for a consignee who is not the beneficial owner of all the contents. An important implication of destuffing cargo at the dock is the excessive handling when compared to a situation where the container is shipped intact to the consignee's warehouse. An increase in the number of times the cargo is handled, increases the total transportation cost as well as the probability of cargo loss and damage.

As it has been shown in Chapter 2, most of the liner trades through West Coast ports is with Pacific Rim countries. In Canada, this is primarily a small lot trade. Orders from buyers are generally not large enough to make up container loads, certainly not of single commodities. Thus, organizations to make up container loads in the Orient are important. Shipments through freight forwarders or consolidation by shipping lines are common. Economies of scale are also achieved by Canadian buyers working together. (10) All of these groups play a major role in the routing of traffic. For them, the container clause is a factor that favours the routing of Canadian cargo through U.S. western ports, especially the ports of Seattle and Tacoma.

Import containers are discharged in Seattle or Tacoma on a Vancouver bill of lading to be carried to a Vancouver off-dock location. Most move directly by truck; some move to Vancouver by rail. The off-dock locations provide
distribution services to receivers in Vancouver and other parts of Canada. Export traffic is also loaded in Vancouver for movement overseas through United States ports.

The movement of containers off or onto docks in the United States West Coast ports is not constrained by the equivalent of the container clause. However, in any event, the movement of containers intact to and from Vancouver would be allowed as the distances involved are well beyond the reach of the distance involved in the container clause. A further examination of the impact of the current institutional frameworks on traffic prospects through the Port of Vancouver is addressed in Chapter seven.

CONTAINER SERVICES THROUGH THE WEST COAST

In North America, especially in the U.S., current trends in containerization are characterized by an accelerated development of intermodal services. The promulgation of the new shipping and rail acts in the U.S. has created an environment which is favourable to the generation of these services. Shippers and consignees can now choose among a variety of transportation systems. Ships, ports, railways and trucks are engaged in an aggressive competition. This section examines some of the current trends of shipping services that
may have an impact on container movements through the West Coast. The examination is based mainly in the U.S., where changes have been most remarkable in the last few years.

The fast growing countries of the Pacific Rim have emerged as the major overseas trading partners of the U.S.. By 1983, the volume of U.S. trade with the Pacific Rim was 24% greater than the trade with Europe. (11) Marketing strategies of West Coast ports, railways and trans-Pacific ocean carriers have been important in the marked shift from the Atlantic and Gulf Coast ports to those in the Pacific. In the trade between the U.S. and the Far East, the West Coast share has increased from about 33% in 1968 to over 70% in 1984, basically as a result of the growth of minibridge services. (12) Ports on the U.S. Gulf and Atlantic Coast have been increasingly served from the West Coast by rail instead of using an all-water service via the Panama Canal.

Simultaneously with the shift towards the use of minibridge systems, the container shipping industry has continued its trend towards increasing vessel size. Recent examples of "jumboization" and newbuildings indicate that economies of vessel size are important enough to attract shipping lines to use larger ships. The size of the largest vessels deployed by shipping lines in their services through the West Coast lies in the 1800 to 2500 range. Some examples are: the largest Sea-Land vessels that can carry 2472 TEUs;
(13) EAC's recently deployed 1800 TEU vessels to replace part of their smaller tonnage; (14) Mitsui's largest ships that are in the 1600-1900 TEU range; (15) APL's largest newbuildings that accommodate the equivalent of 2600 TEUs; (16) Maersk's new deployments with capacity for 2500 TEUs; (17) and the largest Evergreen Line ships serving the West Coast that can carry up to 1810 TEUs. (18)

The deployment of larger vessels has been accompanied by an increase in the overcapacity of liner services. Recent figures indicate that current transpacific export rate through the West Coast is approximately 1.7 million TEUs, whereas the total capacity that is provided reaches 2.6 million TEUs, implying a 53 percent of overcapacity. On the other hand, eastbound overtonnage is estimated to be in the order of 23 to 30 percent. (19) The amount of overtonnaging may encourage shipping lines to compete more aggressively for market share. One feature may be a willingness to serve an increased number of ports in order to maintain and to attract new customers. This is one of the factors that prevents the full utilization of a reduced number of ports, or "load centre" concept.

Several shipping companies are engaged in sophisticated distribution systems for moving containers to and from inland centres. In recent years, traditional "COFC" (containers on flat car) movements have been complemented by double stack
container trains. It seems that important economies of scale can be gained by using this new system, especially on long-haul, high density routes where line-haul cost savings warrant added terminal costs. Figures in the range of 20% to 40% savings with respect to movements on flat cars have been indicated. (20), (21)

Some of the largest shipping lines engaged in intermodal services - Sea-Land, APL, Maersk Lines, U.S. Lines - have already adopted double stack container trains as part of their distribution networks. Double stack trains are currently running from Los Angeles, Oakland, Seattle and Tacoma to cities in the U.S. Midwest and to ports in the Atlantic and Gulf Coast. Most of the double stack trains are for the exclusive use of a shipping line. One remarkable exception is a common carrier service that is provided jointly by the Port of Seattle and Burlington Northern, running from Seattle to the U.S. Midwest. (22) Most double stack trains are owned and operated by competing maritime interests. For example, APL has a contract where railways provide only power units and a right of way, instead of a tariff rate for cargo moved; APL has even contracted a freight forwarder to sale their backhaul movements.

The present situation of overtonnaging of liner services is characterized by a dramatic reduction of freight rates. Figures provided by some shipping lines indicate that in some
trades, revenue per 40-foot container has dropped up to 25 percent. Under these circumstances, shipping lines that provide door-to-door service can offset at least part of their losses in revenue by developing transportation systems that include double stack train services. In the case of the double stack service provided by the Port of Seattle and Burlington Northern, its lower cost allows the generation of transportation systems through the Port of Seattle that may be more attractive than traditional systems offered through the Port of Vancouver. For example, Burlington Northern's price to move a 40-foot container between Seattle and Chicago is about U.S.$1,100, whereas an equivalent price on Canadian railroads between Vancouver and Chicago is U.S.$1,500. (23)

Another trend in liner shipping is the use of cooperative arrangements. This has been a response to excess container slot supply, the deployment of larger ships and the pressure of shippers and consignees for frequent services. Some examples of joint services through the West Coast include the West Coast-Europe weekly service of Johnson Line, EAL Lines and Blue Star Line, (24) the U.S. West Coast-Far East cross charter between EAC Lines and Mitsui O.S.K. Lines, (25) the agreement between Sea-Land and Hapag Lloyd to offer a transpacific container service, (26) and the round-the-world NOL, OOCL and K Line service. (27)
Some shipping lines have recently started a round-the-world service. This is not a new concept in liner shipping. It was used by a number of steamship lines in the days following World War II. APL also operated a similar service until 1977. (28) Current operating services include one offered by U.S. Lines using 4482 TEU vessels - the largest container vessels in the world -. In North America, sailings include direct calls exclusively at some East Coast ports. (29) A much smaller vessel size has been chosen by Evergreen Lines for its round-the-world service. Vessels sailing east and westbound have capacity for 2728 TEUs. West Coast ports are also excluded from their regular itineraries. (30) A third round-the-world service is being provided jointly by OOCL and NOL, and it will shortly include K Line. The largest vessels being used in this service can carry 2300 TEUs. (31) The service contemplates one call at the Port of Long Beach as part of the direct service to the West Coast. (32) The Taiwanese outsider Yang Ming Line has announced plans to inaugurate a round-the-world service with vessel capacities ranging from 2700 to 3200 TEUs. (33)

Rather than representing a trend in liner shipping, round-the-world services are alternate operational strategies developed by shipping lines. Their success will be greatly affected by the response of shippers and consignees to the overall quality and price of the transportation systems associated to those services. An illustration including some
of the remarkable examples of new vessel sizes, routes and inland services that have been previously indicated, is presented in Figure 5.1.

A recent institutional change has been the creation of the Transpacific Westbound Rate Agreement (TWRA). It includes most of the shipping lines engaged in the transpacific trades. This group replaces six conferences in the westbound trade. It covers cargo moving westbound from ports and inland points in the U.S. and in Canada. According to a report prepared by the TWRA, (34) one of the main advantages of a single rate agreement is that "it recognizes that the U.S. and Canada each represent a single market thanks to the emergence of extensive intermodal transportation networks ..." Some of the characteristics of this agreement are: separate tariff categories have been created including local, all-water, minibrige and interior point rates; minimum charges have been defined according to six geographical areas of origin. However, the application of minimum container charges has not been fully implemented yet; the same rate applies to local cargo moving from all West Coast ports in Canada and the U.S.. This is important because as freight levels are not affected by the specific port that is used, it is reasonable to expect that decisions by shipping lines to serve a port, are going to be affected by whether such a port can provide inland transportation at a competitive cost from major inland centres; TWRA allows the lines to take
### FIGURE 5.1

**EXAMPLES OF NEW VESSELS, ROUTES AND INLAND SERVICES**

<table>
<thead>
<tr>
<th>LINE</th>
<th>VESSELS</th>
<th>ROUTE</th>
<th>INLAND TRANSP.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SEA-LAND</strong></td>
<td>12 to be jumboized from 1870 to 2472 TEUs</td>
<td>9 on Trans-Pacific, 3 on Trans-Atlantic</td>
<td>Double stack: Tacoma-Chicago-N.Jersey and L.A.-Chicago</td>
</tr>
<tr>
<td><strong>EVERGREEN</strong></td>
<td>24x2728 TEUs by mid'1986</td>
<td>Round the world: Eastbound and Westbound. Not calling W. Coast</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5x1810 TEUs</td>
<td>Eastbound and Westbound. Not calling W. Coast</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4x900 TEUs</td>
<td>Asia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6x1175 TEUs</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>APL</strong></td>
<td>3x2600 TEUs and 14 smaller vessels</td>
<td>West Coast to Asia</td>
<td>Double stack: L.A.-Atlanta, L.A.-Chicago-N.York and Seattle-N.York</td>
</tr>
<tr>
<td><strong>MAERSK</strong></td>
<td>2500 TEUs</td>
<td>West Coast to Asia</td>
<td>Double stack: Tacoma-Chicago</td>
</tr>
<tr>
<td><strong>OOCL-NOL</strong></td>
<td>9 up to 2300 TEUs (K Line will join shortly)</td>
<td>Round the world: only Long Beach on the West Coast</td>
<td>Liner train service: Long Beach-Houst.-N.Orleans</td>
</tr>
<tr>
<td><strong>US Lines</strong></td>
<td>12x4482 TEUs by fall 1985</td>
<td>Round the world: Not calling W. Coast</td>
<td></td>
</tr>
<tr>
<td><strong>YANG MING</strong></td>
<td>11 to be jumboized from 1920 to 2700 TEUs plus 4x3000-3200 TEUs</td>
<td>Round the world: announced only</td>
<td></td>
</tr>
</tbody>
</table>
independent rate actions, but service contracts are not allowed. (35)

A trend that has emerged as a result of the U.S. Staggers Rail Act is the aggressive response by U.S. railways towards a greater participation in intermodal services. There has been a process of rationalization, where numerous mergers have resulted in a much more streamlined system, eliminating many of the duplications of services, costs, equipment, trackage and other inefficiencies. (36) Major railways are heavily involved in the development of intermodal services. Since 1981, "piggyback" traffic has grown an average of 15% annually, being the fastest growing line of business for railroads carriers. (37) As a result of the increasing involvement of U.S. railways on intermodal services, Canadian railways are facing a strong competition from their U.S. counterparts. A response by C.N. Rail to capture part of the eastern Canadian containers that are being moved by U.S. railways to U.S. West Coast ports, has been the recent introduction of competitive rates from eastern Canada to Chicago for containers destined to U.S. West Coast ports. (38) This move may set a precedent for Canadian railways on their involvement in transportation systems favouring the use of U.S. West Coast ports.

One of the elements that may have an impact on the attractiveness of specific transportation systems is the
strategic location of inland terminals. They are usually served by rail and road and act as a focus for distribution of inbound and outbound cargo. Lower overall freight rates may be achieved by moving cargo through these terminals. In Canada and the U.S. they have been used by carriers for a number of years. However, an experimental project has been initiated in Canada to create a new container distribution system for the Province of Alberta. The implication of this project may be either beneficial or detrimental for the routing of cargo through the Port of Vancouver. Efficiencies could enhance the competitiveness of routing via the Port of Vancouver, but as consideration is being given to link the terminal with U.S. rail lines, the result could be a diversion of cargo through U.S. ports. (39)

Finally, a current trend in intermodal services is that as a result of the new U.S. legislation that grants anti-trust immunity to intermodal rates, ocean carriers are increasingly offering door-to-door services. This has shifted the routing decision from shippers and consignees (including freight forwarders) to shipping companies. The routing of containers by shipping lines will be affected by the characteristics of their sea and land operations. If the control over transportation systems concentrates in one entity, routing decisions will tend to be truly based on the optimization of the overall transportation systems.
REFERENCES


6. Task Group, pp. 30-34.


19. J. Lamb, "TWRA has rough start in its pioneering role," Shipping Digest, June 24, 1985, p. 11.


34. Transpacific Westbound Rate Agreement, pp. 1-5.


36. Task Group, p. 58.

38. Task Group, p. 33.

VI. ECONOMICS OF ALTERNATE ROUTE CONFIGURATIONS

The decisions that shipping lines have to make regarding route configurations require the examination of a number of interacting elements. Geographical relationships, cargo distributions within trading hinterlands, relative marine and inland transport costs, and pricing regimes are some of the important elements to be considered when route patterns are established. (1)

One of the characteristics of the general cargo sector is that cargo origins and destinations are widely distributed around the world. Trying to cope with the need for wide cargo distribution, shipping lines have developed a multiplicity of service patterns. They include, among others, traditional "range to range" itineraries and "round-the-world" services.

This chapter starts by examining some of the relevant factors that are important to shipping lines when assessing different route configurations. It is followed by an examination of the economics of alternate service options. This is done by presenting two quantitative exercises: the first one is a case where the alternatives of calling at one and two ports in the Pacific Northwest are evaluated; the second compares the alternative of calling at one port in California with other alternative that considers calling at
the same port in California plus one port in the Pacific Northwest. Special attention is given to the impact that changes in some of the parameters that determine route configurations may have on the attractiveness of alternate routes. Finally, general conclusions of both exercises are presented.

RELEVANT FACTORS AFFECTING ROUTE CONFIGURATIONS

When considering the economies of ship size at sea, it can be expected that the tendency towards an increase in ship size will be accompanied by the concentration of shipping services in a reduced number of "load centers". Feeder services by sea and land would be developed to move cargo from and to its origin and destination. In practice, the load center approach has seen relatively limited application. Instead, a number of service patterns have been developed. In most cases, the operation of multi-port itineraries plays a major role. (2) Some of the current routing strategies used by shipping lines are quite sophisticated. Figure 6.1 describes the three services that American President Line (APL) provides from the U.S. West Coast to the Far East: the first service involves the Pacific Northwest and includes calls at ports in Japan and Taiwan; the two other services include two ports in California. One provides direct service to Northeast Asia, whereas the other concentrates in Southeast Asia. While Yokohama and Kobe are ports of call in
FIGURE 6.1

APL TRANS-PACIFIC SERVICES

1. PACIFIC NORTHWEST TO JAPAN AND TAIWAN

YOKOHAMA  →  SEATTLE
KOBE
KEELUNG

2. PACIFIC SOUTHWEST TO NORTHEAST ASIA

YOKOHAMA  →  SAN FRANCISCO
BUSAN  →  LOS ANGELES
KOBE
KAOHSIUNG
HONG KONG

3. PACIFIC SOUTHWEST TO SOUTHEAST ASIA

KAOHSIUNG  →  SAN FRANCISCO
HONG KONG  →  LOS ANGELES
PENANG
SINGAPORE
JAKARTA

the first two services, Hong Kong is included in the second and third services. Under this scheme, the mainline vessel of one service acts, for part of its itinerary, in a feeder capacity for a second service. For example, cargo originated at Seattle for Hong-Kong, leave on the first service and is transhiped at Kobe on to a mainline vessel of the second service.

A number of reasons may explain the limited development of the load center concept. They relate to the features of vessels and to the competitive conditions in liner shipping markets.

Large containerships are affected by diminishing economies of size. Little transportation cost reductions, if any, are obtained with vessels over 3000 TEUs capacity; diseconomies of size while vessel is in port contribute to reduce the attractiveness of increasing vessel size. Physical considerations also constrain the increase in vessel size. Supra Panamax ships would be severely restricted in the number of ports they could use. Furthermore, stability limitations when trying to meet Panama Canal size requirements for very large vessels result necessarily in a reduction of the vessel economic speed. (3) This is because additional containers are accommodated mainly by designing vessels with a squarer hull form. Such vessels are characterized by lower economic speeds than those who have a
finer hull form. Such is the case of the recently deployed U.S. Lines 4482 TEU vessels. They have an economic speed of 18 knots, lower than those of containerships around the 3000 TEU capacity that usually exceed 20 knots.

The current excess supply of container slot capacity and the lucrative nature of some cargoes contribute to a more aggressive competition between shipping lines. The lines are willing to make additional calls at ports located close to the main producer/consumer areas in order to gain and to maintain their customers. In the competitive environment, strategic reasons induce shipping lines to value flexibility and avoid a one-country load center situation. Frequency has become an important marketing element and there are only a few ports in the world that possess sufficient traffic to sustain a high frequency service with large vessels operating at a reasonable load factor. (4)

When a liner shipping company is defining route patterns, two steps can be identified. The first is the definition of the ranges of ports that will be covered. For example, West Coast North America to Far East. The second step is the identification of specific ports to serve within each range. The rest of the chapter is devoted to examining the factors influencing the selection of ports to serve.
When a liner shipping company is deciding which route configuration is the most appropriate, a number of interacting elements have to be taken into consideration. Assuming that the line's objective is profit maximization, the chosen route should be the one that combines ship size, speed and frequency in such a way that attracts a proportion of the trade that generates the highest profit. Therefore, optimizing any one of the cited elements independently is not the most appropriate strategy.

A number of feasible operating strategies are usually available to shipping lines. Each strategy has certain quality and price characteristics. Their effectiveness depends on their attractiveness to shippers and consignees who select routes and carriers on the basis of their own needs and their perception of the services available to them. Their concern is with the effectiveness of the whole transportation system, from origin to destination. The components of the system are only of interest to them to the extent that they affect the quality or price of the overall service. (5) Therefore, shipping lines should estimate the response of potential users to each possible route configuration and choose the most adequate on the basis of the economic results for alternate combinations of frequency, ship size and speed. (6)
Once the range of ports that are going to be served have been identified, direct service to any specific port will depend on the economic trade-offs between using the main-line vessel to offer a direct call to that port, or alternatively, to use another port of call plus feeder services by water and/or land modes. Some of the factors affecting these trade-offs are examined next.

RELATIVE COST AND DISTANCES

When comparing the relative advantages of ocean and land services, the cost of individual modes becomes a critical factor. Sea transport, whether by bulk carrier or liner vessel, is less expensive than inland transport. A study made in the U.K. in 1980, shows costs for sea transport being between 10 and 50 times less than the costs of land modes. (7) The relative cost of the two modes is affected, among other factors, by the characteristics of the routes, vehicles and speed associated with the modes that are compared.

The potential substitution of sea for land transportation is affected significantly by geographic conditions and the relative length of haul by the two modes. Large differences in cost per mile between modes can be offset because inland and marine distances may vary considerably. Sometimes, the substitution of sea for land transportation enables large savings in marine distances. For example, eastbound cargo
from the Far East to New York can be unloaded in Seattle and then be moved by railway to its final destination, covering a land distance of 4,600 Km. In contrast, if the cargo is carried in a vessel sailing from Seattle to New York via the Panama Canal, the total distance by sea will be 10,100 Km. The opposite situation may also occur, i.e. relatively small additions to marine distances enable large savings of inland distances.

Inland transport may be used as a substitute for sea movement when lines drop direct calls at a port. Reduction in the number of ports served directly is not a new phenomenon. In some cases, it may be economically feasible to use additional vessels for feeder purposes; the vessels are usually much smaller than those on the main-line service. E.T. Laing (8) shows that in general, the shorter the distance involved in serving an additional port area, the more likely the service is to be provided by surface than water transport.

**AVERAGE CARGO DEMAND**

The amount of cargo available at a port is important to choice of routes made by shipping lines. A sufficient amount of cargo must be expected for lines to schedule a regular
call at a port. The required amount is influenced by the revenue potential of the cargo and by the costs of adding a port of call. Those costs are higher the larger the vessel.

Liner services often advertise that they will only call at certain smaller ports "on inducement". Traditionally, about 500 tonnes was regarded as a common quantity to warrant an additional call to such a port. Today, the development of more expensive container vessels operating to tighter schedules tends to increase the desirable amount of cargo needed.

AVERAGE LENGTH OF THE OCEAN ROUTE

Most shipping lines involved in liner trades try to attract customers by offering a reliable and frequent service. To offer regular calls at an additional port reduces the total number of trips that the line can offer in any period of time (unless time is recovered by sailing at higher speeds and therefore increasing fuel consumption). The impact of adding a call depends on the length of the route that is being considered. For example, assuming that a vessel sails at an average speed of 20 knots and that she spends a total of 10 days in port, the addition of two days in order to call at a smaller port on a 10,000 mile route, represents a reduction of 6% in the number of trips per year; in a 20,000 mile route, the addition of two days represents a reduction
of only 3.7% in the total number of trips. This is one of the reasons that long trade routes frequently have more ports of call than short ones. (9)

MARKETING FACTORS

A direct call by a line in a port can have various effects on the marketing for the service. First, it seems likely that the physical presence of vessels in the port has some positive effect on the line's market share. (10) Second, a direct call by a line can influence the sailing schedule. Shipping lines indicate that maintaining reliable transit time and day of the week in which a call takes place are important. (11) In general, shippers and consignees favour the use of lines that offer faster transit time and that are able to call at a given port on a specific day of the week. Adding a port of call may alter the characteristics of these marketing factors throughout the whole set of ports of a route. The overall response to these changes by shippers and consignees, may either improve or reduce the market share that a shipping line can capture.

OTHER FACTORS

There are additional factors that shipping lines may consider in the process of assessing the attractiveness of route configurations. Four further factors are indicated to
complete this general examination. First, the greater the number of ports, the greater the probability that unexpected events may cause a delay to the ship. Second, an increase in the number of ports complicates the stowage plan and increases the frequencies of double handling with the corresponding increases in cargo handling expenses. Third, for shipping lines involved in intermodal services, the problem of repositioning containers due to imbalanced traffic may have an impact on the attractiveness of routing cargo through certain ports. The effect of inland distribution on the overall transportation costs may favour the use of ports that can offer the alternative of a balanced movement of containers. Fourth, by increasing the number of calling ports, there is a tendency to lose control over the quality of port services that are provided. Efficiency of dock operations and off-dock transportation may suffer because a shipping company calling at many ports can not afford to be as actively engaged in terminal operations as a company calling at a few ports. (12)

EXAMINATION OF THE ECONOMICS OF ALTERNATE SERVICE OPTIONS

Having examined some of the relevant factors that affect route configurations, it is desirable to quantify the relative impact of those factors on the attractiveness of route configurations and to assess the sensitivity of the results to variations of the factors. The approach taken is
to create a model to evaluate the attractiveness of alternate routes. A number of parameters that control route economics have been included in the model. The model compares the impact of serving determined regions by adding a port of call, with the alternative of using land feeder services to and from a "load centre" port. Increased inland costs when using a "load centre" port are compared with shipping cost savings from by-passing the "additional port".

Inevitably, in creating such a model a number of assumptions have been made. Probably one of the most critical assumptions is that the ship's revenue is maintained at the same level for the two alternatives. This may seem inadequate because adding a port of call implies longer routes and additional time in port, both factors increasing the total duration of the voyage of the alternative that has an additional port. As a result, in any period of time, revenues will be different between the two alternatives. Moreover, adding a port will change the transit time and the day of the week on which a call is provided. These changes will occur throughout the whole set of ports in a given route. Thus, the alternatives could differ in the service provided to shippers and consignees.

However, shipping lines can avoid at least some of the negative marketing effects by sailing at higher speeds when an additional port is added to a route, so that the round
trip duration of both alternatives is the same. By treating both alternatives as capable of generating the same level of revenue, their relative attractiveness can be measured in terms of their total costs. The assumption of increasing vessel speed can be supported by one of the current characteristics of the liner trades. Many liner companies have set services based on a fixed interval frequency, i.e. weekly, bi-weekly, etc. This frequency has an important impact on the attractiveness that a line may have on shippers and consignees. Therefore, shipping lines are reluctant to increase the gap between sailings because of the effect that it may have on the perception of the quality of service that they provide. (13) A full description of the assumptions included in the model is presented in Appendix I.

Two exercises are presented in this section. The first one simulates a shipping line that is facing the decision whether to move Canadian cargo via Seattle or Vancouver. The second considers a line that is evaluating the alternative to serve the Pacific North West and all its "natural hinterlands" from the Port of Oakland, or by offering a direct call to the Port of Seattle. The data that are used in the exercises have been extracted from different sources. They do not correspond to any shipping line in particular, but are representative of actual cost experience of shipping lines.
Cost levels vary enormously among shipping lines. Factors such as the cost of inland distribution may be affected by the line's position in negotiating rates with truckers and railroads, or by the use of a line's own vehicles for inland transportation. Ship costs and route characteristics also vary greatly among lines. Moreover, some important elements that are considered when assessing the attractiveness of routing options, like the lack of dedicated terminals and the impact of the "container clause" are not included in the computations. Thus, model results must be viewed as being illustrative. They reflect an attempt to provide an understanding of the relative impact of changes in some of the parameters that affect route configurations and are not intended to be used as a precise measure of the changes.

EXERCISE 1

This first exercise contemplates a scenario where a shipping line is comparing the alternative of serving the Canadian market by calling at the Port of Vancouver with the alternative of moving Canadian cargo via the Port of Seattle. The dominant size of the U.S. market is considered to make the Seattle call imperative. The basic data used are shown in Figure 6.2.

The voyage that is used represents a short route between the West Coast of North America and Asia (12,000 miles). The
FIGURE 6.2

BASIC DATA, EXERCISE 1

ROUND TRIP DURATION : 42 DAYS
VESSEL CAPACITY : 1500 TEUs
DISTANCE ROUND TRIP (without calling at Vancouver) : 12000 MILES
TOTAL DISTANCE ADDED (in order to call at Vancouver) : 128 MILES
AVERAGE SAILING SPEED (without adding a call at Vancouver) : 18 KNOTS
DISTANCE OVER WHICH THE VESSEL INCREASES SPEED IN ORDER TO EQUALIZE ROUND TRIP DURATIONS : 5433 MILES
TOTAL CONTAINERS HANDLED AT VANCOUVER : 400 TEUs
TOTAL WAITING AND BERTHING TIME AT VANCOUVER : 2 HRS
CARGO HANDLING SPEED AT VANCOUVER : 40 TEUs/HR
PORT EXPENSES : 4.2 $/TEU(capac.)/DAY
REPAIRS, MAINTENANCE AND LUBE OIL : 2.9 $/TEU(capac.)/DAY
CARGO DISTRIBUTION :

<table>
<thead>
<tr>
<th>CITY</th>
<th>% CARGO</th>
<th>COST/TEU FROM:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>VANCOUVER</td>
</tr>
<tr>
<td>VANCOUVER</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>CALGARY</td>
<td>12</td>
<td>550</td>
</tr>
<tr>
<td>TORONTO</td>
<td>35</td>
<td>800</td>
</tr>
<tr>
<td>MONTREAL</td>
<td>25</td>
<td>810</td>
</tr>
</tbody>
</table>
The total round voyage takes 42 days. The vessel has a capacity of 1,500 TEUs (the average of the vessels used by Mitsui and EAC in their cross charter agreement between the U.S. West Coast and the Far East). The average sailing speed is 18 knots (the average of the APL vessels used for their line-haul and feeder services). Fuel prices are considered at 200 $/Ton for H.V.F. (high viscosity fuel) and 300 $/Ton for diesel oil. (14) The total distance that is added when calling at Vancouver is 128 miles. It is assumed that the vessel make up this additional sailing time plus the extra time in port, by sailing at a higher speed over a distance of 5,433 miles. (Los Angeles-Yokohama) The total number of Canadian containers to be handled at Vancouver or Seattle are 400 TEUs (200 inbound and 200 outbound, accounting for approximately one-eighth of the vessel capacity). Total berthing and waiting time when calling at Vancouver is 2 hours. Cargo handling speed for the Port of Vancouver is 40 TEUs/hr. (15) Port expenses are calculated at $ 4.2 per TEU (vessel capacity) per day. (16) The figure used for repairs, maintenance and lube oil is $ 2.9 per TEU (vessel capacity) per day. (17) Four Canadian cities have been chosen as representative origin and destination centers for the cargo: Vancouver (28 %), Calgary (12 %), Toronto (35 %) and Montreal (25 %). (18) As distances and route geography are similar between both Seattle and Vancouver and major Canadian cities, inland rates have been assumed to be the same from Vancouver and Seattle to Calgary, Toronto and Montreal. However,
routing through Seattle implies that containers to and from Vancouver have associated an inland transportation cost between the two cities. All rate levels have been validated from quotations provided by shipping companies that offer door-to-door service.

The results of the exercise are summarized in figure 6.3. They show that the alternative of using the Port of Vancouver is not the preferred one. The increase in shipping costs as a result of adding a port of call is greater (by $2,822 per round voyage) than the corresponding reduction of inland costs. The largest shipping cost increase is caused by the additional fuel burned in order to maintain the same frequency of service. This cost item represents 60% of the overall incremental costs, followed by the fuel that is used to sail the extra distance, that accounts for 17%. The two other cost items, i.e. additional port expenses and increase in repairs, maintenance and lube oil costs, share the rest almost equally. When calling at Vancouver, there is an additional sailing time of 7 hours. The extra time in port is also 7 hours. The new speed at which the vessel has to sail in order to make up these additional sailing and port times is 18.88 knots.

The most valuable feature of this exercise is not the magnitude of the results obtained when comparing different alternatives. As previously mentioned, some of the parameters
FIGURE 6.3

TRANSPORTATION COSTS OF ROUTING CONTAINERS THROUGH VANCOUVER AND SEATTLE

A. INCREASED SHIPPING COSTS OF ADDING VANCOUVER AS PORT OF CALL ($/ROUND VOYAGE)

* FUEL TO SAIL ADDITIONAL DISTANCE : 2,727 $/RV
* FUEL TO KEEP SAME ROUND TRIP DURATION : 9,748 $/RV
* ADDITIONAL PORT EXPENSES : 1,838 $/RV
* ADDITIONAL REPAIRS, MAINT. AND LUBE OIL : 1,949 $/RV
TOTAL COST INCREASES : 16,262 $/RV

B. REDUCTION OF INLAND COSTS WHEN ADDING VANCOUVER AS PORT OF CALL ($/ROUND VOYAGE)

* INLAND COSTS WITHOUT CALLING AT VANCOUVER: 232,840 $/RV
* INLAND COSTS ADDING A CALL AT VANCOUVER : 219,400 $/RV
TOTAL COST REDUCTIONS : 13,440 $/RV

C. NET COST SAVINGS BY NOT CALLING AT VANCOUVER : 2,822 $/RV
used to represent operating characteristics of shipping lines and inland modes may vary considerably. Moreover, some non-quantifiable elements, like the impact of the "container clause" and the lack of dedicated terminals are not represented in the computations.

However, it is interesting to see how changes to some of the parameters that determine route configurations may affect the attractiveness of different routes. Consequently, a sensitivity analysis has been performed. Changes of +/- 10% (depending on the direction of current trends) have been applied individually to most of the parameters that determine route configurations. Ideally, percentage changes should have been different for each parameter, trying to represent more accurately their expected variations. However, an indication of the relative importance of changes in those parameters can also be obtained by applying the same percentage. A summary of the results is shown in Figure 6.4.

The impact of inland costs is shown to be very sensitive to the relative attractiveness of the alternatives. An overall increase in inland costs by 10% results in a reduction of the attractiveness of using the Port of Seattle by 48%, from $2,822 per round voyage (RV) to $1,477 per RV; if the 10% inland cost increase applies exclusively to movements to and from Seattle, the net effect is a dramatic deterioration of the alternative of using Seattle. The use of
FIGURE 6.4

RESULTS OF SENSITIVITY ANALYSIS, EXERCISE 1

<table>
<thead>
<tr>
<th>PARAMETER CHANGED</th>
<th>% CHANGE OF PARAMETER</th>
<th>NET ADDITIONAL COST WHEN ROUTING BY VANCOUVER:</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASIC CASE</td>
<td>-</td>
<td>$2,822</td>
</tr>
<tr>
<td>INLAND COSTS (OVERALL)</td>
<td>+ 10 %</td>
<td>$1,477 -48 %</td>
</tr>
<tr>
<td>INLAND COSTS (ONLY TO AND FROM SEATTLE)</td>
<td>+ 10 %</td>
<td>-19,119 -777 %</td>
</tr>
<tr>
<td>VESSEL SIZE</td>
<td>+ 10 %</td>
<td>$3,809 35 %</td>
</tr>
<tr>
<td>CARGO THROUGH VANCOUVER</td>
<td>+ 10 %</td>
<td>$2,018 -28 %</td>
</tr>
<tr>
<td>CARGO HANDLING SPEED AT VANCOUVER AND SEATTLE</td>
<td>+ 10 %</td>
<td>$2,331 -17 %</td>
</tr>
<tr>
<td>PORT CHARGES AT VANCOUVER AND SEATTLE</td>
<td>- 10 %</td>
<td>$2,639 -6.5 %</td>
</tr>
<tr>
<td>VESSEL WAITING AND BERTHING TIME AT VANCOUVER AND SEATTLE</td>
<td>- 10 %</td>
<td>$2,605 -8 %</td>
</tr>
<tr>
<td>ROUTE LENGTH AND PORT DAYS</td>
<td>+ 10 %</td>
<td>FROM $ 67/DAY TO $ 60/DAY -10 %</td>
</tr>
<tr>
<td>VESSEL SPEED</td>
<td>+ 10 %</td>
<td>FROM $ 67/DAY TO $ 155/DAY 131 %</td>
</tr>
<tr>
<td>FUEL CONSUMPTION</td>
<td>- 10 %</td>
<td>$1,819 -36 %</td>
</tr>
<tr>
<td>PROPORTION OF CARGO HANDLING TIME USED AS NET INCREASE WHEN CALLING AT VANCOUVER</td>
<td>+ 10 %</td>
<td>$3,362 19 %</td>
</tr>
</tbody>
</table>
Vancouver becomes the preferred alternative by a difference of $19,119 per RV; when calculating the effect of changes in vessel size, the results indicate that as vessel size increases, the alternative of using the Port of Vancouver becomes even less attractive. A 10% increase in vessel size improves the alternative of using Seattle by 35%, from $2,822 per RV to $3,809 per RV; when increasing the number of TEUs that are moved through the Port of Vancouver, the advantage of using the Port of Seattle becomes smaller. A 10% increase in the number of TEUs moved through Vancouver, reduces the attractiveness of using Seattle 28%, from $2,822 per RV to $2,018 per RV.

Parameters over which port administration may exercise considerable control are the efficiency of cargo handling, the level of port charges and the level of congestion that vessels can expect. The exercise shows that a 10% increase in cargo handling speed (from 40 to 44 TEUs per hour) at both Vancouver and Seattle, reduces the advantage of using Seattle by 17%, from $2,822 per RV to $2,331 per RV. This is explained because fuel costs are reduced by the need for lower increases in speed in order to maintain the same frequency, and by the shortened stay at the Port of Vancouver; when port charges (excluding cargo handling expenses) are reduced 10% for both ports, the advantage of using Seattle is reduced 6.5%, from $2,822 per RV to $2,639 per RV; by reducing waiting and berthing time 10% at
Vancouver, the advantage of using Seattle drops 8%, from $2,822 per RV to $2,605 per RV.

When route length is increased, there is a reduction in the advantage of using Seattle. The exercise shows that by maintaining the vessel speed, and by increasing the basic route as well as the days spent in port by 10%, there is a reduction of 10% in the attractiveness of using Seattle, from $67 per day to $60 per day. Comparisons can no longer be made on a round trip basis because of differences on the total duration of the trip; consequently, daily costs have been used as a unit of comparison. This conclusion is consistent with the tendency for longer routes to have a larger number of ports of call than short ones.

When vessel speed is increased, there is a deterioration of the attractiveness of using Vancouver. By increasing vessel speed 10% and maintaining the same number of port days, the round trip duration decreases 6%. When this happens, the daily difference against the alternative of using Vancouver goes from $-67 per day to $-155 per day, which represents a 131% deterioration. Thus, it would be more costly for fast ships than slow ships to add the Port of Vancouver. This can be explained because as vessel speed increases, fuel consumption increases in a more than proportional manner; the additional fuel cost that is required in order to provide the same frequency of service
increases also in the same form, making the use of an additional port less attractive.

It is not appropriate to perform sensitivity analysis by increasing fuel expenses in one mode at a time because changes in fuel prices would probably affect not only the ocean mode costs but also inland distribution costs. What has been done, however, is to decrease the vessel fuel consumption, trying to capture the general trend towards more fuel efficient ship designs. The results show that by reducing fuel consumption by 10%, the attractiveness of using the Port of Seattle is reduced by 36%, from $2,822 per RV to $1,819 per RV. Thus, less fuel efficient vessels are more reluctant to add a call at the Port of Vancouver.

The last parameter that is modified, corresponds to the proportion of cargo handling time that is considered as net increase when adding a port. As explained in Appendix I, the model considers 50% of the total port time at the additional port as the net increment of port time. When increasing this proportion 10%, the new result indicates that the attractiveness of using the Port of Seattle improves 19%, from $2,822 per RV to $3,362 per RV.
EXERCISE 2

The second exercise contemplates a scenario where a shipping line is comparing the alternative of serving the Pacific North West and all its "natural hinterlands" - including Canadian cargo - by calling at the Port of Seattle, with the alternative of moving the same cargo via the Port of Oakland. The dominant size of the California market is considered to make the Oakland call imperative. The basic data used are shown in Figure 6.5. The sensitivity analysis that is performed in the second exercise includes changes to the same parameters that were modified in the previous case. However, because of the different characteristics of the two scenarios, it is interesting to see whether changes have a similar behaviour.

The voyage that is used represents a route between the West Coast of North America and Asia (11,000 miles). The total round voyage takes 35 days. The vessel has a capacity of 2,400 TEUs (similar to the new APL deployments on the transpacific trade). The average sailing speed is 18 knots (average of the APL vessels used for their line-haul and feeder services). Fuel prices are the same as those in exercise 1, i.e. 200 $/Ton for H.V.F. and 300 $/Ton for diesel oil. The total distance that is added when calling at Seattle is 1,000 miles. It is assumed that the vessel make up this additional sailing time plus the extra time in port, by
FIGURE 6.5

BASIC DATA, EXERCISE 2

ROUND TRIP DURATION : 35 DAYS
VESSEL CAPACITY : 2400 TEUs
DISTANCE ROUND TRIP (without calling at Seattle) : 11000 MILES
TOTAL DISTANCE ADDED (in order to call at Seattle) : 1000 MILES
AVERAGE SAILING SPEED (without adding a call at Seattle) : 18 KNOTS
DISTANCE OVER WHICH THE VESSEL INCREASES SPEED IN ORDER TO EQUALIZE ROUND TRIP DURATIONS : 5433 MILES
TOTAL CONTAINERS HANDLED AT SEATTLE : 1600 TEUs
TOTAL BERTHING AND WAITING TIME AT SEATTLE : 2 HRS
CARGO HANDLING SPEED AT SEATTLE : 60 TEUs/HR
PORT EXPENSES : 4.2 $/TEU(capac.)/DAY
REPAIRS, MAINTENANCE AND LUBE OIL : 2.9 $/TEU(capac.)/DAY
CARGO DISTRIBUTION :

<table>
<thead>
<tr>
<th>CITY</th>
<th>% CARGO</th>
<th>COST/TEU FROM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SEATTLE</td>
<td>OAKLAND</td>
</tr>
<tr>
<td>VANCOUVER</td>
<td>3</td>
<td>120</td>
<td>300</td>
</tr>
<tr>
<td>TORONTO</td>
<td>7</td>
<td>800</td>
<td>880</td>
</tr>
<tr>
<td>SEATTLE</td>
<td>15</td>
<td>0</td>
<td>200</td>
</tr>
<tr>
<td>PITTSBURGH</td>
<td>75</td>
<td>800</td>
<td>880</td>
</tr>
</tbody>
</table>
sailing at a higher speed over a distance of 5,433 miles.
(Los Angeles-Yokohama) The total number of containers to be
handled at Seattle are 1,600 TEUs (800 inbound and 800
outbound, accounting for one-third of the vessel capacity).
Total berthing and waiting time when calling at Seattle is 2
hours. Cargo handling speed for the port of Seattle is 60
TEUs/hr (same rate per crane as in Vancouver, but assuming
three container cranes instead of two). As in Exercise 1,
port expenses are calculated at $4.2 per TEU (vessel
capacity) per day and the figure used for repairs,
maintenance and lube oil is $2.9 per TEU (vessel capacity)
per day. Four cities have been chosen as representative
origin and destination centers for the cargo: Toronto (7 %),
Vancouver (3 %), Seattle (15 %) and Pittsburgh (75 %) (based
on current proportion of containers directed from Seattle to
inland points in the U.S. and assuming that the proportion of
Canadian cargo through Seattle is the same as the proportion
of TEUs handled at Vancouver with respect to Seattle). Inland
rates are assumed to be 10 % higher from Oakland than from
Seattle to inland destinations. All rate levels have been
validated from quotations provided by shipping companies that
offer door-to-door service.

The results of the exercise are summarized in Figure 6.6.
They show that the alternative of using the Port of Seattle
is the preferred one. The total costs are $22,159 less per
round voyage by calling at Seattle than by serving Seattle
FIGURE 6.6

TRANSPORTATION COSTS OF ROUTING CONTAINERS THROUGH SEATTLE AND OAKLAND

A. INCREASED SHIPPING COSTS OF ADDING SEATTLE AS PORT OF CALL ($/ROUND VOYAGE)

* FUEL TO SAIL ADDITIONAL DISTANCE : 23,231 $/RV
* FUEL TO KEEP SAME ROUND TRIP DURATION : 87,625 $/RV
* ADDITIONAL PORT EXPENSES : 6,440 $/RV
* ADDITIONAL REPAIRS, MAINT. AND LUBE OIL : 22,145 $/RV

TOTAL COST INCREASES : 139,441 $/RV

B. REDUCTION OF INLAND COSTS WHEN ADDING SEATTLE AS PORT OF CALL ($/ROUND VOYAGE)

* INLAND COSTS WITHOUT CALLING AT SEATTLE : 1,216,960 $/RV
* INLAND COSTS ADDING A CALL AT SEATTLE : 1,055,360 $/RV

TOTAL COST REDUCTIONS : 161,600 $/RV

C. NET COST SAVINGS BY CALLING AT SEATTLE : 22,159 $/RV
and its hinterland by surface transport from Oakland. The largest shipping cost increase is caused by the additional fuel burned in order to maintain the same frequency of service. This cost item represents 63% of the overall incremental costs. The two items that follow in importance are the increase in fuel attributable to the fuel that is used to sail the additional distance, and the increase in repairs, maintenance and lube oil costs. Both groups account for almost 16%. The less relevant item is the additional port cost, which represents a 5% of the total. When calling at Seattle, there is an additional sailing time of 56 hours. The extra time in port is 15 hours. The new speed at which the vessel has to sail in order to make up these additional sailing and port times is 23.53 knots.

As it was the case in Exercise 1, a sensitivity analysis of some of the parameters that affect routing decisions is included. Again, the same percentage change has been applied to individual parameters. A summary of the results is shown in Figure 6.7.

The impact of inland costs is shown to be very sensitive to the relative attractiveness of the alternatives. An overall increase in inland costs by 10% results in an improvement of the attractiveness of using Seattle by 72%, from $22,159 per round voyage (RV) to $38,319 per RV; if a 10% cost reduction is applied exclusively to movements to
FIGURE 6.7

RESULTS OF SENSITIVITY ANALYSIS, EXERCISE 2

<table>
<thead>
<tr>
<th>PARAMETER CHANGED</th>
<th>% CHANGE OF PARAMETER</th>
<th>NET ADDITIONAL COST WHEN ROUTING BY OAKLAND:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$/PER ROUND VOYAGE % CHANGE</td>
</tr>
<tr>
<td>BASIC CASE</td>
<td>-</td>
<td>22,159</td>
</tr>
<tr>
<td>INLAND COSTS (OVERALL)</td>
<td>+ 10 %</td>
<td>38,319</td>
</tr>
<tr>
<td>INLAND COSTS (ONLY TO AND FROM OAKLAND)</td>
<td>- 10 %</td>
<td>-82,801</td>
</tr>
<tr>
<td>VESSEL SIZE</td>
<td>+ 10 %</td>
<td>13,890</td>
</tr>
<tr>
<td>CARGO THROUGH SEATTLE</td>
<td>+ 10 %</td>
<td>35,149</td>
</tr>
<tr>
<td>CARGO HANDLING SPEED AT OAKLAND AND SEATTLE</td>
<td>+ 10 %</td>
<td>25,002</td>
</tr>
<tr>
<td>PORT CHARGES AT OAKLAND AND SEATTLE</td>
<td>- 10 %</td>
<td>22,803</td>
</tr>
<tr>
<td>VESSEL WAITING AND BERTHING TIME AT OAKLAND AND SEATTLE</td>
<td>- 10 %</td>
<td>22,631</td>
</tr>
<tr>
<td>ROUTE LENGTH AND PORT DAYS</td>
<td>+ 10 %</td>
<td>FROM $ 633/DAY TO $ 674/DAY 6.5 %</td>
</tr>
<tr>
<td>VESSEL SPEED</td>
<td>+ 10 %</td>
<td>FROM $ 633/DAY TO $-128/DAY -120 %</td>
</tr>
<tr>
<td>FUEL CONSUMPTION</td>
<td>- 10 %</td>
<td>31,000</td>
</tr>
<tr>
<td>PROPORTION OF CARGO HANDLING TIME USED AS NET INCREASE WHEN CALLING AT SEATTLE</td>
<td>+ 10 %</td>
<td>18,989</td>
</tr>
</tbody>
</table>
and from Oakland, the net effect is a dramatic deterioration of the alternative of using Seattle. The use of Oakland becomes the preferred alternative by a difference of $82,801 per RV.

When calculating the effect of changes in vessel size, the results indicate that as vessel size increases, the alternative of using the Port of Seattle becomes less attractive. A 10% increase in vessel size reduces the advantage of using Seattle by 37%, from $22,159 per RV to $13,890 per RV. On the other hand, increasing the number of TEUs that are moved through the Port of Seattle increases the advantage of using the Port. A 10% increase in the number of TEUs moved through Seattle, improves its attractiveness by 59%, from $22,159 per RV to $35,149 per RV.

Variations to the factors that were mentioned as being able to be controlled by port administrations show a similar behaviour as in Exercise 1. The most sensitive is the cargo handling performance, where a 10% increase in Seattle and Oakland produces a 13% increase in the attractiveness of using the Port of Seattle, from $22,159 per RV to $25,002 per RV. A 10% reduction in port charges at both Seattle and Oakland, shows a 3% improvement in the attractiveness of using Seattle, from $22,159 per RV to $22,803 per RV.
Decreasing berthing and waiting time at Seattle by 10% represents a 2% improvement on its attractiveness, from $22,159 per RV to $22,631 per RV.

Changes in route length show that, if vessel speed is maintained, increasing the route length as well as the number of days in port by 10%, there is an improvement of 6.5% in the attractiveness of using the Port of Seattle, from $633 per day to $674 per day. As in Exercise 1, daily costs have been used as a unit of comparison. The direction of the changes confirms that longer routes tend to have a larger number of ports of call than short ones.

When vessel speed is increased, using Seattle is no longer the preferred alternative. By increasing vessel speed 10% and maintaining the same number of port days, the round voyage duration decreases 7%. When this happens, the daily difference in favour of using the Port of Seattle shifts from $633 per day to $-128 per day. Thus, faster ships will be more reluctant to use an additional port. Reduced vessel fuel consumption of 10% results in the attractiveness of using the Port of Seattle increasing by 40%, from $22,159 per RV to $31,000 per RV. Finally, the attractiveness of using Seattle deteriorates 14%, from $22,159 per RV to $18,989 per RV if the proportion of port time in Seattle considered as a net increment of port time is increased by 10%.
GENERAL CONCLUSIONS OF THE EXERCISES

Both exercises represent scenarios where parameters associated with ship size and route characteristics vary considerably. In spite of these differences, parameters that have the largest impact on the attractiveness of alternate routing options are the same. They are: inland costs, vessel size, cargo volumes, vessel speed and fuel consumption. The parameters that have little effect on the attractiveness of alternate routing options are also the same. They are: cargo handling speed, port charges, vessel waiting and berthing time, and route length and port days.

It is interesting to note that those parameters with the largest impact in the attractiveness of routes are not controlled by port administration. The implications of the impact of the parameters for container traffic prospects through the Port of Vancouver are addressed in Chapter seven.

Exercise 2 implies an additional sailing distance of 1000 miles, whereas the additional distance for Exercise 1 is only 128 miles. This difference explains the higher speed that is required in Exercise 2 in order to have the same round voyage duration. While the required speed in Exercise 1 is 18.88 knots, the speed in Exercise 2 is 23.53 knots. If the conditions of Exercise 2 would apply, it is unlikely that shipping lines would maintain the same vessels for an
extended period of time. Lines would probably consider the deployment of vessels with a higher economic speed.
REFERENCES


2. S. Gilman, Ship Choice in the Container Age (Marine Transport Centre, University of Liverpool, 1980), p. 60.


4. Ibid., p. 46.


8. E. Laing, Containers and their Competitors (Marine Transport Centre, University of Liverpool, 1975), p. 44.


10. Ibid., pp. 42-45.


12. T. Heaver, p. 44.
13. Other methods can also be used to deal with different generating capacities. For example, a frequently used computation is to compare either the opportunity cost or the average earning capacity of the ship with the additional inland distribution expenses associated with shorter routes.


17. Ibid., pp. 29 and 33, figures increased 20 % to cover inflation.

18. T. Heaver, p. 15.
VII. CONCLUSIONS

The study examines the impact of various factors on container traffic and on the participation of the Port of Vancouver in Westcoast movements. The framework within which the effects of shipping and other developments are evaluated is based on the "transportation system concept".

There is an important reason for the transportation system concept to be specially relevant to the West Coast. This is because the largest proportion of traffic through the ports moves between the Far East and points in the interior of Canada and the United States. Thus, a natural linkage between producers and consumers is obtained by using a combination of sea and land modes through West Coast ports.

The performance of transportation systems is related to a large number of factors such as shipping economics, institutional frameworks and port infrastructure. In practice, the characteristics of the transportation systems are determined by the interaction between all the factors. As a method of examining the overall impact of those factors on container traffic prospects through the Port of Vancouver, each one of them is considered individually. Overall conclusions depend on the consistency of effects associated with each factor.
In terms of costs at sea, the economics of vessel size induce shipping lines to deploy large vessels. Increasing vessel size faces certain limitations that make impractical the generalized use of extremely large container vessels such as the 4,482 TEU vessels of United States Lines. However, as indicated in Chapter four, there is still a marked tendency in West Coast services to deploy vessels in the 2,500 TEU range. It was demonstrated in Chapter six that the attractiveness of ports is heavily affected by changes in vessel size. The larger the ships, the more appropriate for ships to serve a reduced number of ports. The tendency towards increasing vessel size is going to induce some shipping lines to eliminate their calls at the Port of Vancouver if the characteristics of the transportation systems offered through the ports in Western United States are more attractive to shippers and consignees.

Traffic volume was also indicated in Chapter six as an important element in the attractiveness of ports to shipping lines. Therefore, it is possible to infer that the larger population base of ports in California, added to current population and industrial shifts towards southern and western regions in the United States make expansion of shipping
services to California ports more likely than growth in the Pacific Northwest. Vancouver is not competing in the main growth market on the West Coast.

There is, also, a cumulative effect when considering the impact of container volumes. Shipping lines that are evaluating alternate route options will favour the routes through high-volume container ports. By choosing high-volume ports, lines enhance their opportunity to use large vessels fully while maintaining competitive service levels.

The exercises performed in Chapter six have identified two shipping-related factors as having an important effect on the attractiveness of ports. They are vessel speed and level of fuel efficiency of the vessels. In the event of a rapid increase in international trade through the West Coast, shipping lines will probably react, at least in the short term, by increasing vessel speed. If this is the case, the Port of Vancouver would become less attractive to shipping lines. But, on the other hand, if technological developments allow further reductions in vessel fuel consumption, the use of the Port of Vancouver is likely to become more attractive. Also, in the short run at least, a reduction in fuel costs may occur and that would be favourable for the Port of Vancouver.
New legislation in the United States has removed some impediments that were inhibiting transportation modes from competing more freely with their Canadian counterparts. There have also been advances in the American legislation such as granting shipping lines the right to negotiate confidential rates. As confidential terms are now allowed under the "Staggers Rail Act", important volume discounts can be negotiated between railways and shipping lines, specially with those lines engaged in the movement of large container volumes. Considering that confidential terms are not allowed under current Canadian legislation and keeping in mind the generation of a more competitive environment in the United States, it is possible to infer that transportation systems through the United States are going to become more competitive to those in Western Canada. Therefore, the attractiveness of routing containers through the Port of Vancouver is going to be affected negatively.

Another institutional aspect that is relevant to the performance of the transportation systems through the Port of Vancouver is the "container clause". American ports on the West Coast do not have a similar clause. The result is an important incentive to route Canadian cargo through the ports of Tacoma and Seattle. Maintaining the "container clause" in
Vancouver is a factor that detracts from the characteristics of transportation systems provided through the Port of Vancouver.

CONTAINER SERVICES

The movement of containers by double stack container trains is a significant technological development of the last two years. There are important economies of scale associated with the use of these trains. Every large West Coast container port in the United States provides this form of inland transportation. In the meantime, the process of deploying double stack trains through the Port of Vancouver is still at a preliminary stage.

As concluded from both exercises in Chapter six, inland costs have a large impact on the attractiveness of alternate route patterns. The sensitivity to inland costs means that ports must develop their own stack train services to remain competitive. The establishment by the Port of Seattle of its own double stack train is a remarkable example of an aggressive approach towards the development of competitive transportation systems. The lack of double stack trains to serve the Port of Vancouver results in a deterioration of its competitive position.
As indicated in Chapter five, an interesting step towards the development of more efficient transportation systems in Western Canada is the announcement of the construction of a container distribution system for the Province of Alberta. The attractiveness of routing containers through the Port of Vancouver could be enhanced if cost efficiencies are obtained from the new System.

Chapter five also indicated that some large shipping lines have recently started a round-the-world service. Two out of the three existing services do not contemplate a call at West Coast ports, and the third service includes only a call at Long Beach. This is probably because transit time restrictions when sailing through the Panama canal makes impractical the diversion to ports along the West Coast. In the event that this type of routing increases, it can be expected that the practice of routing containers through Pacific Northwest ports is going to decrease.

PORT FEATURES

The exercises in Chapter six have demonstrated that the control that port authorities may exercise on the overall transportation costs is very limited. Cost items that are directly controlled by port authorities have relatively little effect on the attractiveness of the ports they represent. However, there are two non-quantitative features
of the Port of Vancouver that may be relevant to its ability to generate competitive transportation systems. One of them is its lack of dedicated terminals. The availability of a dedicated terminal may be a relevant factor for large shipping lines that are in the process of identifying a suitable port of call in the Pacific Northwest. Both American ports in the region, Seattle and Tacoma, currently provide shipping lines with such possibility. By having their own terminal, shipping lines have greater control over their port operations. Thus, they have access to a port infrastructure that allows the development of more efficient transportation systems. The second feature that may be relevant to the development of efficient transportation systems through the Port of Vancouver is related to its corporate structure. Recognizing that the Port of Vancouver has recently been awarded greater autonomy, it is still subject to decisions emanating from a central authority. Such is not the case for American ports on the West Coast. By depending on a central authority, the ability of a port to react to changes in the competitive environment is reduced. Thus, the time that is required to respond to development of competitive transportation systems is going to be higher for the Port of Vancouver than for American ports.
THE PROSPECTS FOR VANCOUVER

After having examined the impact of factors on the performance of transportation systems, it is useful to indicate some general conclusions. Assessing the relative importance of the factors is a desirable but difficult task to perform and is not considered in this study. However, it is appropriate to indicate that all of the factors, with the exception of the tendency towards more fuel efficient vessels, a short term reduction in fuel prices and the development of the container distribution system for Alberta, indicate that the attractiveness of the Port of Vancouver is being adversely affected by current container shipping developments.

Current changes that are affecting the characteristics of transportation systems through the West Coast are significant. A slow response to develop competitive transportation systems through the Port of Vancouver may have important traffic trend implications for the next decade.

The possibility for the Port of Vancouver to increase, or at least to maintain its share in the container market on the West Coast is going to be determined by its ability to develop competitive transportation systems. In order to develop such systems, it seems essential that a concerted effort takes place. This effort should include each one of
the entities that are part of a transportation system: Port, longshoremen, shipping lines, railways and trucking companies.
APPENDIX I

MODEL TO EVALUATE THE ATTRACTIVENESS OF ALTERNATE SHIPPING ROUTES

The model has been written by using a Visicalc spread-sheet software package. Computations are performed on cost increases and reductions and not on total round trip costs. Therefore, results reflect the overall advantage of one alternative with respect to the other. The assumptions implicit in the model are:

- Only two alternatives are compared at a time. One implies the use of an "additional" port and the other considers moving the same cargo through a "load centre" port.

- Only the cargo that is subject to alternate loading/unloading ports is considered. The rest is assumed to have no effect on the attractiveness of the alternatives.

- The duration of the round trip and the amount of cargo that is being carried are the same for both alternatives. Therefore, the impact that factors like the "physical presence" or the differences in inland transit times from the "additional" and the "load centre" ports may have on the market share that a line can capture are not reflected in the model.

- The round trip voyage that is considered includes two ranges of ports, with a deep sea distance in between.

- The container exchange is supposed to be balanced, i.e. the number of inbound and outbound units are equivalent. This implies that the container system is in equilibrium and that shipping lines do not require to drop off nor to pick up extra units. The model does not make any distinction between loaded and empty containers nor between the proportion of 20 and 40-foot containers.

- Vessel characteristics, including size, are represented exclusively by her TEU capacity.
- The comparison of alternatives implies the same voyage duration. Therefore, capital, manning, insurance, and administration costs are considered to remain constant and none of them is incorporated in the calculations.

- The shipping line has to pay for the incremental cost of inland transportation when cargo is unloaded at the "load centre" rather than at the "additional" port.

- Considerations about fuel consumption during slow steaming in channels, berthing, etc. have been excluded from the model.

- All the cost items that have been considered subject to change when adding a port are:

A. Fuel Expenses:

This cost item increases because of the longer distance that exists under the alternative of adding a port. There is also an increase in fuel consumption because of extra time in port. This extra time can be divided in two sub-items: one is a constant waiting time for reasons like tides, berthing, expected delays, etc.; the second corresponds to the additional cargo handling time that may be considered as a net increase when adding a port of call. For this sub-item, 50% of the total cargo handling at the "additional" port has been used in the calculations. Only a fraction is used because if no additional port is used, the same amount of cargo is supposed to be handled at the "load centre" port. Thus, stowage considerations can allow the loading and unloading of part of this cargo, while the rest of the cargo is being handled at the "load centre" port. Another factor that is responsible for increasing fuel consumption is the extra fuel that has to be burned to provide the increase in speed required for the alternative that includes an additional port. The increase in speed is assumed to occur only while the vessel is sailing on deep sea and in one leg of the trip.

Fuel consumption while the ship is sailing is considered to be a function of the "shaft horse power" (S.H.P.) that is generated. The formulas that have been used are:
I.  S.H.P. = 0.07 * N * V  \hspace{1cm} (1)
where N = vessel capacity in TEUs
V = vessel speed in knots

II.  FUEL CONSUMPTION = K * S.H.P.  \hspace{1cm} (2)
where K = constant for a range of vessel sizes

The constant K that relates fuel consumption to S.H.P. is different for the consumption of H.V.F. (high viscosity fuel oil) and marine diesel oil. The two values of K are obtained from a "representative" vessel for which fuel consumption is known. The fuel consumption curve of this vessel is defined by the following data: (3)

<table>
<thead>
<tr>
<th>VESSEL CAPACITY</th>
<th>1,000 TEUs</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUEL CONSUMPTION</td>
<td>H.V.F.</td>
</tr>
<tr>
<td>AT SEA (@ 21 Knots)</td>
<td>45</td>
</tr>
<tr>
<td>IN PORT</td>
<td>8</td>
</tr>
</tbody>
</table>

In terms of fuel consumption while the vessel is in port, marine diesel oil is assumed to be burned at the same level as when the ship is sailing. (4) The consumption of H.V.F. is calculated by using the same proportion of H.V.F. to diesel of the "representative" vessel while she is in port.

B. Port Expenses:

As explained in Chapter 2, this cost item is determined by factors like vessel size, length of stay, pricing policy and the type of cargo that is being handled. The alternative of adding a port implies that port costs increase because of the use of an additional port. The model assumes that the total waiting and berthing time plus 50% of the cargo handling time at the "additional" port represent the net increase in port time where additional expenses accrue. Cargo handling expenses are assumed to be the same at both, "additional" and "load centre" ports, therefore they are not included in the calculations. The daily cost that is charged as port expenses is also assumed to be the same for both ports.
C. Repairs and Maintenance, and Lube Oil Expenses:

These cost items increase because of the longer routes and higher speed that are required when adding a port. The total cost increase per round trip has been assumed to be in direct proportion to the increase in route length.

D. Inland Distribution Costs:

The model contemplates four cities as origin and destination centres for the cargo. Distribution costs may be different to and from the "additional" and the "load centre" port. As it has been noted, shipping lines are assumed to pay for any incremental cost derived from the use of the "additional" rather than the "load centre" port.

Once all cost items are calculated, the model compares the increase in shipping costs of adding a port of call, with the corresponding reduction of inland costs when using a "load centre" port. Then, it provides a net figure that represents the relative attractiveness of the preferred alternative.
REFERENCES


4. Ibid.