Freight Mode Choice: Air Transport Versus Ocean Transport in the 1990s

by

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Submitted to the Department of Ocean Engineering
in Partial Fulfillment of the Requirements for the
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Abstract

Value density is often considered when making the choice whether to ship cargo by air or by water. However, although cargo value is directly linked to the overall cost of shipment, it is the deciding factor in mode choice only for those cargoes with either an extremely high or extremely low value per pound. For cargo in some middle range other criteria, such as density of stowage, perishability, reliability of service, or the need for more accurate demand forecasting must be considered.

The characteristics of international cargoes shipped by both modes in 1992 are examined and a logistics cost for the distribution of representative goods is calculated. A schedule of premiums is developed, which shows the transportation premium a range of cargo value densities and stowage densities could support if transit time were reduced from the longer times associated with water transport to the shorter times found in air travel. The volume of mode-converted cargo is projected for the year 2030 and the number of aircraft required to transport the cargo is estimated.

Thesis Supervisor: Henry S. Marcus
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Dedication

This work is dedicated to Mary. Without her friendship, faithfulness, encouragement and support, I could not have completed my undergraduate education - and certainly would never have dreamed that I would have the opportunity to pursue graduate work at M.I.T. I owe her more than I can express.

Acknowledgements

I am thankful for the support of the National Aeronautics and Space Administration, which funded the research for this thesis. In addition, I am indebted to Professors Hank Marcus and Bob Simpson, as well as Senior Research Associates Ray Ausrotas and Carl Martland for their insights, questions, suggestions and humor.

Numerous shippers, transportation companies and port authorities have provided data for this project. Although competitive concerns prevent them from being named explicitly, I am grateful to them for their help.

While I have benefitted from the assistance of all these individuals and corporations, I alone take respnsibility for the views put forth in this thesis and for any errors or omissions it contains.

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Chapter One

Factors That Contribute to Logistics Costs

In general, the shipment of goods by ocean involves larger lot sizes, less shipment frequency, much longer in-transit times and less reliability than shipment by air. With this in mind, we will consider six factors that contribute to logistics costs. They are:

1. Interest charges on goods awaiting shipment.
2. Interest charges on goods in transit.
3. Interest charges on goods held as safety stock.
4. Loss, damage or decay of goods between manufacture and sale.
5. Costs of ordering transportation services.
6. Cost of transportation.

The first three costs are directly related to the value of the product to be shipped and increase as its value increases. The fourth is related to the product's perishablility (either its physical life or the length of its marketable life) and will become more important as the ratio of product life to transit time approaches one. Number five will vary considerably, according to whether the shipper has a long term contract with his carrier or is faced with negotiating prices and terms for each individual shipment. Number six, the cost of transportation, will be related to the speed of the vehicle chosen and the number of units of freight that it can carry. A fast-moving, low-volume vehicle will be considerably more costly on cost per ton-mile basis than a vehicle with high capacity and a relatively lower speed. These cost items are now discussed in more detail.[1]

1. Interest charges on goods awaiting shipment.

As a manufacturer produces goods, they are accumulated until reaching a quantity (x) that is deemed large enough to make a shipment. When the shipment is made, the quantity on hand becomes zero and, as more goods are manufactured, they again

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[1] An important cost factor in commodity distribution is the direct cost paid for warehouse space. This cost will vary considerably, depending on the country, region and city location, the amount of technology employed, whether or not refrigeration is used and the type of demand experienced for the commodity. No attempt to model this cost has been made in this report. The reader should be aware that the origin inventory costs shown are in addition to direct warehousing costs.

accumulate up to quantity (x) before the next shipment goes out. The average amount of stock on hand is x/2. The cost of holding x/2 is:

$$\text{Origin Interest Cost} = \left[i*(\text{V})*\left(\frac{\text{x}}{2}\right)\right]$$

Where: i = the annual interest rate
V= the value of each product unit
x = the number of units accumulated for each shipment.

Implicit in the relationship between V and x is the commodity's density. For example, if V is $5 and x is 100 units per shipment, the product of V and x is $500 per shipment. If a unit weighs one pound and this shipment fills a 200 cubic foot container, the commodity's density must be one-half pound per cubic foot. There are three different densities to consider:

1. Density of Stowage = One-half pound per cubic foot.
2. Value Density = 5$ per pound.
3. Cubic Value Density = $2.50 per cubic foot.

A doubling in the value of the goods, the interest rate or the size of the shipment will cause a doubling in the Origin Interest Cost.[2] A doubling in the size of the shipment could mean that inventory has been accumulating for twice as long, which implies that the service frequency has been cut in half.

2. Interest charges on goods in transit.

Goods may be sold to a buyer in a variety of ways. The buyer may take delivery of the goods at the manufacturing plant, at his own facility or at some point in between. During the time goods are in transit, they are in effect a moving inventory. The cost for this intransit inventory for shipments of size (x) is the shipment size times the value per unit times the interest rate per day. This may be expressed as:

$$\text{In Transit Inventory Cost} = \left[(x*V)*\left(i*\frac{T}{365}\right)\right]$$

Where: i = the annual interest rate
x*V= the value of each shipment
T/365 = the fraction of a year that the goods are in transit

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[2] All equations shown in this chapter are adapted from "The Customer's Perspective: A Logistics Framework", C.D. Martland, January, 1992.

A doubling in the value of the goods, the time in transit or the interest rate will cause a doubling of the In Transit Inventory Cost.

3. Interest charges on goods held as safety stock.

Transportation systems are not normally perfectly reliable. The mean transit time may have a standard deviation that ranges from very small to very large. A shipper can protect himself from a stockout by holding a reserve, called a safety stock. Assuming that the distribution of transit times between a specific origin and destination pair is normally distributed, the shipper can choose the level of protection from stockout that he desires by choosing a stockout volume that is a multiple of the standard deviation for the particular origin-destination pair. This may be expressed as:

$$\text{Safety Stock Cost} = \left[\left(\frac{i * V * x}{365} \right) * (k * \sigma) \right]$$

Where: (i*V*x)/365 = the interest cost for one day for a shipment
σ = the standard deviation of the transit times
k = a multiplier that is linked to the degree of protection desired, typically 1.28,1.64 or 2.58, which would respectively give a 90%, 95% or 99% fill rate from stock.

4. Loss, damage or value-decay of goods between manufacture and sale.

Products vary greatly in their ability to hold value. Some, like fresh fish or flowers, have a short physical life and must be gotten to market quickly - or not at all. Others, like clothing, have their highest value early in the selling season and are worth less as the season nears its end.

Other products have life cycles that extend beyond a single season or even a single year. For these, it is necessary to make accurate forecasts concerning demand occuring near the end of the cycle, so that the shipper is not left with excess inventory.

Costs due to loss of product value are not determined by the inventory interest rate. Rather, the value loss is related to a change in demand or product condition that is linked to the portion of the product's life that has passed since its manufacture. The expression for loss due to persishability or value decay has four components:

1. Salvage value at the end of the product life.
2. Value of the shipment.
3. The ratio of transit time to the product's life.

4. A parameter that indicates whether the product declines in value an equal amount each day or holds its full value for some time, then declines toward its salvage value.

Value decay as related to time spent in transit may be expressed as:

$$\text{Perish or Decay Cost} = \left[(1 - Sal) * (V * x) * \left(\frac{T}{L} \right)^{d} \right]$$

Where: Sal = the products salvage value in per cent
T = the time spent in transit in days
L = the product life in days
d = a commodity or industry-specific decay parameter

We can see that as T approaches L, the loss of product value increases. The effects of the decay parameter will be explored in chapters 7 and 8.

5. Costs of ordering transportation services.

The cost of order placement can vary greatly. At the most expensive extreme, a traffic manager can seek the lowest possible transportation price available from each carrier within the chosen mode for each shipment to be made. While this may result in the lowest transportation cost for that particular shipment, the time spent in seeking the lowest bidder has a cost, and the combination of order cost plus transport costs must be considered.

At the other end of the order-cost spectrum, a shipper may sign a long-term contract with a carrier for regular pickups on specific days and only negotiate when the contract nears its end. If the volume of cargo is sufficient, the carrier on a long term contract may actually place an employee in the shipper's office. American President Companies provide this service, which enables the shipper to monitor the movement of his goods from origin to destination without dedicating one of his staff members to the task.

6. Cost of transportation.

The cost of transportation is the price charged by the carrier for the movement of goods from origin to destination. It includes all modes involved and the transfers between modes. In general, faster service and smaller cargo volumes are correlated with higher prices. The expense of this faster service may, or may not, be offset by lower interest costs and quicker market response.

In the following chapters, we will consider the characteristics of air and ocean transport and the commodities that are currently transported by the two modes. We will then compare the cost of bringing representative goods to market by each of the two modes.

Chapter Two

Large Cargo Aircraft and Air Cargo Containers

Air transportation of cargo involves the use of high-speed, relativley low-volume vehicles. Cargo may be transported in all-cargo aircraft or as "belly freight" beneath the passenger deck of a passenger aircraft. International air-freight rates are generally several times higher than surface transportation rates, with the multiple linked to the size of the aircraft used, the length of the route, the cubic value density of the cargo and the demand characteristics of the trade region. At the end of 1992, there were 882 all cargo aircraft in service around the world, with 540 of these aircraft over 20 years old.[3]

Large Cargo Aircraft

The largest cargo aircraft in the world, the Ukranian-built Antonov An-225, can lift at most 500,000 pounds. Only one of these aircraft is currently in service. There are over 30 Antonov An-124s (377,473 pounds payload)in service, 12 of which were built in 1993. The highest capacity aircraft currently built in the United States is the Boeing 747.

Exhibit 2.1

Large Cargo Aircraft

Builder	Model	Maximum Gross Wt. Pounds	Maximum Payload Pounds	Range Naut. Miles
Antonov	An-225	1,230,370	500,000	2425 - 9570
Antonov	An-124	892,872	377,473	2795-10250
Boeing	747-400F	870,000	244,000	4400
Lockheed	C-5	769,000	221,000	
M. Douglas	MD-11 F	625,500	200,000	3623

Source: Janes, World Aviation Directory, Air Cargo World

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[3] Air Cargo World, Shippers Win and Lose With New Aircraft, July, 1994, page 16.

There are several variations of this aircraft, the most recent of which is the 747-400F. Payload capacity of the 747-400F is 244,000 pounds. This cargo can be divided between 30 96-inch by 125-inch pallets on the main deck and 32 LD-1 containers in the lower hold.

The Mcdonnell-Douglas MD-11F, the smallest of the "large aircraft" shown in exhibit 2.1, has a usable internal volume of 15,722 cubic feet.[4] With a maximum payload of 200,000 pounds, this translates to an average cargo density of 12.7 pounds per cubic foot at 100% space utilization. At 85% space utilization, the average cargo density would be 15 pounds per cubic foot and at 70% space utilization, 18.2 pounds per cubic foot.

All Cargo Aircraft Fleet Growth

The Boeing Commercial Airplane Group's 1993 *World Air Cargo Forecast* predicts that the world air freight market will double by the year 2010, based on a growth rate of 6.9% from 1992 to 2010. Boeing has estimated that this growth will generate a need for 400 additional large cargo aircraft by the year 2013.[5]

Air Cargo Containers

The fuselage of an aircraft is shaped much like a cylinder. This poses problems for the stowage of containerized cargo within the aircraft.

Exhibit 2.2

Aircargo Containers

Container	Volume Cubic Ft.	Cargo Weight
A	356	7000
B	178	3500
D	57	2000
Q	12	400
E	16.2	500
LD-1	171	2555
LD-3	150	3100
LD-7	370	9800
LD-11	242	6600

Source:NASA CR-145384

Containers stowed along the centerline can be rectangular, but containers outboard of the centerline must, to make use of the available space, be shaped much like the aircraft's hull.

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[4] Ibid., page 15.

[5] Ibid., page 16.

Therefore, the principal container shapes used in aircraft are small, with a least one rounded surface. Typically, containers range from the 370 cubic-foot Type LD-7 to the 12 cubic-foot Type Q. Respectively, these containers have weight capacities of 9,800 pounds and 400 pounds.[6]

The Boeing 747F can accommodate twin rows of seven ISO 8x8x20 foot M2 containers. In 1982, each M2 container cost $9,000. These rectangular containers do not fill the space between the outboard sides of the containers and the aircrafts hull. The empty 20 foot long M2 container weighs less than 2,100 pounds, in contrast with the 20 foot marine container's empty weight of over 4,000 pounds. [7]

Speed, Reliability and Frequency of Delivery

Large cargo aircraft commonly travel at speeds of over 400 knots. This is more than 20 times as fast as a surface container ship. In addition, while a surface ship must stop at a seaport and make a mode-transfer of its cargo, an air ship can proceed far inland.

The air ship can land at an airport near the cargo destination and transfer the cargo to truck, another quick and highly reliable mode. Alternatively, the air cargo may be transferred to another, smaller aircraft that serves as a feeder for the region. In either case, the cargo is kept moving on small capacity, high velocity vehicles that provide reliable service.

The speed of air transport also enables a shipper to move his product with greater frequency. A point-to-point Transatlantic trade requires 14 days for a single surface ship's roundtrip. It would take two ships to provide weekly service. In contrast, two aircraft operating at 400 knots can provide *twice daily service* over the same route. This enables a shipper to reduce the safety stocks held as a buffer against demand variability, and also enables the shipper to reduce drastically the time that material is in the delivery pipeline, thereby saving interest costs.

Air Transport Prices

Shipper interviews have indicated that the price of air cargo transportation varies from 5 to 30 times the cost per pound of ocean transportation, depending on the season, direction of movement and distance travelled. In general, the price for westbound (backhaul) transportation on the Transpacific routes is much lower than the price for eastbound transportation. Specific price comparisons will be made in chapters 7 and 8.

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[6] Air Cargo: An Integrated Systems View, September, 1978, page 115.

[7] Late Take-off for Air Containers, Containerization International Yearbook, 1982, page 21.

Summary

Air cargo transportation is rapid, frequent and highly reliable. Shippers pay a premium for this service. This premium is justified by the savings in interest costs, improved market response and decreased value decay of the products shipped by air.

Chapter Three

Characteristics of Containerized Ocean Shipping

The System

Ocean freight transportation companies use high-capacity, low-speed vessels to move cargo. They extend their transportation services, via landbridge, across entire continents. The movement of an intermodal container from origin to destination requires extensive multimodal planning, carrier cooperation and efficient interchange between modes.

Full Container Loads

For the movement of a full container (FCL) from the Far East to the North American Midwest, the following moves will be planned:

1. Delivery of the empty container to the customer.
2. Pickup of the full container and drayage to the local port.
3. Short term storage at the port.
4. Loading into position on the container ship, taking into account the unloading sequence and the container's weight.
5. Transportation by ship.
6. Unloading the container from the ship onto a dockside drayage vehicle for transport to the railhead.
7. Loading the container from the drayage vehicle to a train.
8. Discharging the container from the train and loading it onto a local drayage vehicle.
9. Drayage delivery of the container to the customer.
10. Pickup and repositioning of the empty container.

Less Than Container Loads

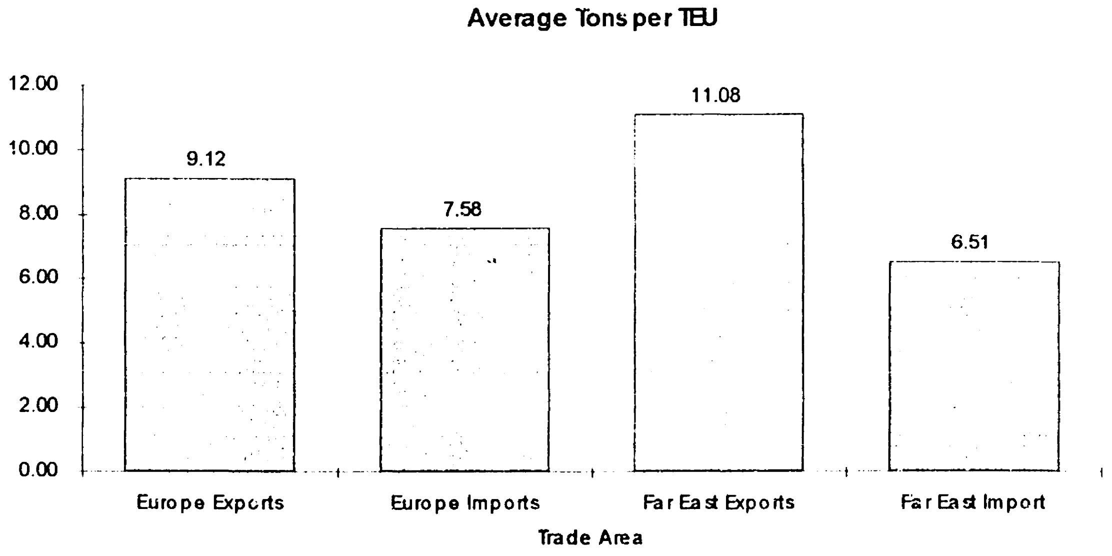
In addition to FCL, cargo is frequently moved in less than full containerloads (LCL). Small lots of cargo are brought by light truck to a Container Freight Station (which is located on or near a port) then consolidated (stuffed) into containers for shipment. After the container is stuffed, steps 3 through 5 are the same as for FCL cargo. At the receiving port, the container is taken to another Container Freight Station, where the cargo is stripped from the container and made ready for over the road delivery to the customer.

At every step in the process, the container's movement is recorded in a computer database. The carrier, the shipper and the customer all have access to information concerning container location and freight payment status.

Container Sizes and Capacities

Intermodal containers for international trade exist in 20, 40, 43 and 45 foot lengths, with heights ranging from 8 to 9.5 feet, but the standard unit used in rating a container ship's capacity is the teu, or twenty-foot equivalent unit. One teu is equal to a container that is 20 feet long, 8 feet wide and 8 feet high. A 20 foot dry container has a tare (empty) weight of about 4400 pounds and can carry a maximum of 48,000 pounds.[8] As is shown below, the actual weight carried per teu is much less, with the principal world trades averaging between 6.5 short tons (13,000 pounds) and 11 short tons (22,000 pounds) per teu.

Figure3.1



Although the teu is the standard unit for capacity measurement, it is not the most prevalent size carried. Lightweight cargoes, those with a density of stowage less than 37 pounds per cubic foot, "cube out" before they "weigh out". Since the costs for handling a 40 foot container are less than double the costs for handling a 20 foot container, it is to

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[8] Atlanticargo company brochure, 1994.

the shipper's advantage to use 40 or 45 foot long containers whenever shipping a sufficient quantity of a lightweight commodity.[9]

Exhibit 3.1

Intermodal Container Dimensions and Capacities

Length	Height	Width	Volume in Cubic Feet	Empty Container (pounds)	Maximum Pounds Payload
20	8	8	1280	4400	48000
20	9.5	8	1520	4600	48000
40	8	8	2560	8000	59000
40	9.5	8	3040	8700	59000
43	8	8	2752		
43	9.5	8	3268		
45	8	8	2880		
45	9.5	8	3420		

Source: Review of trade advertisements.

Container Ships

The first ship to carry intermodal containers in the modern era was the "Ideal X", owned by Malcolm McLean. The ship, a tanker carrying 35 foot-long trailers as deck cargo, sailed from Newark, New Jersey to Houston, Texas in April of 1956. Since that time, ships have evolved from combination vessels,carrying containers as deck cargo and other cargo below decks, to fully cellularized container ships.

Exhibit 3.2

Ship Type	Ships	teu slots
Fully Cellular	1,514	2,112,308
Semi Container	1,952	668,832
Bulk/Container	384	336,483
Other	1,359	625 534
TOTAL	5,209	3,743,157

From: Cont. International Yearbook, 1994

At the end of 1992, there were 5,209 container carrying ships with a capacity of 3,743,157 teu in service around the world. Of these, 1,514 (29%) were fully cellular

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[9] Container handling charges in a port are generally done on a "per container" basis, with the same price charged to lift on/off whether the container is 20 or 40 feet long.

container ships which accounted for 56% of the world's container capacity. Fully cellular vessels are completely dedicated to the container trade. Their holds are fitted with guideways that form container slots, rendering the ships unusable for any other service.

Ship Sizes and Capacities

The maximum size of container ships has increased tremendously since the "Ideal X" first sailed. The Journal of Commerce reported in October, 1994 that American President Lines has ordered a 5000 teu vessel, and that there were blueprints for an 8000 teu vessel on display at the Berlin Maritime Fair.[10] Howe-Robinson ship brokers estimate that 101 ships with capacities of 2000 teu or greater will enter service between now and 1996.[11] At present, the capacity distribution of container ships in service throughout the world is as shown.

Exhibit 3.3

TEU Capacity	Ships
1500 to 1999	253
2000 to 2499	121
2500 to 3499	255
over 3500	60

A sample of the dimensions for ships in these categories shows:

Exhibit 3.4

Ship	DWT	TEU	Speed (knots)	Length (meters)	Draft (meters)	Crew
President Kennedy	53,613	4,300	24.2	275	12.7	USA 21
Hyundai Challenger	43,567	2,984	21.7	244	12.5	PAN 18
Hanjin Elizabeth	43,967	2,692	22	242	11.7	KOR 17
President Hoover	39,419	2,000	22	240	10.7	USA 42
Belforest	39,218	1,692	15	199	10.7	SING 22

Source: Lloyd's Register of Shipping

DWT is the abbreviation for Deadweight Tons, the weight of cargo that a ship can lift. Two ships with the same DWT rating may show different teu capacities, since teu stowage is directly tied to the ship's usable volume.

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[10] Journal of Commerce, 03 October, 1994, page 2b.

[11] JOC, 26 July 94, page 7b.

Ship Deployment

Container ship companies operate liner services, in which ships are scheduled to call at a series of ports in a specific rotation. The ships sail on schedule, whether they are full or not, and the shippers that use the service can plan their activities accordingly. Ship operators usually decide on service intervals for each port that are from one week to one month apart, with one week intervals the most common.

The number of ships required is related to the desired service frequency at each port, distance between ports and time spent in each port. An Atlantic service that requires a combined 28 days of steaming and port time will provide weekly service with 4 ships. Similarly, a 42 day Pacific route can be operated using 6 ships calling at one week intervals.

The maximum capacity of each ship required in the service will be related to both the volume of cargo to be loaded/discharged at each port and to the expected transoceanic load of the vessel. For example, a ship arriving at its first inbound port of call with 2800 teu on board will need to have a capacity of at least 3000 teu, if 100 teu are to be discharged and 300 teu loaded at the port.

Typically, several port calls are made on the coast of one continent. At the last port, the ship should (ideally) be loaded to over 85% capacity and then steam across the sea, where a series of port calls are made before the ship sails on its return voyage.

Risk Sharing

The capital investment needed for an individual line to establish a multiple-ship service is not limited to the vessels alone. The shipping line must invest in shoreside infrastructure (offices, cranes, container gates), computer systems, containers and chassis. The risk can be reduced if the line joins into a cooperative agreement with other liner companies. These "strategic alliances" can:

1. increase the effective frequency of ship calls made to a port by a line.
2. reduce the capital outlay required by each of the partners.
3. reduce the probability of entrance into the market by a new competitor
4. stabilize prices on a particular trade route.[12]

An example:

Consider shipping lines A and B, each of whom serve the port of Savannah, Georgia as one call on a 28 day transatlantic route. Each company has four 1800 teu ships in the

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[12] See "Strategic Alliances in the Liner Shipping Industry" by Peng-Yen Koay. Master's Thesis in Ocean Systems Management. M.I.T., May, 1994.

trade. A calls in Savannah each Monday and B calls in Savannah each Thursday. By cooperating, they can realize the following benefits:

1. Increased Frequency with less Capital Outlay

   A and B can each sign space-charter agreements on the other's vessels, agreeing to charter space on each voyage. Now, both A and B can advertise twice weekly sailings, which will be important to shippers who are trying to minimize origin inventory costs. In addition, both A and B have avoided the incremental capital outlay of purchasing the additional ships that would otherwise have been required to provide increased frequency.

2. Reduced Entrance by Competitors

   Company C, already operating a service on a different trade route, may express an interest in establishing a service in the transatlantic trade. A and B may decide that the best way to keep C from bringing 7,200 teu extra capacity into the trade (4 ships at 1800 teu for a weekly service) is to offer C a space charter on each of their ships. This will give A and B guaranteed revenue for each voyage, allow C to test the market and also reduce the risk of a rate war brought on by overcapacity.

3. Stabilized Prices on the Trade Route

   Companies A and B can agree to forgo ruinous rate competition and charge the same prices for providing the same service.

Conference Agreements

Without entering into vessel sharing agreements, carriers serving a trade route may join together in a "conference", a shipping line cartel. Conferences first appeared in 1875, when the UK-Calcutta shipping conference was formed to regulate rates and suppress competition from non-conference members. Agreements with these goals flourish today, with the TSA (Transpacific Stabilizing Agreement) actually setting rates and requiring members to reduce capacity over a period during the 1990s. (See exhibit 4.2 for TSA reductions.)

By reducing price competition, the conference system helps to insure that sufficient capacity will exist in each trade to satisfy the needs of shippers. However, the system is not perfect and members often cheat. In particular, low cost operators that are partnered with high-cost operators may see a great opportunity to increase their market share by reducing their prices to levels that more closely reflect their costs.

Modal Integration

This chapter began by outlining the 10 steps required to move cargo from the Far East to the North American Midwest. It should be noted that only steps 4,5 and 6 were directly concerned with ocean transportation. Container ship companies have become multimodal transportation companies, sharing information and coordinating modal interchanges with railroad and trucking partners.

Consider the American President Companies (APC), who operate ships in the Far Eastern trades.[13] APC gathers, processes and distributes information in four broad categories:

1. Data Collection and Reporting Systems - provide information on what has already happened in terms of time and costs.
2. Proactive Analytical Systems - predict the optimum cargo routing for both land and ocean modes. There may be 20 different viable routings for some origin-destination pairs.
3. Employee Tools - enable employees to accurately store, retrieve and load containers, minimizing delay at ports.
4. Operational Decision Support Tools - allow managers to anticipate problems. Taking into account its capacity constraints, APC prepares cargo forecasts six weeks in advance, allocates space on ships accordingly, then monitors bookings, actual cargo and updated forecasts as it develops flow over the network. Flows may be adjusted for different objectives - balancing between maximizing short term profit, empty container distribution and different customer service requirements.

Writing in the Journal of Business Logistics, John Firman of APC gives this example:

> "...suppose APC is moving cargo from Asia to the United States on the traffic lane from Hong Kong to Yokohama to San Pedro to Chicago, but some cargo is going to run into a bottle neck at Yokohama. The margin might be $1,200, but if space relief is purchased and the back up space costs $800, the shipment still nets $400. However, once this is done, the route from San Pedro to Chicago develops a capacity problem. Although enough (rail)cars were available on this lane prior to the extra cargo, there is now insufficient rolling stock capacity. By repositioning stack cars, capacity needs can be met. This all occurs several weeks prior to the shpiment from Hong Kong. Thus the same information in the decision support database used by the controller in Hong Kong is used by the controller in San Pedro to reposition cars.

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[13] Logistics Control Systems in the 21st Century, John T. Mentzer and John Firman, Journal of Business Logistics, Volume 15, Number 1, 1994.

> The space relief decisions are one and the same. Even though each controller is at a remote station with their own personal computer, each is able to bring the data down into their environment from the same common database."

American President Companies handled the highest volume of containerized Far Eastern imports for all carriers in 1992, with 391,608 teu imported. The company has 23 ships, 16 types of railcars, over 100,000 containers and over 4,200 chassis. In addition to their international cargo, APC handles over 500,000 domestic container moves per year.

Transit Times and Distances

As seen in exhibit 3.4, container ship speeds vary by over 50%. In addition, most trades are not based on a single port call on one continent paired with a single port call on another continent. Therefore, cargo transit times between two ports will vary according to the both the speed of the specific ship used and the number of other ports served in the vessel rotation.

An example can give some sense of the transit times involved. Yokohama is a likely spot for a final port call for a vessel leaving Japan, bound for the United States Pacific Northwest. At 20 knots, the transit time for the 4245 nautical miles to Seattle would be 212.5 hours, or about 9 days. Exhibit 3.5 shows that the entire transit time from a Japanese manufacturer to a customer on the North American East Coast would typically be about 21 days.

Exhibit 3.5

Activity	Days
Dayage to Port	1
Storage at Port	1
Ship Loading	1
Transit to U.S.	9
Discharge at Port	1
Drayage to Rail	1
Rail to Chicago	3
Change Trains	1
Rail tc East Coast	2
Drayage to Customer	1
TOTAL	21

Exhibit 3.6

Roundtrip Transit Times for Pacific Trade

Speed: 21 knots

From	To	Miles	Sailing Days	Days in Port
Singapore	Hong Kong	1,410	2.80	0.7
Hong Kong	Kaohsiung	390	0.77	0.7
Kaohsiung	Busan	1,010	2.00	0.7
Busan	Kobe	380	0.75	0.7
Kobe	Yokohama	350	0.69	0.7
Yokohama	Los Angeles	4,680	9.29	0.7
Los Angeles	Oakland	400	0.79	0.7
Oakland	Yokohama	4,385	8.70	0.7
Yokohama	Kobe	350	0.69	0.7
Kobe	Busan	380	0.75	0.7
Busan	Kaohsiung	1,010	2.00	0.7
Kaohsiiung	Hong Kong	390	0.77	0.7
Hong Kong	Singapore	1,410	2.80	0.7
Roundtrip		**16,545**	**32.83**	**9**
Singapore	Los Angeles	**8,220**	**16.3**	**4**
Los Angeles	Singapore	**8,325**	**16.5**	**5**

TOTAL DAYS **41.93**

Roundtrip Transit Times for Atlantic Trade

Speed: 19 knots

From	To	Miles	Sailing Days	Days in Port
Antwerp	Felixstowe	145	0.32	0.7
Felixstowe	Bremerhaven	340	0.75	0.7
Bremerhaven	Rotterdam	310	0.68	0.7
Rotterdam	LeHavre	270	0.59	0.7
Lehavre	New York	3115	6.83	0.7
New York	Baltimore	470	1.03	0.7
Baltimore	Norfolk	190	0.42	0.7
Norfolk	Charleston	410	0.90	0.7
Charleston	New York	680	1.49	0.7
New York	Antwerp	3320	7.28	0.7
Roundtrip		**9,250**	**20.29**	**7**
Antwerp	New York	**4,180**	**9.17**	**3.5**
New York	Antwerp	**5,070**	**11.12**	**3.5**

TOTAL DAYS **27.29**

Earlier in this chapter, it was stated that a transpacific trade could be operated with 6 ships on a 42 day service and that weekly service in the Atlantic could be provided with 4 ships. Exhibit 3.6 shows the time required to complete each leg of these routes, assuming 21 knots for the vessel in the Far Eastern trade and 19 knots for the vessel in the European trade.

Railroad Transit Times

In 1984 American President Lines began double-stack train service across the United States. This landbridge service uses ships to bring containers from the Far East to the U.S. Pacific Coast, then transfers the containers to trains for the trip to the East Coast. The cost reduction made possible by double-stack made it less expensive to ship goods by landbridge than by using the all-water route through the Panama Canal.

Exhibit 3.7

Transit Time Comparison, Landbridge vs All-Water

Speed: **21** Knots

All Water Service

From	To	Miles	Days
Yokohama	Panama	7,682	15.24
Canal Transit			1
Panama	Savannah	1,510	3.00
	TOTAL	**9,192**	**19.24**

Landbridge Service

From	To	Miles	Days
Yokohama	Los Angeles	4680	9.29
Mode Transfer			1
Los Angeles	Savannah	2700	6
	TOTAL	**7,380.00**	**16.29**

Derived From Distance Tables and APC Information

At a ship speed of 21 knots, the landbridge saves three days as compared to the all-water mode. It would be necessary to increase ship speed to 31 knots to equalize the transit times for the two modes. Double-stack service is now offered by most of the carriers in the Far Eastern trade. As a result, the share of containerized goods handled through U.S. West Coast ports has increased from 41% in 1970 to 76% in 1992.[14]

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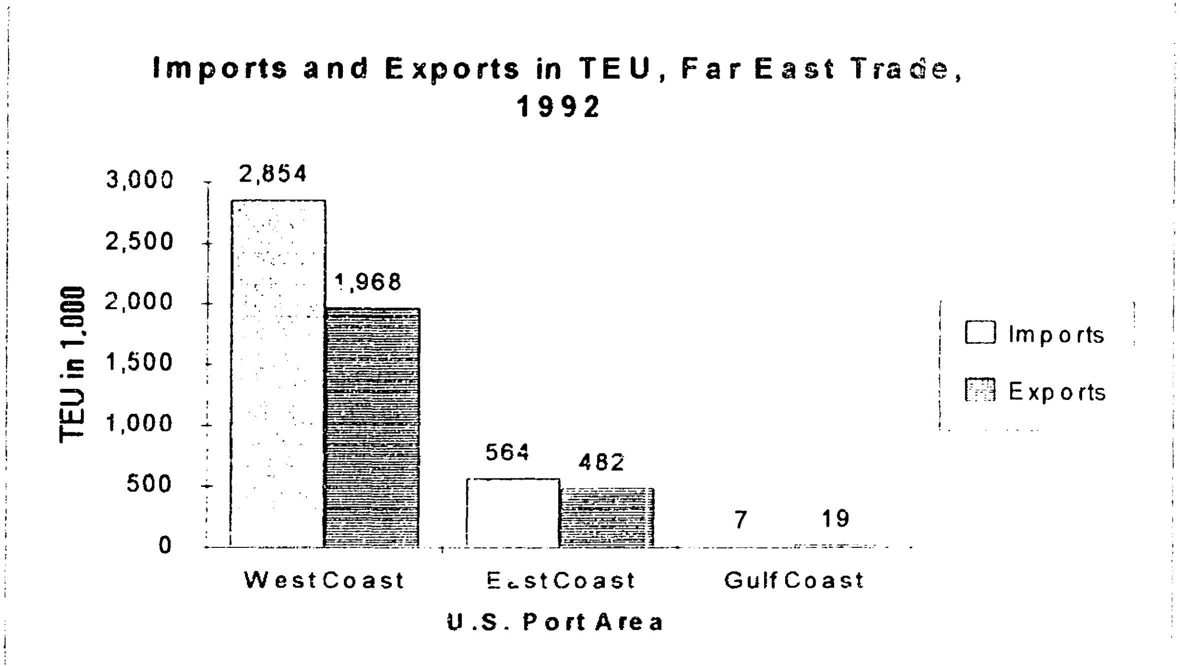
[14] Review of United States Liner Trades, Maritime Administration, September 1993, page 54.

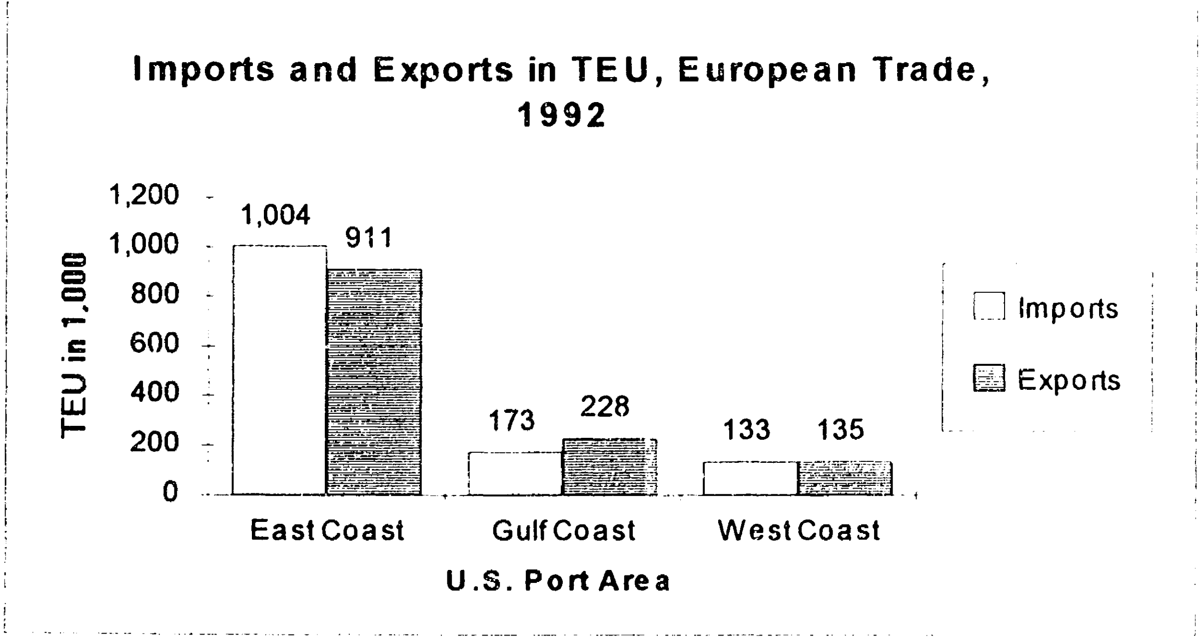
Figure 3.2



Data Source: Review of U.S. Liner Trades, MARAD, 1993.

A similar condition exists in trade with Europe. 77% of the imports and 71% of the exports in the European trade flow into ports on the U.S. East Coast.

Figure 3.3



Data Source: Review of U.S. Liner Trades, MARAD, 1993.

The shortest transit time for service across North America is 5 days. Short distances overland are generally served by truck, while the longer hauls are served by double-stack train.

Exhibit 3.8

Overland Transit Times

American President Companies

Pacific South Express			Westbound	Eastbound
City	**Mode**	**City**	**Days**	**Days**
New York	**DST**	**Long Beach**	6	5
Boston	DST	Long Beach	8	8
Philadelphia	DST	Long Beach	7	6
Chicago	DST	Long Beach	5	4
Memphis	DST	Long Beach	6	5
Charleston	DST	Long Beach	8	6
Atlanta	DST	Long Beach	7	5
Cincinnatti	DST	Long Beach	6	5
Kansas City	DST	Long Beach	6	3
St. Louis	DST	Long Beach	5	4
Dallas	DST	Long Beach	5	3
Phoenix	Truck	Long Beach	3	2
San Diego	Truck	Long Beach	2	2

Pacific North Express			Westbound	Eastbound
City	**Mode**	**City**	**Days**	**Days**
Seattle	DST	Portland	2	2
Seattle	DST	Minneapolis	4	4
Seattle	DST	Chicago	6	4
Seattle	DST	Milwaukee	5	5
Seattle	DST	Columbus	6	7
Seattle	DST	New York	8	7
Seattle	DST	Boston	8	7

DST = Double Stack Train

Source: Pacific Shipper, April 18, 1994

Truck Connections

In general, trucks are used in two ways. First, drayage trucks are used to deliver containers to railheads near ports and to customers that are within 50 miles of the port. Trucks are also used for deliveries of containers that will travel less than 500 miles from the port.[15] Beyond 500 miles, containers are normally shipped by rail and are loaded onto trucks for drayage at the end of the rail journey.[16]

Reliability

Interviews have been conducted with shippers who, in the aggregate, ship over $2 billion worth of goods each year. These shippers indicate that international intermodal shipments normally vary less than two days, and that they hold about 2 days safety stock due to transit time variability.

Summary

The present intermodal container transport system provides service that has more than enough capacity, serves shippers with at least weekly frequency and is highly reliable. Shippers, carriers and customers are electronically linked and cargo movement information is readily available.

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[15] Truck drivers are limited to a 10 hour driving day. At an average of 50 mph, 500 miles is equivalent to one driver-day.

[16] Interview with Intermodal Marketer.

Chapter Four

Costs, Prices and Profits in Containerized Ocean Shipping

Overview

Costs and pricing found in the container ship trades can be characterized by the following traits:

1. Prices depressed due to overcapacity.
2. Substantial costs to container ship companies for inland transportation of containers.
3. Profits generally below 6% of revenue, with many operators losing money.
4. Costs per ton-mile in the range of $0.19 to $0.35 in the Pacific Trade and from $0.22 to $0.55 in the Atlantic Trade, including inland transport.

Overcapacity

The container ship business has, in recent years, been plagued with overcapacity which has driven down prices and reduced profitability. Very few older ships have been scrapped, newbuildings have been plentiful and the trend toward larger vessels has given us ships with capacities of over 4000 teu. In addition, the use of rail as a landbridge has dramatically increased the effective capacity of the pacific fleet.

In the five year period from 1987 to 1992, the world container market saw 633,000 teu added in newbuildings and only 50,000 teu lost to scrapping. This equals a net gain of over 115,000 teu per year. Looking ahead to 1997, Drewry Shipping Consultants predict that this trend will continue.

Not only are the newbuildings plentiful, they are quite large. In 1992, there were 100 container ships with capacities of over 3000 teu, 75 of which were over 3400 teu and 26 at over 4000 teu.[17] The 1994 Containerization International Yearbook shows that 44 new ships of over 4000 teu capacity each are scheduled to go into service in 1994/1995. In addition, there are another 37 newbuildings that have capacities between 3000 and 4000 teu. [18]

Landside technology has also contributed to the capacity problem. In 1984, double-stack train service began between the West and East Coasts of North America.

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[17] Drewry, page 152,153.

[18] Ibid, figure 4.9

This innovation shortened the time required for a roundtrip voyage from the Far East to the United States from about 60 days to about 40 days, since vessels could begin to call at West Coast ports instead of East Coast ports. Shortening the cycle time by 20 days increased the effective capacity of the ships in this trade by 65%.

The chart below shows the size of the current container fleet and the size distribution of the ships on order. Note that the teu slots on order total 13% of the current world capacity.

Exhibit 4.1

Ship Type	Ship size in teu 1500-1999	Ship size in teu 2000-2499	Ship size in teu 2500-3499	Ship size in teu >3500	**Total**
Fully Cellular					
present world slots	307,570	198,117	720,902	240,549	2,112,308
number of ships	176	90	247	60	1,514
slots on order	66,481	43,305	42,855	267,609	469,033
ships on order	38	19	14	63	183
Semi Container					
present world slots	0	0	0	0	668,832
number of ships	0	0	0	0	1,952
slots on order	5,940	0	0	0	17,584
ships on order	3	0	0	0	28
Bulk/Container					
present world slots	68,605	20,837	0	0	336,483
number of ships	41	10	0	0	384
slots on order	0	0	0	0	0
ships on order	0	0	0	0	0

Types of vessels not shown in this chart include Ro-Ro, Breakbulk, Barge Carrier and cellular converted ships. They ARE included in the overall total.

Overall Total					
present world slots	434,687	262,046	743,751	240,549	3,743,157
number of ships	253	121	255	60	5,209
slots on order	72,421	43,305	42,855	267,609	490,395
ships on order	41	19	14	63	227

From: Containerization International Yearbook, 1994

As can be seen, 56% of the world's container capacity is provided by fully cellular container ships. The next largest share is provided by semi-container ships, most of which are of less than 1000 teu and therefore not on this chart. There are 1,952 semi-container ships, 1,581 of which carry less than 500 containers. Two-thirds of all combination Bulk/Container ships (of which there are 384), carry fewer than 1000 teu.

This growth in capacity has resulted in a depression of prices. To combat this depression:

> "The first ever trade lane agreement, the TSA (Transpacific Agreement), introduced a new approach to the mismatch which intense competition had brought to the world's main container trade routes by simply declaring a portion of container space to be unusable. All vessels operating under the auspices of the TSA on the eastbound transpacific trade have, since March 1989, been deemed to have lower capacities than their physical container intake. The space which has been declared unusable has been taken off the market in an attempt to stabilise freight rates by narrowing the gap between supply and demand. The capacity Management Programme for the proposed TAA (Transatlantic Agreement) envisages a similar system of artificial space capping, although due to the extreme oversupply of capacity in that trade some physical removal of space by actual vessel withdrawals is both likely and desirable."[19]

The effects of the TSA space restrictions on vessel utilization have been projected by Drewry Shipping Consultants. The projections for the Pacific are shown below. Note that the newbuildings coming on line in 1992, 1993 and 1994 push vessel utilization downward, in spite of the TSA.[20]

Exhibit 4.2
Transpacific Trade - Forecast Supply/Demand

Year	Eastbound Capacity (000 teu)	TSA Reduction (in %)	Net Eastbound (000 teu)	Eastbound Demand (000 teu)	Vessel Utilization (in %)
1990	3,942	11.5%	3557	2986	75.7%
1991	4,026	12.0%	3615	3187	79.2%
1992	4,109	11.0%	3725	3400	81.7%
1993	4,274	13.0%	3802	3250	76.0%
1994	4,430	12.0%	3978	3400	76.7%
1995	4,510	11.0%	4088	3550	78.7%
1996	4,590	10.0%	4200	3700	80.6%
1997	4,690	10.0%	4291	3900	83.2%

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[19] Drewry, 5.12.

[20] Drewry, figure 5.9,5.11,5.13.

The eastbound trade is expected to improve to 83% by 1997. The westbound (backhaul) trade is lower, dropping from 61% in 1990 to 58.5% in 1997.

The projection for the Atlantic trade shows an improvement from 64.7% utilization in 1990 to 82% in the year 1997. Eastbound utilization is expected to decline from 75% in 1992 to 58% in 1997.

Exhibit 4.3
TransatlanticTrade - Forecast Supply/Demand

Year	Westbound Capacity (000 teu)	TAA Reduction (in %)	Net Westbound (000 teu)	Westbound Demand (000 teu)	Vessel Utilization Westbnd
1990	1944	0	1944	1258	64.7%
1991	1914	0	1914	1150	60.1%
1992	1917	0	1917	1200	62.6%
1993	1856	15	1675	1150	68.7%
1994	1877	20	1633	1300	79.6%
1995	2027	15	1845	1400	75.9%
1996	2177	10	2055	1500	73.0%
1997	2177	15	1948	1600	82.1%

TAA Update

The TAA went into use in 1993, before it was approved by the Federal Maritime Commission (FMC). The FMC has since decided not to allow the agreement.[21] Given this, the rates on the Atlantic are expected to remain depressed.

COST

What is the current relationship between prices and costs in the East-West Trades? This information is closely guarded by shipping companies, but recent publications show that, as would be expected from the current state of overcapacity, the Transpacific Trades are operating at about a 5% profit per container while the Transatlantic Trades are operating at a loss. Consider the examples from the following two sources: *Economies of Container Ship Size*, by Seok-Min Lim and *Container Market Profitability to 1997* by Drewry Shipping Consultants, LTD.

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[21] Journal of Commerce, Nov, 1994.

DREWRY SHPPING CONSULTANTS

We will now consider two cost examples developed by Drewry Shipping Consultants. For the calculation of capital charges, both the Pacific and Atlantic examples use a blend of ships, with some built in 1982, some in 1987 and others in 1992. In a similar fashion, the crew costs are calculated using a medium cost crew.

Pacific Trade Example, 1992

Drewry's figures are based on a six ship service, travelling a 42-day route and calling once per week at each port. The exhibit shows the expenses for one ship travelling a complete cycle, stopping at a total of 8 ports between Singapore and Los Angeles. The port rotation is as follows: Singapore, Hong Kong, Kaohsiung, Busan, Kobe, Tokyo, Los Angeles, Oakland, Tokyo, Kobe, Busan, Kaohsiung, Hong Kong, Singapore. The ship moves eastbound with 2288 teu and westbound with 1806 teu. (See Appendix A-2)

Cost per ton-mile

A vessel in this trade would normally be in service about 360 days per year, which would result in 8.57 roundtrips. With an average of 4094 containers carried per roundtrip, 8275 miles per Pacific crossing and a range of 5 to 15 short tons per teu, the cost per ton-mile falls between $0.042 and $0.014. The cost per ton-mile is calculated as follows.

$$\frac{\$0.0189}{\text{ton mile}} = \left(\frac{\$60{,}469{,}000}{1 \text{ year}}\right) \div \left[\left(\frac{4094 \text{ teu}}{1 \text{ roundtrip}}\right) * \left(\frac{8.57 \text{ roundtrips}}{1 \text{ year}}\right) * \left(\frac{8275 \text{ miles}}{1}\right) * \left(\frac{11 \text{ tons}}{1 \text{ teu}}\right)\right]$$

The range of costs per tonmile, when considering the range from 5 tons per teu to 15 tons per teu, is as follows.

Exhibit 4.4

Transpacific Trade
Costs per single ship on annual basis.

Teu per Roundtrip	Roundtrips per Year	Cost Per Roundtrip	Yearly Cost per Ship	Miles per Crossing
4094	8.57	$7,114,000	$60,469,000	8275

Tons per Teu	Cost per teu-mile	Cost per ton-mile
5	$0.208	$0.042
6	$0.208	$0.035
7	$0.208	$0.030
8	$0.208	$0.026
9	$0.208	$0.023
10	$0.208	$0.021
11	$0.208	$0.019
12	$0.208	$0.017
13	$0.208	$0.016
14	$0.208	$0.015
15	$0.208	$0.014

Derived from Drewry Shipping Consultants, 1992

As was shown in Figure 3.1, the average tons per teu was 11.08 for exports to the Far East and 6.51 for Far Eastern imports. These densities have costs per ton-mile of $0.019 and $0.032, respectively.

Costs and Revenues per teu

Drewry finds that eastbound revenues average $2000 per teu and westbound revenues about $1640 per teu. The cost per teu is estimated at $1733. The six ships in this service would generate a total profit of $21.6 million in 1992. Looking ahead to the years from 1994 to 1997, Drewry predicts profits in 1993 of $8.2 million, a small profit in 1994, then growing losses through 1997 for a 6 ship service in this trade. The loss in 1997 is predicted to be about $433,000 per ship.

The profits in this trade are from the eastbound traffic and fit with the trade pattern we will see in Chapter 5, which clearly shows that eastbound goods are much greater in value (and command a higher tariff) than westbound goods.

Costs per Container

The detailed costs per container may be derived as follows.

Exhibit 4.5

Cost Per Container, Transpacific

FIXED COSTS	%	Per TEU
Bunkers	3.5	$61
Ports	3.6	$62
Capital	9.7	$168
Operating	7.7	$133
Administration	16.2	$281
Subtotal	**40.8**	**$707**
DIRECT COSTS		
Terminals	16.5	$286
Transport	27.1	$470
Depots	0.4	$7
Refrigeration	0.4	$7
Subtotal	**44.4**	**$769**
INDIRECT COSTS		
Empty Containers	4.9	$85
Equipment Provision	5.1	$88
Maint. & Repair	3.9	$68
Cargo Insurance	0.9	$16
Subtotal	**14.8**	**$256**
TOTAL COSTS	**100**	**$1,733**

COSTS PER TEU	**$1,733**

Note that the costs for Transport and Administration, which are the prices paid by the carrier for cargo movement on modes other than ship, account for 43% of the total cost.

The figure used here for transport is an average. Some cargoes will only require local drayage at a cost of less than $100, while others will require transcontinental rail movement at a cost of over $1000. (Drayage refers to the local movement of a container from the container port to a nearby rail head, customer or industrial site.) In general, drayage will be less than 50 miles. Drayage costs for delivery near the following cities falls in these ranges:

Exhibit 4.6

Seattle	$120.00
Los Angeles	$105.00
Chicago	$127.00
Atlanta	$85.00
New York	$155.00

Source: Intermodal Operator

In general, the following ranges of costs will apply for rail movement across the United States.

Exhibit 4.7

Eastbound	20 foot	40 foot
WCNA-ECNA	$910.00	$1,200.00
WCNA-Midwest	$600.00	$840.00
ECNA-Midwest	$480.00	$530.00

Westbound	20 foot	40 foot
ECNA-WCNA	$900.00	$1,170.00
Midwest-WCNA	$530.00	$755.00
Midwest-ECNA	$495.00	$560.00

Source: Intermodal Operator and Drewry Shipping Consultants

The rail cost for eastbound movements is higher than the cost for westbound movements. Again, this reflects the higher value and volume of the goods moving from west to east.

DREWRY SHIPPING CONSULTANTS

Atlantic Trade Example, 1992

For the transatlantic trade, Drewry uses an example with four vessels of 1600 teu, sailing on a 28 roundtrip cycle and calling once a week at each port in the service. The port rotation for each individual ship is Antwerp, Felixstowe, Bremerhaven, Rotterdam, Le Havre, New York, Baltimore, Norfolk, Charleston, New York and Antwerp. Each ship moves westbound with 780 teu and eastbound with 1200 teu. The cost categories are defined the same for this trade as they were for the transpacific. The detailed cost items for a year's operation are show in Appendix A - 3.

Converting the figures for the Atlantic trade to a cost per ton-mile basis, we find that the range falls between $0.066 and $0.022 per ton-mile, when considering the range of densities from 5 to 15 tons per teu.

Exhibit 4.8

Tranatlantic Trade
Costs per single ship on annual basis.

Teu per Roundtrip	Roundtrips per Year	Cost Per Roundtrip	Yearly Cost per Ship	Miles per Crossing
1980	12.9	$3,023,000	$38,867,143	4625

Tons per Teu	Cost per teu-mile	Cost per ton-mile
5	$0.330	$0.066
6	$0.330	$0.055
7	$0.330	$0.047
8	$0.330	$0.041
9	$0.330	$0.037
10	$0.330	$0.033
11	$0.330	$0.030
12	$0.330	$0.028
13	$0.330	$0.025
14	$0.330	$0.024
15	$0.330	$0.022

Derived from Drewry Shipping Consultants, 1992

Referring to figure 3.1, we find that exports to Europe have an average density of 9.12 tons per teu and that imports have a density of 7.58 tons per teu. The costs per ton-mile for these densities are $0.037 and $0.044, respectively.

Cost and Revenue per teu

Drewry finds that eastbound revenues average $1,380 and westbound revenues about $1,092. The cost per teu for this service is about $1350, which means that on a roundtrip there is a net loss per teu of $112. On an annual basis, this operator (with 4 ships in service) would incur a loss of approximately $27.5 million. Drewry predicts that this service will see a brief period of profitability in 1994 (about $4 million), then see these profits evaporate. For 1995, 1996 and 1997, the pressure of newbuildings coming into service will drive prices even lower, and losses for this operator for these years would be expected to be $8 million, $18 million and $19 million.

The costs per voyage shown in Appendix A - 3 may be translated into detailed costs per container as follows.

Exhibit 4.9

Cost per Container, Transatlantic

FIXED COSTS	%	Per TEU
Bunkers	2.8	$38
Ports	5.3	$72
Capital	10.8	$146
Operating	10.2	$138
Administration	19.1	$258
Subtotal	**48.2**	**$651**
DIRECT COSTS		
Terminals	24	$324
Transport	10.4	$140
Depots	1.7	$23
Refrigeration	0.5	$7
Subtotal	**36.6**	**$494**
INDIRECT COSTS		
Empty Containers	3.1	$42
Equipment Provision	6.5	$88
Maint. & Repair	4.4	$59
Cargo Insurance	1.1	$15
Subtotal	**15.2**	**$205**
TOTAL COSTS	**100**	**$1,350**

COSTS PER TEU	$1,350

SEOK-MIN LIM STUDY

Pacific Trade, 1993

Working from data provided by Asian shipping interests, Seok-Min Lim of the Department of International Trade, Hanshin University has studied how pricing, profit and costs are related to container ship size. In his study, he considers 5 ships, ranging in size from 1200 to 4000 teu. Four of the ships are currently in service and the fifth, a 4000 teu vessel, is considered as a hypothetical case. The vessel descriptions, operating costs, utilization ratios and revenues for a one year period are shown in Appendix B.

These figures represent a very low-cost operator, as can be seen from calculating the crew expense per day, which varies between $82 and $114 per man. The crews vary in size from 17 to 22 men and the age of the ships varies from 14 years old to a proposed newbuilding. The ships are deployed as follows:

1. Ship A-1, 1200 teu, sails between East Asia and the U.S. Pacific Northwest.
2. Ship A-2, 1700 teu, sails between East Asia and the U.S. Pacific Northwest.
3. Ship A-3, 2700 teu, sails between East Asia and the U.S. East Coast.
4. Ship A-4 sails in a pendulum service between Europe, North America and Asia, with Asia as the fulcrum. Capacity: 2700 teu
5. Ship A-5 is estimated for a 4000 teu-class vessel sailing between East Asia and the U.S. Pacific Southwest. Capacity: 4000 teu

We calculate the range of costs per ton-mile to be as follows:

Exhibit 4.10

Cost per ton mile at various ton per teu ratios.

Vessel	**A-1**	**A-2**	**A-3**	**A-4**	**A-5**
Cost per teu mile	$0.18	$0.18	$0.11	$0.07	$0.19

Tons per teu	**Cost per ton mile** **A-1**	**A-2**	**A-3**	**A-4**	**A-5**
5	$0.036	$0.036	$0.022	$0.014	$0.038
6	$0.030	$0.030	$0.018	$0.012	$0.032
7	$0.026	$0.026	$0.016	$0.010	$0.027
8	$0.023	$0.023	$0.014	$0.009	$0.024
9	$0.020	$0.020	$0.012	$0.008	$0.021
10	$0.018	$0.018	$0.011	$0.007	$0.019
11	$0.016	$0.016	$0.010	$0.006	$0.017
12	$0.015	$0.015	$0.009	$0.006	$0.016
13	$0.014	$0.014	$0.008	$0.005	$0.015
14	$0.013	$0.013	$0.008	$0.005	$0.014
15	$0.012	$0.012	$0.007	$0.005	$0.013

Derived from Seok-Min Lim, 1994

Ship A-2, sailing in the Far Eastern trade, shows costs per ton-mile of $0.028 for 6.5 tons per teu and $0.016 for 11 tons per teu. Remembering that this is a low-cost vessel operated with a low-cost crew, these numbers are what would be expected, given that Drewry's figures indicate costs of $0.032 and $0.019 for a medium cost operation.

Profitability

We also find that the profit per teu ranges from 5% to 9.7% for the ships currently in service, while in the hypothetical case, the 4000 teu vessel operates at a 15% loss.

Exhibit 4.11

Per Teu	A-1	A-2	A-3	A-4	A-5
Revenue	$1,168	$1,170	$1,275	$1,229	$1,157
Cost	$1,108	$1,057	$1,194	$1,139	$1,340
Profit	$60	$113	$81	$90	($183)
Per Cent	5.1%	9.7%	6.4%	7.3%	-15.8%

Derived from Seok-Min Lim, 1994

The lack of profit for A-5 is due to its low capacity utilization.

Translating the cost in Appendix B - 1,2 to a cost-per-teu basis, we find that operating the five vessels incurs the following costs.

Exhibit 4.12

Costs per TEU	**A-1**	**A-2**
Stevedorage (load & discharge)	$247	$248
Haulage (rail, truck, dray)	$442	$443
Cargo/Terminal (stuff,strip, etc.)	$43	$43
Agency Fee	$28	$28
Port Charges (pilot,tow,dockage)	$32	$24
Bunker Charges (Fuel)	$76	$56
Crew Expense	$33	$23
Ship Expense (stores, water,etc)	$40	$35
Insurance (hull, machinery,P&I)	$10	$9
Depreciation (ship,containers,etc)	$49	$45
Administrative (office,salary,etc)	$78	$80
Non Operation Exp (interest,etc)	$29	$23
Total Cost per TEU	**$1,108**	**$1,057**

Derived from Seok-Min Lim, 1994

Costs per TEU	**A-3**	**A-4**	**A-5**
Stevedorage (load & discharge)	$344	$313	$327
Haulage (rail, truck, dray)	$153	$238	$264
Cargo/Terminal (stuff,strip, etc.)	$71	$52	$47
Agency Fee	$40	$44	$30
Port Charges (pilot,tow,dockage)	$61	$74	$27
Bunker Charges (Fuel)	$78	$68	$57
Crew Expense	$25	$18	$12
Ship Expense (stores, water,etc)	$107	$92	$97
Insurance (hull, machinery,P&I)	$9	$7	$9
Depreciation (ship,containers,etc)	$60	$42	$63
Administrative (office,salary,etc)	$148	$90	$281
Non Operation Exp (interest,etc)	$97	$100	$125
Total Cost per TEU	**$1,194**	**$1,139**	**$1,340**

Derived from Seok-Min Lim, 1994

Exhibit 4.13

Inland Transportation as Per Cent of Total Cost

Pacific Trade	Total Cost/teu	Transport per teu	Admin per teu	Per cent of Total
Vessel				
A-1	$1,108	$442		39.9%
A-2	$1,057	$442		41.8%
Drewry	$1,733	$470	$281	43.3%

Atlantic Trade	Total Cost/teu	Transport per teu	Admin per teu	Per cent of Total
Vessel				
A-3	$1,194	$153		12.8%
Drewry	$1,350	$140	$258	29.5%

Other Trade	Total Cost/teu	Transport per teu	Admin per teu	Per cent of Total
A-4	$1,139	$238		20.9%

Derived from Seok-Min Lim and
Drewry Shipping Consultants

Comparing the figures from our two sources, we find that the costs for inland transportation in the Pacific trades are around 40%. This is consistent with the use of double-stack rail to reach into the American Midwest. The inland transportation costs for the Atlantic trade are lower, between 13% and 30%, as you would expect from the shorter land movement distances involved.

Summary

The transpacific trades, including inland transportation, provide transportation at a cost ranging between $0.18 and $0.21 per teu-mile. The cost per ton-mile falls between:

$0.016 to $0.028 per ton-mile for low-cost operators to
$0.019 to $0.032 per ton-mile for medium-cost operators,
depending on the tons-per-teu chosen.

The transatlantic trades, including inland transportation, provide transportation at a cost ranging between $0.03 and $0.055 per ton-mile, based on an average cost of $0.33 per teu-mile. The difference in costs between the Atlantic and Pacific trades is due in large part to the fact that the voyage distances between the two trades vary by over 3000 miles.

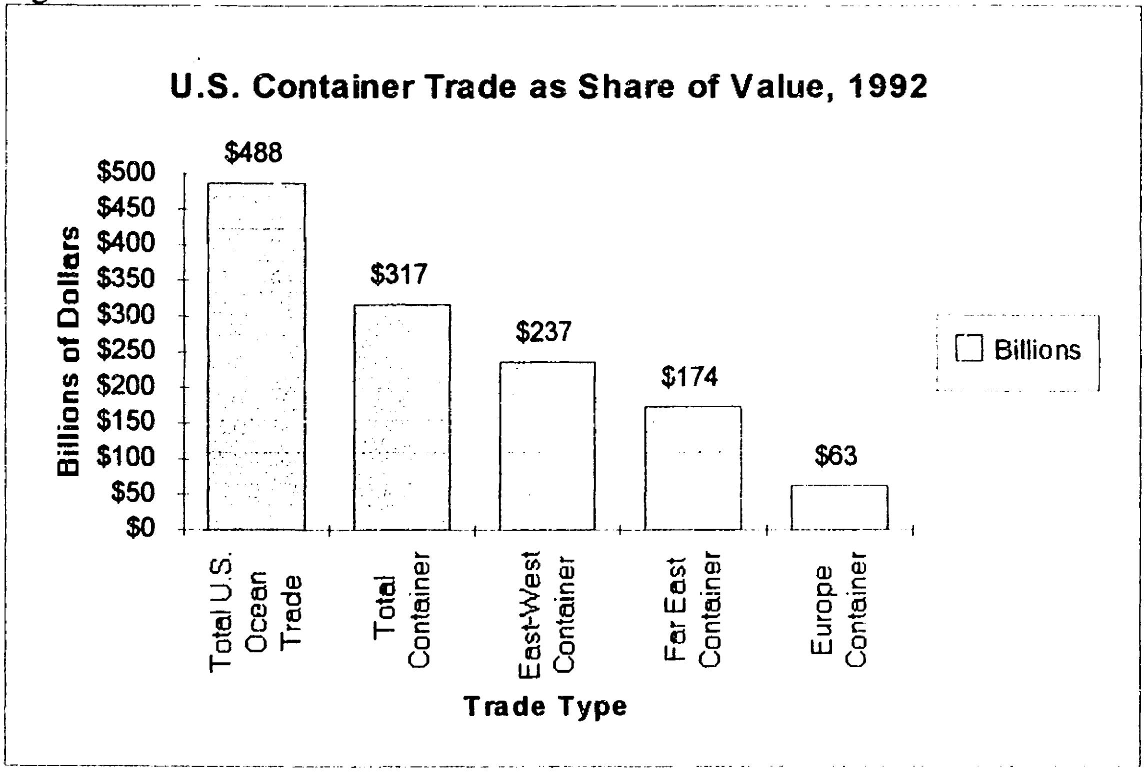
Prices are depressed in both markets. It is apparent that prices cannot go down further, without reducing profits to zero for those operators that are now profitable. We also see that sufficient capacity exists to flood any part of the market in which prices happen to rise. Capacity will increase dramatically this year, with the teu slots on order sufficient to increase the world supply by 13% during 1994. Given these conditions, it seems that prices and profits will remain depressed until substantial portions of the current fleet are scrapped.

Chapter Five

Goods Shipped By Ocean Container

In 1992, the total value of all oceanborne trade between the United States and its foreign partners was $488 billion. The total volume was 117 million metric tons. Containerized cargoes made up 65% of the total value and 13.5% of the total volume.[22] In looking at Figure 5.1, we see that East-West trade makes up 75% by value of the total container trade. In dollar value, trade with the Far East makes up 74% of the East-West trade and 55% of the overall containerized trade.

Figure 5.1



For the year, the world total for movements of ocean containers was 100,734,472 teu, a gain of 7.6% over the previous year. This figure includes the movement of all empty containers, as well any containers that were transshipped. The United States had the

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[22] Public Port Financing in the United States, 1993.

Figure 5.1A

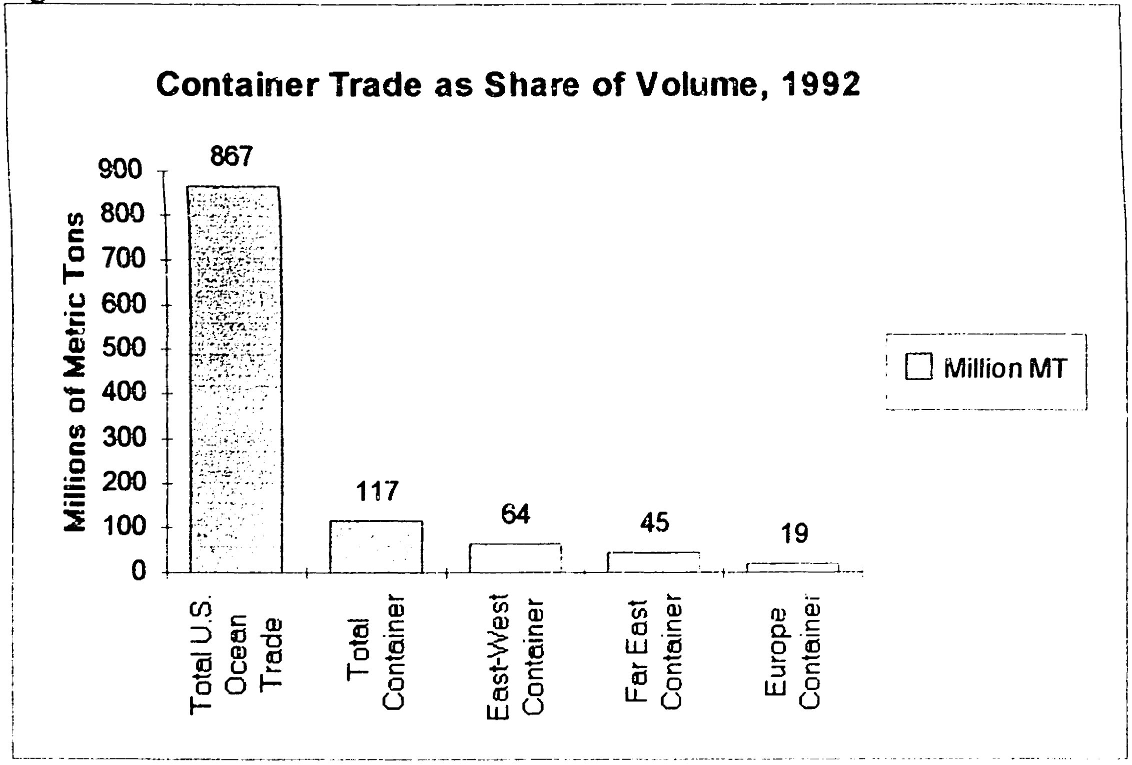


Exhibit 5.1

World Container Traffic, Containers Handled

Country	1992 teu (000s)	1991 teu (000s)	1990 teu (000s)	1989 teu (000s)
USA	16,741	15,545	15,244	14,632
Japan	8,935	6,781	7,955	7,539
HongKong	7,972	6,191	5,223	5,278
Singapore	7,560	6,354	5,100	4,364
Taiwan	6,178	6,129	5,450	4,463
UK	4,378	4,087	4,041	3,786
Netherlands	4,200	3,856	3,761	3,725
Germany	3,601	3,512	3,267	3,092
S. Korea	2,751	2,570	2,348	2,158
U. Arab Em.	2,506	2,072	1,929	1,768

Includes empty and transshipped containers.

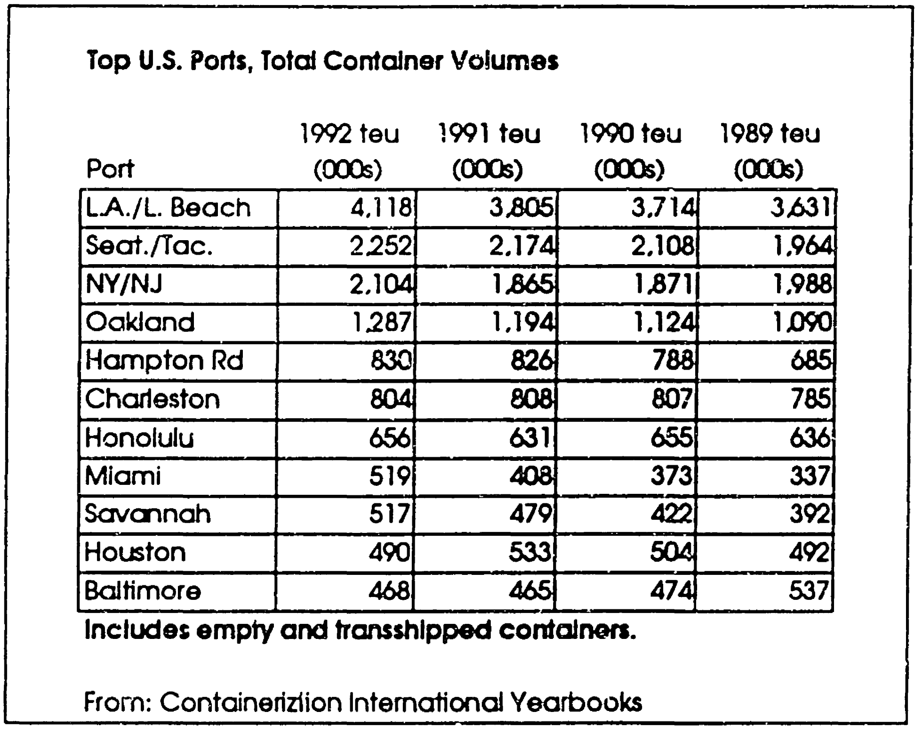
From Containeriztion International Yearbooks

highest volume of containers handled, with a total of 16,741,880 teu. Japan, Hong Kong and Singapore occupied the next three spots, with volumes about half that of the United

States. See Exhibit 5.1 for a list of the top 10 container-handling countries over the last 4 years.

Within the United States, the ports of Los Angeles and Long Beach, California accounted for one quarter of the country's volume, with a combined 4.1 million teus handled. L.A./Long Beach was followed by Seattle/Tacoma, with 2.2 million teus and the port of New York/New Jersey with 2.1 million teus. As we will see in more detail, the highest dollar-volume cargoes handled in the United States are those imported through the West Coast ports. See Exhibit 5.2 for a list of the top 10 U.S. container ports, by teu volume, over the last 4 years.

Exhibit 5.2



Top U.S. Ports, Total Container Volumes

Port	1992 teu (000s)	1991 teu (000s)	1990 teu (000s)	1989 teu (000s)
L.A./L. Beach	4,118	3,805	3,714	3,631
Seat./Tac.	2,252	2,174	2,108	1,964
NY/NJ	2,104	1,865	1,871	1,988
Oakland	1,287	1,194	1,124	1,090
Hampton Rd	830	826	788	685
Charleston	804	808	807	785
Honolulu	656	631	655	636
Miami	519	408	373	337
Savannah	517	479	422	392
Houston	490	533	504	492
Baltimore	468	465	474	537

Includes empty and transshipped containers.

From: Containerizion International Yearbooks

Containerized trade between the United States and its partners can be divided into three main categories. There are two East-West trades, one with Europe and the other with the Far East. There is also a North-South interamerican trade. For 1992, these three trades accounted for 97% of all loaded teu movements to and from the United States, with 84% coming from the two East-West trades. See Exhibit 5.3 for a distribution of the teu volumes with each of the trade regions.

Exhibit 5.3

1992
Loaded TEU Movements

TRADE ZONE	TEU	%
Export to Far East	2,569,114	25.1%
Import from Far East	3,424,740	33.4%
Exports to Europe	1,274,167	12.4%
Imports from Europe	1,310,576	12.8%
Exports to L America	852,954	8.3%
Imports from L. America	532,202	5.2%
Exports to Middle East	64,789	0.6%
Imports from Middle East	35,741	0.3%
Exports to Australasia	110,591	1.1%
Imports from Australasia	76,510	0.7%
Total	10,251,384	100%

From: Marad Review of U.S. Liner Trades, 1993.

Exhibits 5.4 through 5.7 show the total dollar values (at wholesale) and tonnages of all the containerized cargoes moving between the United States and its partners in the East-West trades for 1992. The total trade was $237,150,954,000. The key ports involved, NY/NJ, LA/Long Beach and Seattle/Tacoma, accounted for 60% of the dollar volume for the year.

Exhibit 5.4

IMPORTS From Europe	**Total Dollars**	**Total Long Tons**	**Per Cent of Total Dollars**	**Per Cent of Total Tons**
To all of U.S.	$35,344,578,860	8,865,608	100.00%	100.00%
New York/NJ	$11,719,237,738	2,424,509	33.16%	27.35%
Hampton Roads	$4,352,898,340	919,368	12.32%	10.37%
Charleston	$3,896,826,925	837,821	11.03%	9.45%
Miami	$272,524,849	71,152	0.77%	0.80%
Savannah	$1,117,933,226	253,541	3.16%	2.86%
Baltimore	$2,013,527,039	510,845	5.70%	5.76%
Jacksonville	$262,079,322	39,381	0.74%	0.44%
Port Everglades	$680,898,695	200,299	1.93%	2.26%
Palm Beach	$1,962,216	3,437	0.01%	0.04%

Exhibit 5.5

EXPORTS **To Europe**	**Total Dollars**	**Total Long Tons**	**Per Cent of Total Dollars**	**Per Cent of Total Tons**
From all of U.S.	$28,583,803,220	10,378,253	100.00%	100.00%
New York/NJ	$6,335,378,752	1,185,773	22.16%	11.43%
Hampton Roads	$4,842,589,726	1,394,274	16.94%	13.43%
Charleston	$2,856,964,093	1,261,941	10.00%	12.16%
Miami	$241,318,624	105,745	0.84%	1.02%
Savannah	$1,163,838,285	542,372	4.07%	5.23%
Baltimore	$2,064,204,567	752,968	7.22%	7.26%
Jacksonville	$640,139,880	328,713	2.24%	3.17%
Port Everglades	$134,904,075	17,936	0.47%	0.17%
Palm Beach	$557,484	60	0.00%	0.00%

Exhibit 5.6

IMPORTS From the Far East	**Total Dollars**	**Total Long Tons**	**Per Cent of Total Dollars**	**Per Cent of Total Tons**
To all of U.S.	$130,344,582,782	19,913,995	100.00%	100.00%
L.A./Long Beach	$69,201,105,028	9,619,603	53.09%	48.31%
Oakland	$10,840,910,266	1,880,952	8.32%	9.45%
Seattle/Tacoma	$32,944,971,169	4,103,606	25.28%	20.61%
Portland	$1,086,710,057	147,447	0.83%	0.74%
San Francisco	$804,785,189	261,426	0.62%	1.31%

Exhibit 5.7

EXPORTS **To the Far East**	**Total Dollars**	**Total Long Tons**	**Per Cent of Total Dollars**	**Per Cent of Total Tons**
From all of U.S.	$42,878,188,554	25,426,080	100.00%	100.00%
L.A./Long Beach	$15,269,915,874	7,544,947	35.61%	29.67%
Oakland	$6,387,628,562	2,912,217	14.90%	11.45%
Seattle/Tacoma	$7,614,111,599	5,732,931	17.76%	22.55%
Portland	$2,375,218,085	1,549,635	5.54%	6.09%
San Francisco	$773,487,943	502,474	1.80%	1.98%

We see that for most ports, the per cent by volume and the per cent by value are very similar. The exception is found in Exhibit 5.5, which shows the exports for the port of New York/New Jersey. New York's value to volume ratio is nearly 2 to 1. We will see later that New York has by far the most valuable export items of all East Coast ports.

Now, we know the volume of cargo that moved in containers through American ports. What is the composition of this cargo? First, imports are more valuable per pound than exports. Imports from Europe have an average value of $1.78 per pound, while exports are worth $1.23. Imports from the Far East have an average value of $2.92 per pound, while exports are worth only 75 cents. Second, we can state that this cargo does not physically decay in less than one month, since the transit times involved may be as long as 30 days. Third, import cargoes are primarily manufactured goods, while export commodities, which generally are lower-value "backhaul" goods, are a mix of manufactured goods and high-density items like lumber, scrap paper, cotton, animal feed and fruit.[23]

Figure 5.2

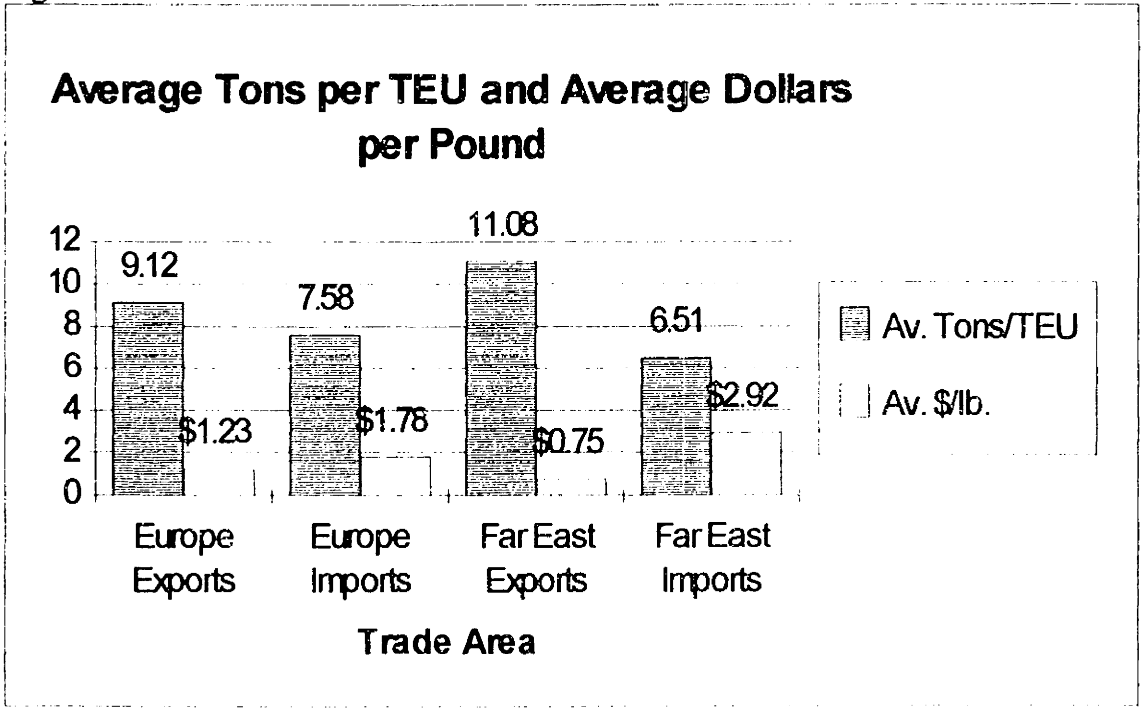


Figure 5.2 shows clearly the relationships between value and density for the European and Far Eastern trades. Exports to the Far East are high density and low value, while imports are low density and high value. The difference between European exports and imports is less pronounced. Unfortunately, we saw earlier that European trade is only a third of Far Eastern trade. Consequently, since Far Eastern trade has such high volumes

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[23] From a line-by-line review of MARAD-supplied values and volumes for the ports of Los Angeles, Long Beach, Seattle, Tacoma and New York/New Jersey, 1992.

Exhibit 5.8

The Growth of World Container Trade

Year	TEU in Millions	Year	TEU in Millions
1973	15.0	1982	42.8
1974	16.2	1983	45.6
1975	17.4	1984	53.3
1976	20.2	1985	55.9
1977	23.0	1986	60.9
1978	26.5	1987	67.3
1979	32.0	1988	73.8
1980	37.2	1989	79.8
1981	40.9	1990	84.2

Source: Drewry Shipping Consultants
from Containerization Int. Yearbooks

Containerization and General Cargo Trade

Year	Total Gen. Cargo (MT)	Container Cargo (MT)	% in Containers
1980	560	129	23.0%
1981	579	142	24.5%
1982	550	147	26.7%
1983	520	157	30.2%
1984	538	181	33.6%
1985	514	189	36.8%
1986	541	208	38.4%
1987	511	236	46.2%
1988	548	264	48.2%
1989	598	284	47.5%
1990	659	299	45.4%

Source: Drewry Shipping Consultants

The percentage of general cargo shipped by container has increased from 23% in 1980 to 45% in 1990. (Exhibit 5.8) This shift is explained clearly by Drewry Shipping Consultants, who state:

> "...whole industries have effectively migrated from high cost regions such as Europe and North America to low cost production centres nearer raw material sources, and traditional movements of (heavy) primary produce have been replaced by movements of light, value-added manufactures. The clothing and footwear industries are prime examples of this trend, and together account for a significant volume of global container traffic. The upshot has been that the nature of the general cargo market has changed as weight cargoes have started to give way to volume cargoes. Thus there has been a major commodity substitution in world general cargo trade which is reflected in the growth of container volumes, but not in the weight of cargo moved."[24]

To determine more specifically the composition of the goods in the East-West trades, we will take a sample of the commodities shipped in 1992 (from unpublished MARAD data) and separate them into segments at $5 per pound intervals. The sample captures 100% of the containerized cargo moving through the ports of NY/NJ, LA/Long Beach and Seattle/Tacoma during 1992. Exhibits 5.9 and 5.10 show the results of the stratification at $5 per pound intervals. Looking at the import commodities in Exhibit 5.9, we see that 10 to 20 percent of the commodities had values of over $5 per pound. Going above this point, the percentages decline rapidly. 2 to 4 per cent had values over $10 per pound and only about 1 per cent were worth more than $15 per pound.

Moving on to exhibit 5.10, we see that the export picture is very different. For exports to the Far East, only 1 to 3 % are valued at over $5 per pound and less than 1 per cent are worth more than $15. The situation in New York is better, with 12% of the exports worth over $5 per pound and about 4 per cent worth over $10.

Based on this sample, what are the overall sizes of the stratified European and Far Eastern markets? From exhibit 5.11, we see that our sample ports have value densities that are higher than the average for their markets. For example, the average value per pound imported from Europe into the port of New York is $2.16, while the average value per pound for all imports in this market is $1.78. The average value of the imports from Europe through ports other than New York is $1.64 per pound.

The same sort of differences are apparent for the west coast ports as well. When estimating the overall size of the market for each of the stratified value densities we adjust

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[24] Drewry Shipping Consultants, Container Profitability to 1997.

Exhibit 5.9

1992 DATA

Containerized Imports for LA/Long Beach

Value per lb.	Long Tons	Value	% Tons	% Value
All Cargo	9,619,312	$69,201,105,028	100	100
Over $5/lb	1,861,684	$35,729,927,641	19.4	51.6
Over $10/lb	462,602	$14,236,603,466	4.8	20.6
Over $15/lb	47,141	$3,279,009,965	0.5	4.7
Over $20/lb	35,566	$2,826,547,791	0.4	4.1
Over $25/lb	32,150	$2,662,948,102	0.3	3.8
Over $30/lb	32,095	$2,659,525,947	0.3	3.8

Containerized Imports for Seattle/Tacoma

Value per lb.	Long Tons	Value	% Tons	% Value
All Cargo	4,103,606	$32,944,971,169	100	100
Over $5/lb	887,423	$17,376,803,665	21.6	52.7
Over $10/lb	168,900	$5,812,548,847	4.12	17.6
Over $15/lb	44,535	$2,360,600,696	1.09	7.2
Over $20/lb	27,359	$1,742,169,891	0.67	5.3
Over $25/lb	13,047	$1,019,384,388	0.32	3.1
Over $30/lb	12,772	$1,000,910,851	0.31	3

Containerized Imports for New York/New Jersey

Value per lb.	Long Tons	Value	% Tons	% Value
All Cargo	2,424,509	$11,719,237,738	100	100
Over $5/lb	264,991	$5,292,685,983	10.9	45.2
Over $10/lb	42,670	$1,788,233,421	1.8	15.3
Over $15/lb	21,011	$1,208,828,863	0.9	10.3
Over $20/lb	11,886	$863,342,509	0.5	7.4
Over $25/lb	6,823	$606,035,378	0.3	5.2
Over $30/lb	1,780	$279,943,408	0.1	2.4

Derived from unpublished MARAD data.

Exhibit 5.10

1992 DATA

Containerized Exports for LA/Long Beach

Value per lb.	Long Tons	Value	% Tons	% Value
All Cargo	7,544,947	$15,269,915,874	100	100
Over $5/lb	248,084	$4,773,571,438	3.3	31.3
Over $10/lb	45,711	$1,820,213,731	0.6	11.9
Over $15/lb	18,145	$1,112,368,841	0.2	7.3
Over $20/lb	12,720	$907,865,730	0.2	5.9
Over $25/lb	9,447	$737,566,918	0.1	4.8
Over $30/lb	8,512	$679,671,849	0.1	4.5

Containerized Exports for Seattle/Tacoma

Value per lb.	Long Tons	Value	% Tons	% Value
All Cargo	5,732,931	$7,614,111,599	100	100
Over $5/lb	88,569	$1,538,087,160	1.5	20.2
Over $10/lb	9,674	$367,318,923	1.7	4.8
Over $15/lb	3,638	$214,002,456	0.6	2.8
Over $20/lb	1,144	$120,038,383	0.2	1.6
Over $25/lb	551	$90,046,657	0.1	1.2
Over $30/lb	507	$87,488,522	0.1	1.1

Containerized Exports for New York/New Jersey

Value per lb.	Long Tons	Value	% Tons	% Value
All Cargo	1,185,773	$6,335,378,752	100	100
Over $5/lb	143,353	$3,198,083,618	12.1	50.5
Over $10/lb	42,237	$1,710,862,558	3.6	27
Over $15/lb	21,070	$1,174,737,727	1.8	18.5
Over $20/lb	7,527	$614,709,746	0.6	9.7
Over $25/lb	4,330	$454,184,063	0.4	7.2
Over $30/lb	4,036	$435,509,347	0.3	6.7

Derived from unpublished MARAD data.

Exhibit 5.11

1992

IMPORTS From Europe	**Total Dollars**	**Total Long Tons**	**Average Dollars Per Pound**
To all of U.S.	$35,344,578,860	8,865,608	$1.78
NY/NJ	$11,719,237,738	2,424,509	$2.16
Hampton Roads	$4,352,898,340	919,368	$2.11
Charleston	$3,896,826,925	837,821	$2.08
Miami	$272,524,849	71,152	$1.71
Savannah	$1,117,933,226	253,541	$1.97
Baltimore	$2,013,527,039	510,845	$1.76
Jacksonville	$262,079,322	39,381	$2.97
Port Everglades	$680,898,695	200,299	$1.52
Palm Beach	$1,962,216	3,437	$0.25

EXPORTS To Europe	**Total Dollars**	**Total Long Tons**	**Average Dollars Per Pound**
From all of U.S.	$28,583,803,220	10,378,253	$1.23
NY/NJ	$6,335,378,752	1,185,773	$2.39
Hampton Roads	$4,842,589,726	1,394,274	$1.55
Charleston	$2,856,964,093	1,261,941	$1.01
Miami	$241,318,624	105,745	$1.02
Savannah	$1,163,838,285	542,372	$0.96
Baltimore	$2,064,204,567	752,968	$1.22
Jacksonville	$640,139,880	328,713	$0.87
Port Everglades	$134,904,075	17,936	$3.36
Palm Beach	$557,484	60	$4.15

IMPORTS From Far East	**Total Dollars**	**Total Long Tons**	**Average Dollars Per Pound**
To all of U.S.	$130,344,382,782	19,913,995	$2.92
L.A./Long Beach	$69,201,105,028	9,619,603	$3.21
Oakland	$10,840,910,266	1,880,952	$2.57
Seattle/Tacoma	$32,944,971,169	4,103,606	$3.58
Portland	$1,086,710,057	147,447	$3.29
San Francisco	$804,785,189	261,426	$1.37

EXPORTS To Far East	**Total Dollars**	**Total Long Tons**	**Average Dollars Per Pound**
From all of U.S.	$42,878,188,554	25,426,080	$0.75
L.A./Long Beach	$15,269,915,874	7,544,947	$0.90
Oakland	$6,387,628,562	2,912,217	$0.98
Seattle/Tacoma	$7,614,111,599	5,732,931	$0.59
Portland	$2,375,218,085	1,549,635	$0.68
San Francisco	$773,487,943	502,474	$0.69

the estimates to compensate for this difference. The results are shown in Appendices C-1 through C -4. Note that Far Eastern imports account for $130 billion.

Exhibit 5.12 brings together the percentages from these appendices. Exhibit 5.12 shows that there is a reasonable balance of high-value goods in the European trade, but that high-value Far Eastern imports and exports are far out of balance. This is significant, when considering the possible conversion of high value goods from ocean to air transport, since it indicates that an air system sized to handle eastbound goods will have a great deal of overcapacity in the westbound trade.

Exhibit 5.12

1992 -Tons of Cargo in Each Value Density Range

Value Density	Europe Imports	Europe Exports	Far East Imports	Far East Exports
Over 5$/lb	9.0%	6.2%	17.6%	0.3%
Over $10/lb	1.5%	1.9%	4.0%	0.4%
Over $15/lb	0.7%	0.9%	0.6%	0.2%
Over $20/lb	0.4%	0.3%	0.4%	0.1%
Over $25/lb	0.2%	0.2%	0.3%	0.1%
Over $30/lb	0.1%	0.2%	0.3%	0.1%

Derived from unpublished MARAD data.

The extent of this imbalance is made clear when the tons per teu for each of the trades are multiplied by the number of tons at each dollar value level, which gives us the following table.

Exhibit 5.13

1992 Stratified Balance of United States Containerized Trade Volumes

Far East	Export TEU	Import TEU
Over $5/lb	63,762	603,531
Over $10/lb	12,525	88,484
Over $15/lb	4,926	12,845
Over $20/lb	3,135	8,817
Over $25/lb	2,261	6,333
Over $30/lb	2,040	6,287
Over $0/lb	2,569,114	3,424,740

Europe	Export TEU	Import TEU
Over $5/lb	79,429	118,087
Over $10/lb	18,084	19,510
Over $15/lb	9,038	9,707
Over $20/lb	3,060	5,424
Over $25/lb	1,975	3,209
Over $30/lb	1,556	996
Over $0/lb	1,274,167	1,310,576

Derived from unpublished MARAD sample data for 1992.

Figures 5.3 and 5.4 represent the value distributions shown in Exhibit 5.13.

Figure 5.3

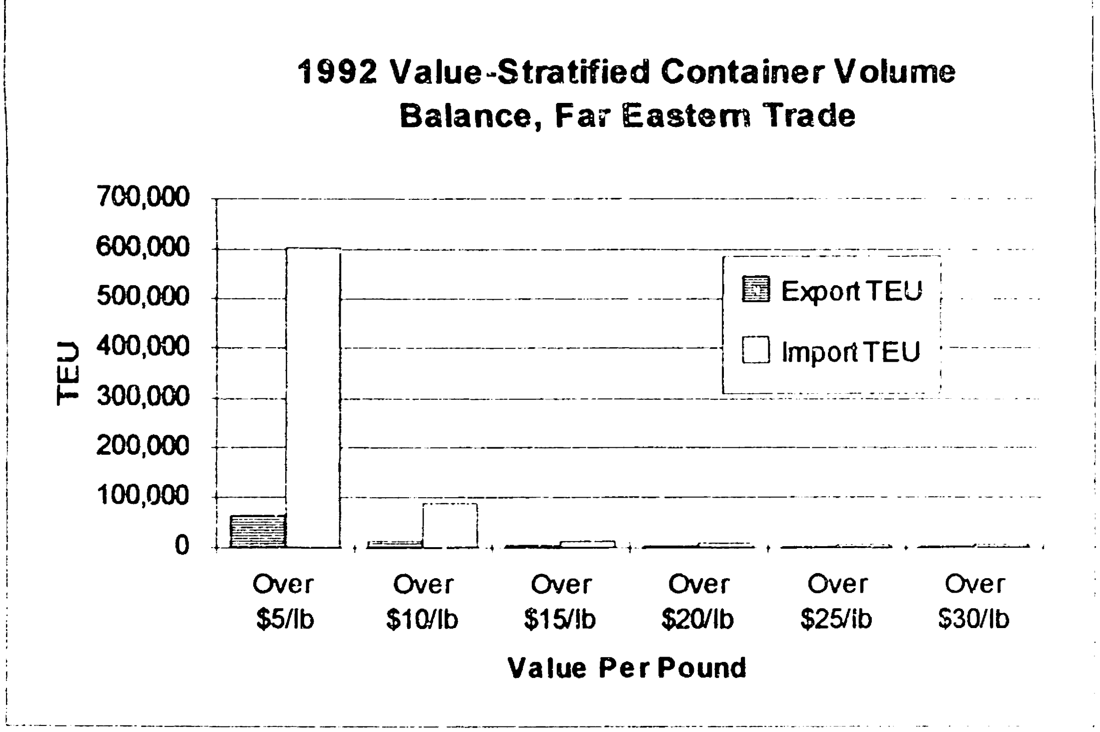
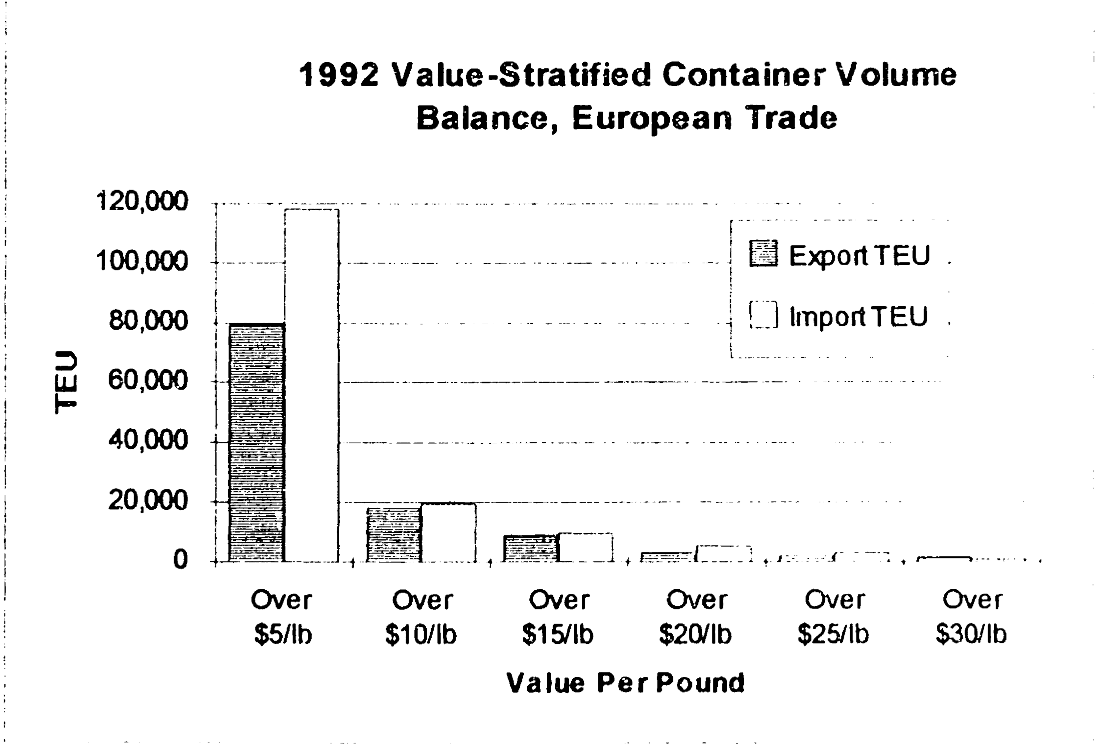


Figure 5.4



We have seen the overall relationships between volume and value. Now, what individual commodities account for the greatest share of value in the East-West trades? The top commodities with high values (over $10 per pound) are shown in Appendices C - 5 through C - 10. In Chapter 7, we will use a comparative logistics cost model to consider which of these commodities might be diverted to air transport.

Chapter Six

Goods Shipped by Air

Absolute Size of the International Air Market

The volume of goods shipped by air between the United States and its trading partners is equal to less than one percent by weight of the goods shipped by water. However this comparison is misleading, since most waterborne trade is made up of bulk items, like coal, grain, ore, oil, kaolin and similar commodities. It is more reasonable to compare air cargo volumes to the volume of goods shipped by ocean container, since containerized goods are considered (by their shippers) as having enough value to require shipment as discrete, protected units.

In 1992, goods transported by air equaled about four percent of the volume of containerized oceanborne goods. Exhibit 6.1 shows that when total air transport is divided into European and Far Eastern trade, European airborne cargo equals 8.4% of the volume of European ocean containerized cargo and a similar comparison for Far Eastern air cargo yields a figure of 2.7%.

Exhibit 6.1

1992 World Trade Comparison

Trade Area	Metric Tons Ocean All Cargo	Metric Tons Ocean Container	Metric Tons Air All Cargo	Air Tons as % of Ocean
World	867,000,000	117,000,000	4,224,045	3.6%
Europe		19,000,000	1,591,589	8.4%
Far East		45,000,000	1,232,549	2.7%
Other		53,000,000	1,399,907	2.6%

Source: MARAD and U.S.D.O.T.

About 45% of airborne trade volume was in other than East-West trades, which is even less than the 54% we find in oceanborne containerized trades.

Exhibit 6.2

AIR FREIGHT MOVEMENTS BETWEEN U.S. AND OTHER COUNTRIES (tons)

WORLDWIDE	1991		1992		1993	
TOTAL TRADE	3,864,147	100%	4,224,045	100%	4,691,293	100%

FAR EAST	1991		1992		1993	
REGIONAL	1,256,365	32.51%	1,232,549	29.18%	1,373,636	29.28%
TOP COUNTRIES	**1991**		**1992**		**1993**	
JAPAN	637,388	16.49%	655,203	15.51%	679,287	14.48%
KOREA	237,596	6.15%	237,509	5.62%	267,413	5.70%
TAIWAN	181,419	4.69%	129,135	3.06%	151,867	3.24%
HONG KONG	99,320	2.57%	105,066	2.49%	145,429	3.10%
SINGAPORE	35,281	0.91%	39,355	0.93%	55,304	1.18%
Total for these countries	1,191,004	30.82%	1,166,268	27.61%	1,299,300	27.70%

EUROPEAN	1991	% of total	1992	% of total	1993	% of total
REGIONAL	1,509,335	39.06%	1,591,589	37.68%	1,741,244	37.12%
TOP COUNTRIES	**1991**		**1992**		**1993**	
U.K.	346,500	8.97%	395,893	9.37%	442,417	9.43%
GERMANY	342,362	8.86%	355,830	8.42%	376,603	8.03%
FRANCE	184,585	4.78%	210,608	4.99%	230,062	4.90%
NETHERLANDS	196,357	5.08%	191,164	4.53%	219,343	4.68%
ITALY	104,890	2.71%	117,192	2.77%	118,793	2.53%
SWITZERLAND	67,069	1.74%	71,138	1.68%	85,155	1.82%
BELGIUM	85,985	2.23%	62,217	1.47%	78,694	1.68%
SPAIN	32,080	0.83%	39,586	0.94%	36,647	0.78%
Total for these countries	1,359,828	35.19%	1,443,628	34.18%	1,587,714	33.84%

TOTAL FOR ALL LISTED COUNTRIES	2,550,832	66.01%	2,609,896	61.79%	2,887,014	61.54%

Source: U.S.D.O.T. publication U.S. International Air Passenger and Freight Statistics
Calendar Years 1992 and 1993

Trading Partners

For the years 1991, 1992 and 1993, Japan was the United States' top partner in air freight movement, with about 15% of the total market for each year. Japan was followed by the United Kingdom (9%), Germany (8%), Colombia (8%), Korea (6%), the Netherlands (5%) and France (5%). No other country accounted for more than 4% of the total air volume for these years. Exhibit 6.2 shows the volumes of U.S. trade (in metric tons) with the top countries in the European and Far Eastern trades for the last 3 years.

Equivalent Container Volumes

Since the standard unit for measuring volume in the containership business is the teu, it is reasonable to express the air freight volumes in terms of teu in order to establish some direct comparisons. There is a tremendous range of cargo densities found among ocean containerized cargoes, many of which are low value commodities, so it would be misleading to use the average of 11.4 tons per teu found when dividing total containerized tons by total teu volume.

A tons per teu conversion factor that reflects the cargo stowage densities of goods currently transported by air should be chosen. In 1979 Nawal Taneja reported that the Cargo Analysis and Development Unit of the Boeing Commercial Airplane Company rated cargoes with densities between 8 and 20 pounds per cubic foot as being most likely to travel by air.[25] In September, 1978, a NASA publication stated that "in a 1968-1969 survey, Douglas found that the average density of a cargo package was 229kg/m^3 (14.31 lb/ft^3)."[26] Note that both of these were written before the advent of the personal computer, video-casette recorder, telephone facsimile machine and cellular telephone, all items with high values that may travel by either air or ocean.

Working from more recent data, we see from appendix D-3 that a 251,000 metric ton sample (60% by weight) of the air exports from New York has an average density of 20 pounds per cubic foot. 251,000 metric tons is equal to 12% of U.S. East Coast international airfreight and to 6% of all U.S. international airfreight.

At the opposite end of the range predicted by Boeing, we have the goods shipped by Company B, which is shown as a case illustration in Chapter 8. The company ships $2.1 billion (over 46,000,000 pounds) of its products each year, with just over half going by air. Company B's products typically stow at 7 pounds per cubic foot. At an even lower density (5 pounds per cubic foot), we have the tons of cut flowers that are shipped

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[25] The U.S. Airfreight Industry, Nawal K. Taneja, 1979, page 97.

[26] Air Cargo: An Integrated Systems View, NASA, 1978, page 113.

through Miami. Given that we have evidence of substantial volumes at both high and low densities, it seems best to refer to the chart in Exhibit 6.3 when considering specific commodities, rather than attempt to assign a single conversion factor for changing tons into teus.

Exhibit 6.3

Short Tons Per Teu at Various Stowage Densities

1280 Cubic Feet per teu

Pounds per cu. ft.	**Container Space Utilization**				
	70%	75%	80%	85%	90%
5	2.24	2.40	2.56	2.72	2.88
6	2.69	2.88	3.07	3.26	3.46
7	3.14	3.36	3.58	3.81	4.03
8	3.58	3.84	4.10	4.35	4.61
9	4.03	4.32	4.61	4.90	5.18
10	4.48	4.80	5.12	5.44	5.76
11	4.93	5.28	5.63	5.98	6.34
12	5.38	5.76	6.14	6.53	6.91
13	5.82	6.24	6.66	7.07	7.49
14	6.27	6.72	7.17	7.62	8.06
15	6.72	7.20	7.68	8.16	8.64
16	7.17	7.68	8.19	8.70	9.22
17	7.62	8.16	8.70	9.25	9.79
18	8.06	8.64	9.22	9.79	10.37
19	8.51	9.12	9.73	10.34	10.94
20	8.96	9.60	10.24	10.88	11.52
21	9.41	10.08	10.75	11.42	12.10
22	9.86	10.56	11.26	11.97	12.67
23	10.30	11.04	11.78	12.51	13.25
24	10.75	11.52	12.29	13.06	13.82
25	11.20	12.00	12.80	13.60	14.40

Top U.S. Airports for International Cargo Shipment

Miami, New York and Anchorage were the top three international air cargo cities in the United States in 1993. Combined, the three cities accounted for 2,743,229 metric tons of international air cargo, 58% of the country's volume.

Exhibit 6.4

Top United States Air Cargo Cities

Worldwide Total Trade	1991 3,864,147	1992 4,224,045	1993 4,691,293

Top Cities East Coast	1991 Tons	1992 Tons	1993 Tons
Miami	812,438	962,725	1,128,170
New York	805,402	835,514	846,691
Newark	92,728	112,509	154,090
Atlanta	93,586	96,364	105,322
Boston	89,544	85,536	91,077
Seattle	62,735	45,625	NA
Washington	NA	NA	59,730
East Coast Total	1,956,433	2,138,273	2,385,080

Top Cities Central	1991 Tons	1992 Tons	1993 Tons
Chicago	288,543	310,155	336,982
Houston	86,113	94,941	90,486
Dallas	56,271	63,149	65,698
Detroit	NA	NA	51,138
Central Total	430,927	468,245	544,304

Top Cities West Coast	1991 Tons	1992 Tons	1993 Tons
Anchorage	785,122	752,474	768,368
Los Angeles	375,230	409,652	452,916
San Francisco	177,316	180,973	205,418
Fairbanks	66,950	77,913	81,014
East Coast Total	1,404,618	1,421,012	1,507,716

Source: U.S.D.O.T.

We see from Exhibit 6.4 that most air cargo was handled on either the east or west coast. Only 544,306 tons (12%) moved through airports in the central region. We will now turn our attention to New York, which is a leading port for both waterborne and airborne goods.

Specific Cargoes shipped through New York

The port of New York is ranked first on the East Coast in terms of the value of its containerized ocean exports and is ranked second, after Miami, in terms of annual air tonnage. On average, the goods shipped by air out of New York are worth 21 times as much per pound (21:1 value density ratio) as the general cargo shipped by water.

Exhibit 6.5

Exports by Air and Ocean, Port of New York
(Nonbulk Products)

YEAR 1992	Metric Tons (Thousands)	Dollars (Millions)	Average Value/lb.
Ocean	4,354	$17,739	$1.82
Air Cargo	415	$36,032	$38.76

Source: Port of New York Data

Exhibit 6.5 captures all the general cargo ocean exports. Appendix D shows the leading 24 exports in detail. The commodities are ranked in descending order by total dollar value for a year's exports.

It is worth taking the time to examine the *differences* in value between the commodities shipped by air and those shipped by water. Consider Electric Motors and Generators in Appendix C-1. As you would expect, the value per pound is higher for motors shipped by air than for those shipped by water. The difference is $33 per pound, which is significant. However, the really important thing to consider here is that Electric Motors and Generators stow at a density of 36 pounds per cubic foot.

$$\text{Difference in Cubic Value Density} = \left(\frac{\$39.90}{1\ \text{Pound}} - \frac{\$6.90}{1\ \text{Pound}}\right) * \frac{39\ \text{Pounds}}{1\ \text{Cubic Foot}}$$

When the density of stowage is multiplied times the difference in value per pound, the difference in cubic value density is found to be $1,188.00 per cubic foot. When you consider that an 85% full 20 foot container holds 1080 cubic feet, you find that there is a difference in value of $1,292,544 per teu between Electric Motors shipped by Ocean and Electric Motors shipped by Air. At a 20% cost of capital, the *difference* in interest charge per day between these two cargoes is $708.

The cubic value densities for each of the 24 leading non-bulk commodities through New York are shown in D-1 and D-2. Examination of these exhibits shows that Fish, Clothing, and Motor Vehicles fall short of a $300 difference in cubic value density. Why would these low value commodities be transported by air? We will use a comparative logistics cost model to consider mode choice for these and other commodities in the next chapter.

Chapter Seven

The Comparative Logistics Cost Model

In Chapter One, four equations were used to show how cargo value, transit time, loss of product value and frequency of shipment relate to logistics costs. In this chapter, these equations are modified to allow for a user-specified demand period.[27] The equations are used to construct a spreadsheet that calculates a product's logistics costs for air and ocean transport, then displays the two results for comparison. It is expected that a shipper would choose the mode with the lower logistics costs. The spreadsheet model is used to consider specific commodities in these groups:

1. High value-density cargoes now shipped by ocean.
2. High value-density cargoes now shipped by air.
3. Low value-density cargoes now shipped by ocean.
4. Low value-density cargoes now shipped by air.

The Comparative Logistics Cost Model

The assumptions used to calculate the logistics costs for each commodity are shown in the Model Input section. For all examples, door-to-door transit times, service reliability parameters and shipment frequencies reflect the differences in Air versus Ocean modes on routes from New York to the Far East. For consistency with previous chapters, teus are used as the units of container volume, even though teus are not commonly used in aircraft.

Attached to the Model Input section there is a small section labelled "Per TEU". The total cost per teu is shown for each mode, along with the difference between the two modes.

The calculated container requirement is shown in the next panel. The requirement is calculated at the space utilization rate shown in the Model Input section. The maximum weight per container is limited to the industry standards shown in Exhibit 3.1.

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[27] See Appendix E-1 for the modified equations.

The final two sections show the detailed cost items for each mode. In addition, they show the total cost of shipment for the demand period.

Sample Data

The cost examples shown below use the sample data for the Port of New York shown in Appendices D-1, D-2 and D-3.

Considering High Value-Density Cargoes Now Shipped by Ocean

The average value for Aircraft and Parts shipped by ocean container from the port of New York is $38.60 per pound. These parts stow at 8 pounds per cubic foot, which which translates to 4.35 tons per teu at an 85% space utilization rate per container.

Exhibit 7.2 shows the detailed logistics cost per teu for Aircraft and Parts shipped to the Far East. The model is run with the cost per teu for ocean transport shown by Drewry Shipping Consultants. The 7 to 1 transportation price ratio comes from shipper interviews. The logistics cost per teu is $6,052 higher for shipment by air than by water. In this case, the savings on inventory are not enough to overcome the expense of air shipment. To make air transport equally attractive on a cost basis, the transportation price ratio must be reduced to 3 to 1.

Considering High Value-Density Cargoes Now Shipped by Air

The average value for Electric Motors and Generators shipped by air from the port of New York is $39.90 per pound, almost the same value as for Aircraft and Parts (at $38.60), which are shipped by ocean. Both commodities are used in manufacturing processes, neither experiences rapid physical decay and they have almost the same value per pound. Why is the mode choice different?

Electric Motors and Generators stow at over 4 times the density of Aircraft and Parts. There is a substantial difference in the value per cubic foot (cubic value density) between the two commodities, which means that there will be a substantial difference in the value per teu.

Exhibit 7.1

Commodity	Value Pound	Pounds per Cubic Foot	Value per Cubic Foot	Value Per TEU
Electric Motors	$39.90	36	$1,436	$1,562,803
Aircraft	$38.60	8	$309	$335,974

The increased value per teu translates into much higher inventory costs for Electric Motors. The increase in inventory costs overwhelms the air transportation cost, making it almost $10,000 per teu less expensive to ship by air than ocean. The interest cost savings for the use of air transport for this commodity are great enough that the commodity could support an air transport cost ratio of over 12 to 1. (See Exhibit 7.3 for a detailed breakdown of the costs for each mode.)

Considering Low Value-Density Cargoes Now Shipped by Ocean

In 1992, there were 182,000 tons of Road Motor Vehicles shipped out of the port of New York in ocean containers. These vehicles were worth $3.70 per pound, or about $9,200 per 2500 pound vehicle. They stow at 6 pounds per cubic foot. Based strictly on transportation and inventory costs, it would cost approximately $10,085 more to ship these vehicles by air than by water. Here, the choice is clearly to ship by ocean container. (See Exhibit 7.4).

Unexpectedly, the sample also shows that there were 6,000 tons of Road Motor Vehicles shipped out by air (approximately 4,800 vehicles). These vehicles were worth $11.10 per pound, or about $28,000 per vehicle. When the model is run with the value of $11.10 per pound, the results change very little. The output shows that it is still over $9,000 more expensive to ship the vehicles by air. (See Exhibit 7.5) This expense would seem to indicate that ocean shipment, not air shipment, should be chosen. There are several possible reasons why a shipper would choose to use air when the inventory and transport costs would seem to indicate ocean transport.

1. Special vehicles may be shipped by air as project cargo.
2. Ocean service may not be provided to a port near the cargo destination.
3. There may be a special customer requirement for immediate delivery.
4. There may be a special risk of damage during ocean transit.

The individual circumstances must be known before a mode choice based on other than inventory and transport costs can be explained.

Considering Low Value-Density Cargoes Now Shipped by Air

The decision to ship fresh fish by air is an obvious one. The length of transit time for either an atlantic or pacific voyage is too great for unfrozen fish to arrive in saleable condition. Therefore, even though the inventory and transportation costs of shipment by water are quite low, the 100% loss of product value makes the overall expense too high.

It is more interesting to consider the 9,000 tons of clothing that were shipped by air from New York in 1992. With a value per pound of $14.50, a stowage density of 18 pounds per cubic foot and a cubic value density of $261 per cubic foot, clothing shipped by air does not have enough value per container to justify air shipment solely on the basis of inventory cost savings.

However, clothing is a seasonal product. We may assume that clothing with a wholesale value of $14.50 per pound is a "seasonal fashion" item, while clothing with a wholesale value per pound of $4.20 (which is moved by ship) is more of a staple item. For a seasonal item, each day that the product is not in the marketplace represents lost sales opportunities. Therefore, each day that the product is in transit represents a potential loss. The loss of value to a shipper during a specified demand period, due either to physical or economic decay of a product, may be modelled in this manner:

$$\text{Perishable Cost} = \left[(1-\text{Sal})*(V*S)*\left(\frac{T}{L}\right)^{d}\right]$$

Where: Sal = the product's salvage value in terms of percent.
V = the value per container
S = the period demand, in containers
T = the time spent in transit, in days.
L = the product life in days
d = a commodity or industry-specific parameter.

The result may be divided by S to show the loss per container during the container's transitt from door-to-door.

The parameter "d" may be chosen to reflect the penalty expected in the marketplace for each day of lost sales opportunities. A parameter of 1 gives a result that reflects a constant daily loss of sales. A parameter of .5 imposes a higher penalty for missing the first days of a season. (It could also represent the penalty for delay in replenishment of retailer supply during the season.)[28] A parameter of 2 relaxes the penalty, since it is assumed that full-price sales can be made later in the season. Examples of each of these parameter/penalty relationships, based on clothing shipments out of New York, are shown in figures 7.1 through 7.6.

When the model is run with a "seasonal fashion" shelf life of 90 days, a salvage value of 40% and a linear decay parameter, (1), the lost sales costs (or product value

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[28] Benetton Corporation, an Italian sportswear company that is a heavy user of aircargo, annually distributes 50 million pieces of clothing to 5000 stores in 60 countries from a single warehouse. This reduces the number of stocking points for low -volume items, pools the stock-out risk for all products and cuts replenishment leadtime to half that of their competitors. Logistics Management, Volume 2, Number 1, 1991, page 40.

decay) per container are over $47,000 for shipment by ocean. This is $40,000 greater than the value lost during air transit. The result is that the mode choice is clearly air. (See Exhibt 7.6).

Conclusion

A product's cubic value density is an important consideration in mode choice, but does not control the decision process. The shipper's overall aim is to provide the maximum profit for his company. With this in mind, the shipper must consider not just transportation and inventory costs, but how well the transportation modes available meet the company's needs for expedited customer service, market timing and increased market share.

Exhibit 7.2

Commodity: Aircraft and Parts

Model Input

$38.60	Value Per Pound
8	Density of Stowage (lb/cu.ft.)
20%	Annual Carrying Charge
365	Demand Period (days)
8960000	Period Demand (lb)
365	Shelf Life (days)
40%	Per Cent Salvage Value
7.0	Air to Ocean Freight Price Ratio
8	Perish/Decay parameter

Ocean

$1,733	Transport Cost/Container
25	Average Trip Time (days)
1	Std. Dev. of Trip Time (days)
1.7	Std. Deviations for Safety Stock
52	Shipments per Demand Period

Air

$12,131	Transportation Cost/Container
4	Average Trip Time (days)
0.5	Std. Dev. of Trip Time (days)
1.7	Std. Deviations for Safety Stock
104	Shipments per Demand Period

Container

85%	Container Space Used
20	Container Length (ft)
8	Container Width (ft)
8	Container Height (ft)

Per	Air	Ocean	Difference
Cont.	$13,347	$7,294	($6,052.46)

Calculated Container Requirement

1,120,000	Cubic ft. Annual Demand
1,088.00	Cubic ft. Used per Container
8,704	Cargo Wght. per Cont. (lb)

1029	Containers Demand in Period
$335,974	Value per Container
$345,856	Period Value of Commodity (000s)

DETAILED MODEL OUTPUT - OCEAN plus RAIL

52	Shipments per Demand Period
19.8	Average Shipment Size
$0	Perishable Cost/Cont.
$646	Origin Inventory/Cont.
$4,602	In-Transit Inventory/Cont.
$313	Safety Stock/Cont.
$1,733	Transportation Cost/Cont

$7,508,999	**Annual Logistics Cost**

Per Container

$5,561	Interest & Perish Costs
$1,733	Transportation Costs
$7,294	**Logistics Cost**

DETAILED MODEL OUTPUT - AIR

104	Shipments per Demand Period
9.9	Average Shipment Size
$0	Perishable Cost/Cont.
$323	Origin Inventory/Cont.
$736	In-Transit Inventory/Cont.
$156	Safety Stock/Cont.
$12,131	Transportation Cost/Cont

$13,739,472	**Annual Logistics Cost**

Per Container

$1,216	Interest & Perish Costs
$12,131	Transportation Costs
$13,347	**Logistics Cost**

Exhibit 7.3

Commodity: Electric Motors and Generators

Model Input

$39.90	Value Per Pound
36	Density of Stowage (lb/cu.ft.)
20%	Annual Carrying Charge
365	Demand Period (days)
42560000	Period Demand (lb)
365	Shelf Life (days)
40%	Per Cent Salvage Value
7.0	Air to Ocean Freight Price Ratio
8	Perish/Decay parameter

Ocean

$1,733	Transport Cost/Container
25	Average Trip Time (days)
1	Std. Dev. of Trip Time (days)
1.7	Std. Deviations for Safety Stock
52	Shipments per Demand Period

Container

85%	Container Space Used
20	Container Length (ft)
8	Container Width (ft)
8	Container Height (ft)

Air

$12,131	Transportation Cost/Container
4	Average Trip Time (days)
0.5	Std. Dev. of Trip Time (days)
1.7	Std. Deviations for Safety Stock
104	Shipments per Demand Period

Per Cont.	Air	Ocean	Difference
	$17,787	$27,602	$9,815.52

Calculated Container Requirement

1,182,222	Cubic ft. Annual Demand	1087	Containers Demand in Period
1,088.00	Cubic ft. Used per Container	$1,562,803	Value per Container
39,168	Cargo Wght. per Cont. (lb)	$1,698,144	Period Value of Commodity (000s)

DETAILED MODEL OUTPUT - OCEAN plus RAIL

52	Shipments per Demand Period
20.9	Average Shipment Size
$0	Perishable Cost/Cont.
$3,005	Origin Inventory/Cont.
$21,408	In-Transit Inventory/Cont.
$1,456	Safety Stock/Cont.
$1,733	Transportation Cost/Cont

$29,992,821	**Annual Logistics Cost**

Per Container

$25,869	Interest & Perish Costs
$1,733	Transportation Costs
$27,602	**Logistics Cost**

DETAILED MODEL OUTPUT - AIR

104	Shipments per Demand Period
10.4	Average Shipment Size
$0	Perishable Cost/Cont.
$1,503	Origin Inventory/Cont.
$3,425	In-Transit Inventory/Cont.
$728	Safety Stock/Cont.
$12,131	Transportation Cost/Cont

$19,327,267	**Annual Logistics Cost**

Per Container

$5,656	Interest & Perish Costs
$12,131	Transportation Costs
$17,787	**Logistics Cost**

Exhibit 7.4

Commodity: Road Motor Vehicles

Model Input

$3.70	Value Per Pound
6	Density of Stowage (lb/cu.ft.)
20%	Annual Carrying Charge
365	Demand Period (days)
407680000	Period Demand (lb)
365	Shelf Life (days)
40%	Per Cent Salvage Value
7.0	Air to Ocean Freight Price Ratio
8	Perish/Decay parameter

Container

85%	Container Space Used
20	Container Length (ft)
8	Container Width (ft)
8	Container Height (ft)

Ocean

$1,733	Transport Cost/Container
25	Average Trip Time (days)
1	Std. Dev. of Trip Time (days)
1.7	Std. Deviations for Safety Stock
52	Shipments per Demand Period

Air

$12,131	Transportation Cost/Container
4	Average Trip Time (days)
0.5	Std. Dev. of Trip Time (days)
1.7	Std. Deviations for Safety Stock
104	Shipments per Demand Period

Per	Air	Ocean	Difference
TEU	$12,218	$2,133	($10,085.59)

Calculated Container Requirement

67,946,667	Cubic ft. Annual Demand
1088	Cubic ft. Used per Container
6,528	Cargo Wght. per Cont. (lb)

62451	Containers Demand in Period
$24,154	Value per Container
$1,508,416	Period Value of Commodity (000s)

DETAILED MODEL OUTPUT - OCEAN plus RAIL

52	Shipments per Demand Period
1201.0	Average Shipment Size
$0	Perishable Cost/Cont.
$46	Origin Inventory/Cont.
$331	In-Transit Inventory/Cont.
$22	Safety Stock/Cont.
$1,733	Transportation Cost/Cont

$133,196,682	**Annual Logistics Cost**

Per Container

$400	Interest & Perish Costs
$1,733	Transportation Costs
$2,133	**Logistics Cost**

DETAILED MODEL OUTPUT - AIR

104	Shipments per Demand Period
600.5	Average Shipment Size
$0	Perishable Cost/Cont.
$23	Origin Inventory/Cont.
$53	In-Transit Inventory/Cont.
$11	Safety Stock/Cont.
$12,131	Transportation Cost/Cont

$763,051,910	**Annual Logistics Cost**

Per Container

$87	Interest & Perish Costs
$12,131	Transportation Costs
$12,218	**Logistics Cost**

Exhibit 7.5

Commodity: Road Motor Vehicles

Model Input

$11.10	Value Per Pound
6	Density of Stowage (lb/cu.ft.)
20%	Annual Carrying Charge
365	Demand Period (days)
13440000	Period Demand (lb)
365	Shelf Life (days)
40%	Per Cent Salvage Value
7.0	Air to Ocean Freight Price Ratio
6	Perish/Decay parameter

Ocean

$1,733	Transport Cost/Container
25	Average Trip Time (days)
1	Std. Dev. of Trip Time (days)
1.7	Std. Deviations for Safety Stock
52	Shipments per Demand Period

Air

$12,131	Transportation Cost/Container
4	Average Trip Time (days)
0.5	Std. Dev. of Trip Time (days)
1.7	Std. Deviations for Safety Stock
104	Shipments per Demand Period

Container

85%	Container Space Used
20	Container Length (ft)
8	Container Width (ft)
8	Container Height (ft)

Per	Air	Ocean	Difference
TEU	$12,393	$2,932	($9,460.78)

Calculated Container Requirement

2,240,000	Cubic ft. Annual Demand
1088	Cubic ft. Used per Container
6,528	Cargo Wght. per Cont. (lb)

2059	Containers Demand in Period
$72,461	Value per Container
$149,184	Period Value of Commodity (000s)

DETAILED MODEL OUTPUT - OCEAN plus RAIL

52	Shipments per Demand Period
39.6	Average Shipment Size
$0	Perishable Cost/Cont.
$139	Origin Inventory/Cont.
$993	In-Transit Inventory/Cont.
$67	Safety Stock/Cont.
$1,733	Transportation Cost/Cont

$6,037,425	**Annual Logistics Cost**
	Per Container
$1,199	Interest & Perish Costs
$1,733	Transportation Costs
$2,932	**Logistics Cost**

DETAILED MODEL OUTPUT - AIR

104	Shipments per Demand Period
19.8	Average Shipment Size
$0	Perishable Cost/Cont.
$70	Origin Inventory/Cont.
$159	In-Transit Inventory/Cont.
$34	Safety Stock/Cont.
$12,131	Transportation Cost/Cont

$25,515,496	**Annual Logistics Cost**
	Per Container
$262	Interest & Perish Costs
$12,131	Transportation Costs
$12,393	**Logistics Cost**

Exhibit 7.6

Commodity: Clothing

Model Input

$14.50	Value Per Pound
18	Density of Stowage (lb/cu.ft.)
20%	Annual Carrying Charge
365	Demand Period (days)
20160000	Period Demand (lb)
90	Shelf Life (days)
40%	Per Cent Salvage Value
7.0	Air to Ocean Freight Price Ratio
1	Perish/Decay parameter

Container

85%	Container Space Used
20	Container Length (ft)
8	Container Width (ft)
8	Container Height (ft)

Ocean

$1,733	Transport Cost/Container
25	Average Trip Time (days)
1	Std. Dev. of Trip Time (days)
1.7	Std. Deviations for Safety Stock
52	Shipments per Demand Period

Air

$12,131	Transportation Cost/Container
4	Average Trip Time (days)
0.5	Std. Dev. of Trip Time (days)
1.7	Std. Deviations for Safety Stock
104	Shipments per Demand Period

Per	Air	Ocean	Difference
TEU	$20,731	$53,762	$33,030.40

Calculated Container Requirement

1,120,000	Cubic ft. Annual Demand
1088	Cubic ft. Used per Container
19,584	Cargo Wght. per Cont. (lb)

1029	Containers Demand in Period
$283,968	Value per Container
$292,320	Period Value of Commodity (000s)

DETAILED MODEL OUTPUT - OCEAN plus RAIL

52	Shipments per Demand Period
19.8	Average Shipment Size
$47,328	Perishable Cost/Cont.
$546	Origin Inventory/Cont.
$3,890	In-Transit Inventory/Cont.
$265	Safety Stock/Cont.
$1,733	Transportation Cost/Cont

$55,342,806	**Annual Logistics Cost**

Per Container

$52,029	Interest & Perish Costs
$1,733	Transportation Costs
$53,762	**Logistics Cost**

DETAILED MODEL OUTPUT - AIR

104	Shipments per Demand Period
9.9	Average Shipment Size
$7,572	Perishable Cost/Cont.
$273	Origin Inventory/Cont.
$622	In-Transit Inventory/Cont.
$132	Safety Stock/Cont.
$12,131	Transportation Cost/Cont

$21,340,921	**Annual Logistics Cost**

Per Container

$8,600	Interest & Perish Costs
$12,131	Transportation Costs
$20,731	**Logistics Cost**

Loss of product value, decay parameter 1
Product Life in Days = 90
Salvage Value = 40%

Figure 7.1

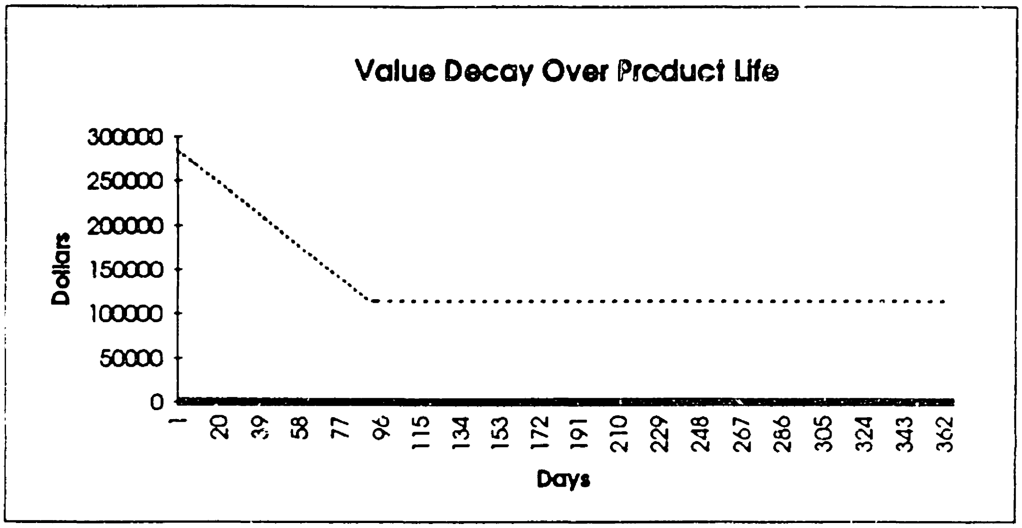
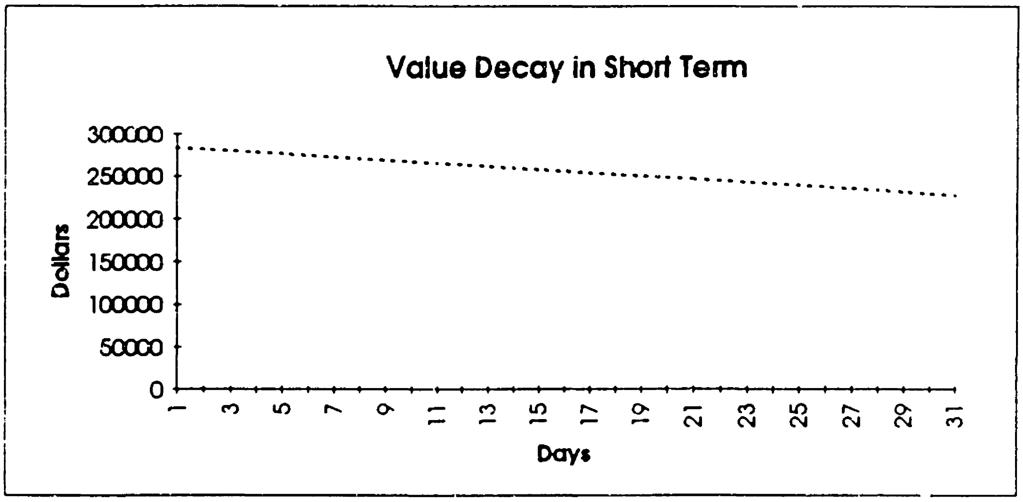


Figure 7.2



Original Value/Cont.	$283,968

Ocean, Days in Transit	25	Air, Days in Transit	4
Loss of Value/Cont.	$47,328	Loss of Value/ Container	$7,572

Difference in Value Loss,Air versus Ocean:	**$39,756**

Loss of product value, decay parameter	2
Product Life in Days =	90
Salvage Value =	40%

Figure 7.3

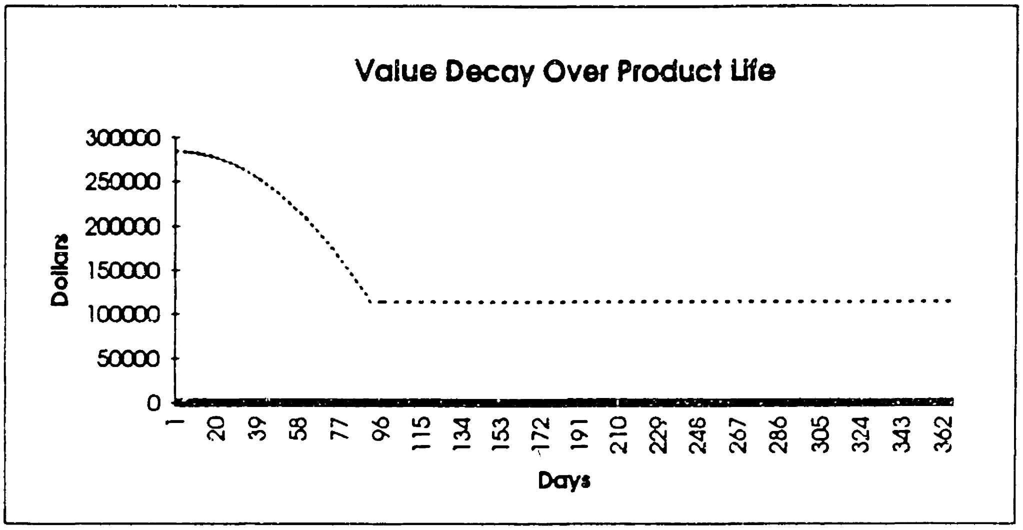
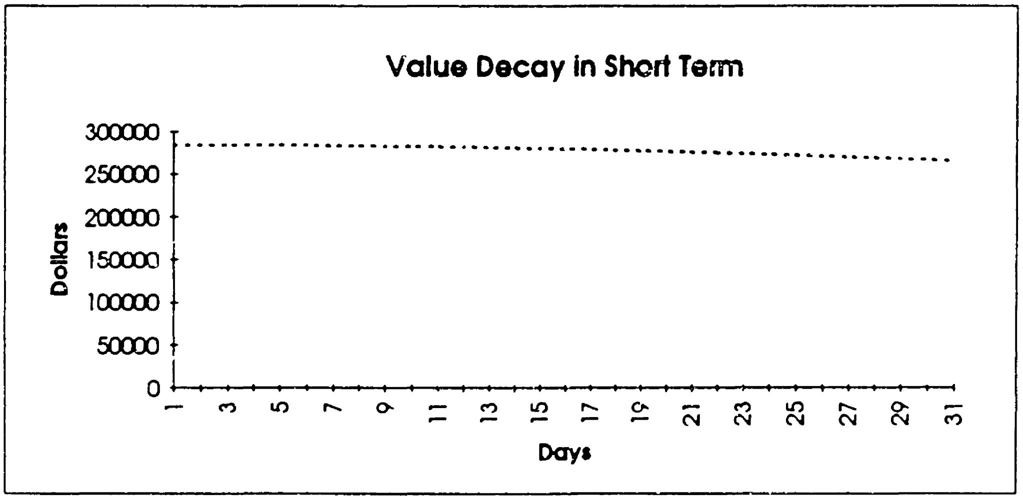


Figure 7.4



Original Value/Cont.	$283,968

Ocean, Days in Transit	25	Air, Days in Transit	4
Loss of Value/Cont.	$13,147	Loss of Value/ Container	$337

Difference in Value Loss,Air versus Ocean:	**$12,810**

Loss of product value, decay parameter		0.5
Product Life in Days =	90	
Salvage Value =	40%	

Figure 7.5

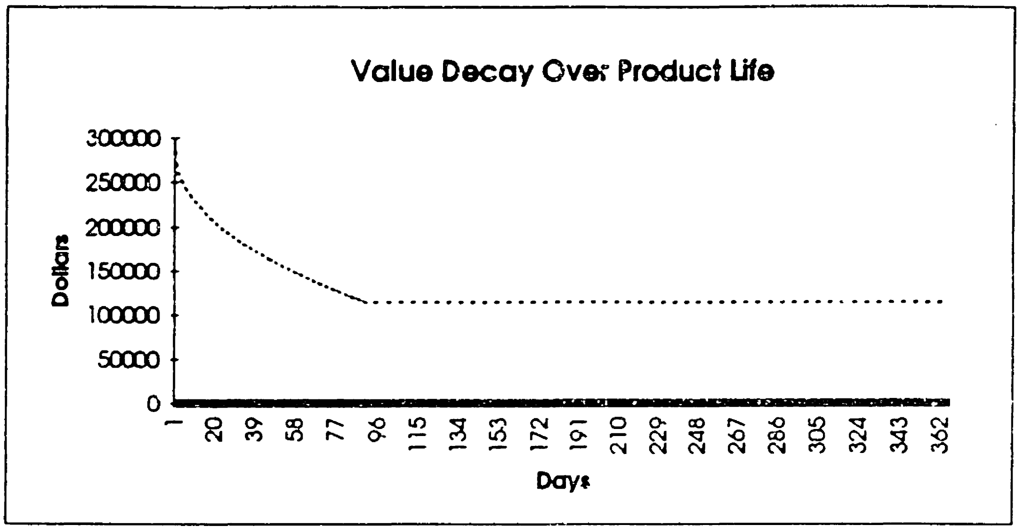
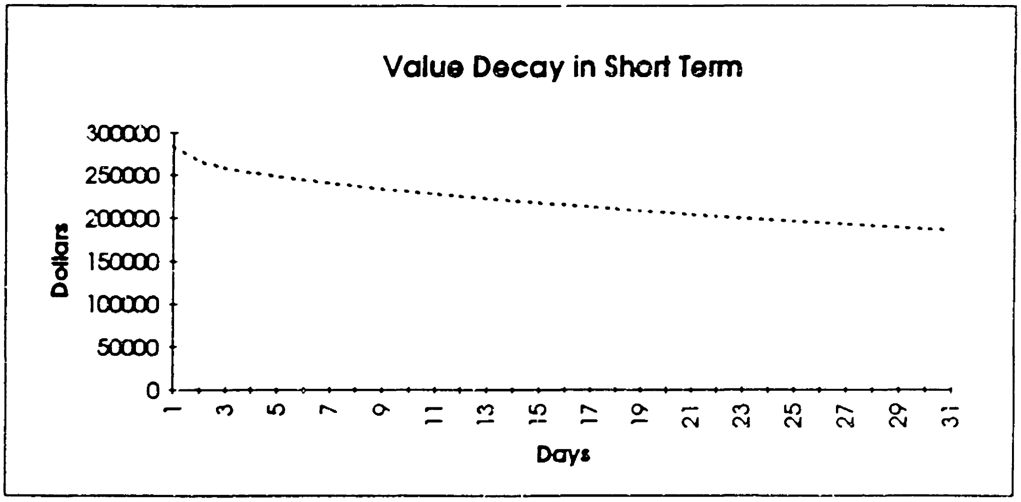


Figure 7.6



Original Value/Cont.	$283,968

Ocean, Days in Transit	25	Air, Days in Transit	4
Loss of Value/Cont.	$89,799	Loss of Value/ Container	$35,919

Difference in Value Loss Air versus Ocean:	$53,879

Chapter Eight

Cases Illustrating Transportation/Inventory Tradeoffs

Shipping Manufactured Goods - Company A

The electronic goods manufactured by Company A typically have a wholesale value of $10 per pound and stow for shipment at a density of about 9 pounds per cubic foot. Each forty foot container carries approximately $200,000 of product. Each year, the company ships about 250 forty foot containers (FEUs) from the United States East Coast to Japan and about 150 FEUs to Hong Kong. This 400 FEU volume equals 800 TEU, which accounts for 6.4% of all U.S. containerized exports to the Far East of cargoes worth $10 or more per pound.

In addition, the company ships approximately 250 FEU per year to Europe. This volume accounts for 2.8% of all U.S. containerized exports to Europe of cargoes worth $10 or more per pound.

For all three markets, 40% of the product is shipped between September and December. The remaining 60% is shipped in equal parts divided between the other 8 months.

Surface Mode Sequence

The company normally moves its product using this mode sequence: truck, rail, ship, truck. The door to door tranist time from the U.S. to Japan is consistently 21 days, ± 1 day. The total intermodal trip time to Europe is normally 10 days with the same variability.

Air Transport

A small portion of the company's goods are transported by air. At present the cost for air intermodal shipment to Japan is about 7 times that of marine intermodal shipment. However, air deliveries spend less than 4 days in transit from door-to-door and have a very low variability. Similarly, air transport to Europe requires less than 3 days. Air shipment to Europe is about 20 times as expensive as marine intermodal shipment.

Cost Savings Due to Air Transport

There are two occasions on which Company A employs air transport. First, air transport is used whenever there is an emergency shipment to be made. The second occasion is more interesting. As part of its business in the Far East, Company A ships parts to Japan that are then used as components in a Japanese manufacturing process. There is a definite end point for each manufacturing model year, after which Company A's parts are of no value to the Japanese manufacturer. Any parts received from A that are still in inventory become obsolete. Since the intransit time for air is 17 days less than that for intermodal, Company A can wait 17 days, get a better forecast of final demand and then use air transport to deliver the product.

Following this plan during the last 60 days of the model year minimizes A's loss due to unused inventory, which more than compensates the company for the higher cost of air transport. For example, a 40 foot container of A's product has a wholesale value of $199,424. The cost for ocean shipment is $7,097 and the cost for air transport of a shipment to Japan is $30,138. If one container too many is shipped by ocean the loss is $206,521, but the revenue realized from an air shipment is $169,286.

Spreadsheet Model

The accompanying spreadsheet model shows the relative logistics cost of air versus ocean transport for the products shipped by Company A to Japan (Exhibit 8.1). When the model is run in a simplified form, showing demand as constant, the logistics cost per intermodal container is $7,097. When the model is run with the figures for peak shipping months, the cost per intermodal container shipment rises by only $26, to a total of $7,123. For either case, at the current 7:1 price ratio (for transport prices), the total logistics cost of using air transport as a regular pipeline is over $30,000 per container.

The results for shipment to Hong Kong are very little different from shipment to Japan. The seven additional days in transit time add only $765 per teu to the ocean cost, which is still over $22,000 less expensive than air shipment. (Exhibit 8.2)

The cost for air transport to Europe has a much higher price ratio than cost for shipment to the Far East. This, coupled with the small savings in inventory cost made possible by air transport in this trade, makes air transport to Europe over $50,000 per teu more expensive than ocean transport. (Exhibit 8.3)

Maximum Air Transport Ratios

At today's ocean transport rates, the shipment of A's goods by air to the Far East on a regular basis is worthwhile only when air transport is no more than 1.5 times as expensive as ocean transport. For shipments to Europe, the indifference point is reached at a price ratio of 1.3 to 1.

Shipping Manufactured Goods - Company B

In 1993, Company B shipped 43,250,000 pounds of electronic goods from the Far East to the United States. Regardless of the mode chosen, these goods were worth, on average, $50 per pound and stowed at 7 pounds per square foot. 44% (by weight) of their products were moved by ocean carrier, and the balance was moved by air transport.

Mode Choice

Company B ships substantial quantities of its products by two different modes. Why? Examination of Exhibits 8.4 and 8.5 shows that, for Company B, the direct cost per pound for door-to-door transportation is greatly different, $0.24 for ocean shipments and $1.11 for air shipments. However, when the savings on interest charges are considered, the difference in total logistics cost between air shipments and ocean shipments is small. Taking the figures from Exhibits 8.4 and 8.5 and dividing the total logistics cost per container by the pounds per container, we find that the modal difference in total logistics costs per container comes to less than $0.10 per pound, which amounts to about 0.2% of the product's value. There is no clear cost advantage for either mode.

In this case, lot size and demand characteristics are very important. For some products, demand is steady, or at least has a small forecast error. For these products, production is setup to create a steady stream of inventory in large lot sizes. This steady stream of inventory is shipped by ocean carrier. The average order filled by ocean shipment weighs over 15,000 pounds and fills 85% of a forty foot container. To fill these orders, 1,161 forty foot containers were shipped from the Far East in 1993.

Other products have uncertain demand. These products are made in smaller batches, are not generally held as inventory and are normally shipped by air. The average air shipment weighed 619 pounds and filled 67% of a Type B air cargo container. In 1993, there were 39,000 small shipment orders filled by air cargo.

Mode Choice Conversion

We see in Exhibit 8.4 that for goods shipped by ocean freight, there is a savings of $939.01 per container. This equals a savings of just $0.06 per pound for a product with a wholesale value of $50 per pound. It appears that a substantal reduction of air freight rates would give Company B a strong incentive to modify its production schedules and shift all its business to air cargo. This shift would give it:

1. A measurable cost savings.
2. The ability to provide more rapid customer service.
3. The opportunity to use forecasts that are 27 days more accurate.

Shipping Manufactured Goods - Company C

Company C ships over 200 different products as part of its international business. These products have a wide range of values, densities, demands and destinations. The company has developed an economic model that calculates a mode choice indifference point, call it "z", for each product/destination combination. The higher the z value for a product/destination combination, the more likely it is that air transport will be chosen. The model considers the following variables:

1. Product's unit weight.
2. Product's unit cost.
3. Air and Water times to the destination.
4. Mean demand for the product.
5. Demand forecast error.
6. Current sea transportation rate.

These primary concerns are overlaid with other considerations: packaging, convenience of product aggregation and administrative expense. There is also a concern with the density of high-value products shipped by air. Air freight forwarders will override (increase) their standard dollars-per-pound rates if the company tends to select products for air shipment that are light but too "fluffy".[29]

A sample of the results from Company C's model are shown in Exhibit 8.12. In general, goods with a higher value per cubic foot (cubic value density) tend to go by air (have higher z scores), due to the savings on intransit inventory costs. There are goods with low cubic value densities that have higher than expected z scores. In general, these goods have either low demand (meaning that there is a value in holding them at a central stocking point) or have a high forecast error (which means that the increased forecast accuracy gained by waiting later to produce the products offsets the cost of air transport).

Note that the vector for forecast error is not shown. This information was not provided by Company C. Also note that the physical size of each demand unit is not shown. The demand unit size is constant for all products.

Cubic Value Density and Demand Compared to Z Score

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[29] Interview with Company C representative.

The relationship between each product's value density, stowage density, demand and the z score (indifference point) assigned to the product/destination combination is shown in Exhibits 8.7 through 8.11. Each commodity's value density and stowage density have been combined to give the product's cubic value density (CVD). This is plotted on the vertical axis. The company assigned indifference point (z value), which indicates the likelihood of air transport, is plotted on the horizontal axis. If there were perfect linear correlation between commodity cubic value density and likelihood of air transport, the plot of z values would be a straight line beginning at the origin and extending upwards to the right.

How do annual product demand and forecast error change the z value of a product? To see this we will start in Exhibit 8.7 with all products in the graph, regardless of the amount demanded. In each succeeding graph, we will remove those products that do not clear a minimum level of annual demand. This "demand hurdle" will be increased from 0 units to 40, then 200, then 550 and finally to 1070 demand units per year. At each step, removing low demand items produces plots that are increasingly close to linear.

The forecast error vector for each product was not supplied, so the relationships between forecast error and mode choice cannot be shown directly. However, in Exhibit 8.11 all the commodities shown have high demand levels and known cubic value densities. Therefore, we may infer that any deviation from linearity is attributable to the change in z score caused by the demand forecast error variable.

Regarding 8.7

All 235 data points provided by Company C are shown, regardless of the number of units demanded during the demand period. There is a general trend toward higher z scores with higher cubic value density (CVD). There are seven products with demand less than 40 units that have CVDs of less than $1000 per cubic foot and z scores of more than one. These populate the lower right portion of the graph.

Regarding 8.8

All products with period demand less than 40 units have been eliminated. For the remaining products, the minimun CVD at which the indifference point exceeds 1 is $1,500 per cubic foot. Note that raising the minimum demand for inclusion in the chart to 40 units per demand period results in the exclusion of 142 products. However, the remaining 93 products account for 99% of the company's volume. The relationship between CVD and z score among these products is stronger than for the total product line.

Regarding 8.9 through 8.11

These exhibits raise the minimum period demand for inclusion to 200, 550 and 1070 units. These demand hurdles correspond respectively to 95%, 90% and 80% of the company's total demand during the period.

Forecast Demand Variable

Even with these increased demand hurdle rates, there is not perfect correlation between cubic value density and z score. It must be assumed that some factor other than cargo value or demand rate causes this variation. Since cargo value is directly related to intransit and origin inventory costs (and hence to the ability of inventory savings to offset increased transportation costs), these variations are accounted for. Therefore, the conclusion is that some variation in z score (which is an indicator of likelihood of Company C's air transport mode selection) is attributable the forecast demand variable, which reflects the effect of demand forecast error on mode choice.

Summary

As was seen in Chapter Seven, cubic value density has a great deal to do with mode choice selection, but does not explain all choices. Rather, there is a functional combination of demand rate, product value, distance to destination, market timing, demand variability and transportation cost that yields the mode choice most profitable for the individual shipper.

Considering this with regard to the conversion of cargoes from ocean to air modes, we see that lower-valued cargoes are convertible only when they are:

1. physically perishable.
2. subject to rapid economic obsolescence.
3. demanded in low or irregular volumes or, so that it is to the company's economic advantage to fill orders quickly from a central location.
4. needed as emergency shipments.

The same four conditions apply to high-value cargoes as well. However, the cost of air transport for high-value products can more easily offset by the savings on interest costs made possible by the reduced transit times associated with air transport. This reduction in transport cost makes it more probable that high-value goods will be shipped by air. For goods with extremely high cubic value densities, the interest savings due to air transport far offset the mode's cost. For these goods, air transport is the natural choice.

Exhibit 8.1

Commodity: Company A - Electronic Goods Shipped to Japan

Model Input

$10.00	Value Per Pound
9.5	Density of Stowage (lb/cu.ft.)
20%	Annual Carrying Charge
365	Demand Period (days)
4,985,500	Period Demand (lb)
365	Shelf Life (days)
30%	Per Cent Salvage Value
7.0	Air to Ocean Freight Price Ratio
5	Perish/Decay parameter

Container

82%	Container Space Used
40	Container Length (ft)
8	Container Width (ft)
8	Container Height (ft)

Ocean

$4,200	Transport Cost/Container
21	Average Trip Time (days)
1	Std. Dev. of Trip Time (days)
2	Std. Deviations for Safety Stock
52	Shipments per Demand Period

Air

$29,400	Transportation Cost/Container
4	Average Trip Time (days)
0.5	Std. Dev. of Trip Time (days)
2	Std. Deviations for Safety Stock
104	Shipments per Demand Period

Air	Ocean	Difference
$30,138	$7,097	($23,041.24)

Calculated Container Requirement

524,789	Cubic ft. Annual Demand
2099.2	Cubic ft. Used per Container
19,942	Cargo Wght. per Cont. (lb)

250	Containers Demand in Period
$199,424	Value per Container
$49,855	Period Value of Commodity (000s)

DETAILED MODEL OUTPUT - OCEAN plus RAIL

52	Shipments per Demand Period
4.8	Average Shipment Size
$0	Perishable Cost/Cont.
$384	Origin Inventory/Cont.
$2,295	In-Transit Inventory/Cont.
$219	Safety Stock/Cont.
$4,200	Transportation Cost/Cont

$1,774,186	**Annual Logistics Cost**

Per Container

$2,897	Interest & Perish Costs
$4,200	Transportation Costs
$7,097	**Logistics Cost**

DETAILED MODEL OUTPUT - AIR

104	Shipments per Demand Period
2.4	Average Shipment Size
$0	Perishable Cost/Cont.
$192	Origin Inventory/Cont.
$437	In-Transit Inventory/Cont.
$139	Safety Stock/Cont.
$29,400	Transportation Cost/Cont

$7,534,379	**Annual Logistics Cost**

Per Container

$738	Interest & Perish Costs
$29,400	Transportation Costs
$30,138	**Logistics Cost**

Exhibit 8.2

Commodity: Company A - Electronic Goods Shipped to Hong Kong

Model Input

$10.00	Value Per Pound
9.5	Density of Stowage (lb/cu.ft.)
20%	Annual Carrying Charge
365	Demand Period (days)
2,991,300	Period Demand (lb)
365	Shelf Life (days)
30%	Per Cent Salvage Value
7.0	Air to Ocean Freight Price Ratio
5	Perish/Decay parameter

Container

82%	Container Space Used
40	Container Length (ft)
8	Container Width (ft)
8	Container Height (ft)

Ocean

$4,200	Transport Cost/Container
28	Average Trip Time (days)
1	Std. Dev. of Trip Time (days)
2	Std. Deviations for Safety Stock
52	Shipments per Demand Period

Air

$29,400	Transportation Cost/Container
4	Average Trip Time (days)
0.5	Std. Dev. of Trip Time (days)
2	Std. Deviations for Safety Stock
104	Shipments per Demand Period

	Air	Ocean	Difference
	$30,138	$7,862	($22,276.04)

Calculated Container Requirement

314,874	Cubic ft. Annual Demand
2099.2	Cubic ft. Used per Container
19,942	Cargo Wght. per Cont. (lb)

150	Containers Demand in Period
$199,424	Value per Container
$29,913	Period Value of Commodity (000s)

DETAILED MODEL OUTPUT - OCEAN plus RAIL

52	Shipments per Demand Period
2.9	Average Shipment Size
$0	Perishable Cost/Cont.
$384	Origin Inventory/Cont.
$3,060	In-Transit Inventory/Cont.
$219	Safety Stock/Cont.
$4,200	Transportation Cost/Cont

$1,179,289	**Annual Logistics Cost**

Per Container

$3,662	Interest & Perish Costs
$4,200	Transportation Costs
$7,862	**Logistics Cost**

DETAILED MODEL OUTPUT - AIR

104	Shipments per Demand Period
1.4	Average Shipment Size
$0	Perishable Cost/Cont.
$192	Origin Inventory/Cont.
$437	In-Transit Inventory/Cont.
$109	Safety Stock/Cont.
$29,400	Transportation Cost/Cont

$4,520,627	**Annual Logistics Cost**

Per Container

$738	Interest & Perish Costs
$29,400	Transportation Costs
$30,138	**Logistics Cost**

Exhibit 8.3

Commodity: Company A - Electronic Goods Shipped to Europe

Model Input

$10.00	Value Per Pound
9.5	Density of Stowage (lb/cu.ft.)
20%	Annual Carrying Charge
365	Demand Period (days)
4,985,500	Period Demand (lb)
365	Shelf Life (days)
30%	Per Cent Salvage Value
20.0	Air to Ocean Freight Price Ratio
5	Perish/Decay parameter

Ocean

$3,100	Transport Cost/Container
10	Average Trip Time (days)
1	Std. Dev. of Trip Time (days)
2	Std. Deviations for Safety Stock
52	Shipments per Demand Period

Container

82%	Container Space Used
40	Container Length (ft)
8	Container Width (ft)
8	Container Height (ft)

Air

$62,000	Transportation Cost/Container
3	Average Trip Time (days)
0.5	Std. Dev. of Trip Time (days)
2	Std. Deviations for Safety Stock
104	Shipments per Demand Period

	Air	**Ocean**	**Difference**
	$62,629	$4,795	($57,834.06)

Calculated Container Requirement

524,789	Cubic ft. Annual Demand
2099.2	Cubic ft. Used per Container
19,942	Cargo Wght. per Cont. (lb)

250	Containers Demand in Period
$199,424	Value per Container
$49,855	Period Value of Commodity (000s)

DETAILED MODEL OUTPUT - OCEAN plus RAIL

52	Shipments per Demand Period
4.8	Average Shipment Size
$0	Perishable Cost/Cont.
$384	Origin Inventory/Cont.
$1,093	In-Transit Inventory/Cont.
$219	Safety Stock/Cont.
$3,100	Transportation Cost/Cont

$1,198,674	**Annual Logistics Cost**

Per Container

$1,695	Interest & Perish Costs
$3,100	Transportation Costs
$4,795	**Logistics Cost**

DETAILED MODEL OUTPUT - AIR

104	Shipments per Demand Period
2.4	Average Shipment Size
$0	Perishable Cost/Cont.
$192	Origin Inventory/Cont.
$328	In-Transit Inventory/Cont.
$109	Safety Stock/Cont.
$62,000	Transportation Cost/Cont

$15,656,898	**Annual Logistics Cost**

Per Container

$629	Interest & Perish Costs
$62,000	Transportation Costs
$62,629	**Logistics Cost**

Exhibit 8.4

Commodity: Company B - Electronic Goods Shipped Transpacific by Water (1993)

Model Input

$50.00	Value Per Pound
7	Density of Stowage (lb/cu.ft.)
25%	Annual Carrying Charge
365	Demand Period (days)
19100560	Period Demand (lb)
182	Shelf Life (days)
40%	Per Cent Salvage Value
6.2	Air to Ocean Freight Price Ratio
6	Perish/Decay parameter

Container

85%	Container Space Used
40	Container Length (ft)
8	Container Width (ft)
8	Container Height (ft)

Ocean

$3,700	Transport Cost/Container
30	Average Trip Time (days)
1	Std. Dev. of Trip Time (days)
1.7	Std. Deviations for Safety Stock
1161	Shipments per Demand Period

Air

$19,220	Transportation Cost/Container
3	Average Trip Time (days)
0.5	Std. Dev. of Trip Time (days)
1.7	Std. Deviations for Safety Stock
2,508	Shipments per Demand Period

Per	**Air**	**Ocean**	**Difference**
Cont.	$21,266	$20,327	($939.01)

Calculated Container Requirement

2,728,651	Cubic ft. Annual Demand
2,176.00	Cubic ft. Used per Container
15,232	Cargo Wght. per Cont. (lb)

1254	Containers Demand in Period
$761,600	Value per Container
$955,028	Period Value of Commodity (000s)

DETAILED MODEL OUTPUT - OCEAN plus RAIL

1161	Shipments per Demand Period
1.1	Average Shipment Size
$9	Perishable Cost/Cont.
$82	Origin Inventory/Cont.
$15,649	In-Transit Inventory/Cont.
$887	Safety Stock/Cont.
$3,700	Transportation Cost/Cont

$25,489,910	**Annual Logistics Cost**

Per Container

$16,627	Interest & Perish Costs
$3,700	Transportation Costs
$20,327	**Logistics Cost**

DETAILED MODEL OUTPUT - AIR

2508	Shipments per Demand Period
0.5	Average Shipment Size
$0	Perishable Cost/Cont.
$38	Origin Inventory/Cont.
$1,565	In-Transit Inventory/Cont.
$443	Safety Stock/Cont.
$19,220	Transportation Cost/Cont

$26,667,410	**Annual Logistics Cost**

Per Container

$2,046	Interest & Perish Costs
$19,220	Transportation Costs
$21,266	**Logistics Cost**

Exhibit 8.5

Commodity: Company B - Electronic Goods Shipped Transpacific by Air (1993)

Model Input

$50.00	Value Per Pound
7	Density of Stowage (lb/cu.ft.)
25%	Annual Carrying Charge
365	Demand Period (days)
24,149,440	Period Demand (lb)
182	Shelf Life (days)
43%	Per Cent Salvage Value
0.0	Air to Ocean Freight Price Ratio
6	Perish/Decay parameter

Container

67%	Container Space Used
7	Container Length (ft)
4.83	Container Width (ft)
3.9	Container Height (ft)

Ocean

$126	Transport Cost/Container
30	Average Trip Time (days)
1	Std. Dev. of Trip Time (days)
1.7	Std. Deviations for Safety Stock
1161	Shipments per Demand Period

Air

$685	Transportation Cost/Container
3	Average Trip Time (days)
0.5	Std. Dev. of Trip Time (days)
1.7	Std. Deviations for Safety Stock
39,000	Shipments per Demand Period

Per Cont.	**Air**	**Ocean**	**Difference**
	$767	$802	$34.86

Calculated Container Requirement

3,449,920	Cubic ft. Annual Demand	39021	Containers Demand in Period
88.41	Cubic ft. Used per Container	$30,944	Value per Container
619	Cargo Wght. per Cont. (lb)	$1,207,472	Period Value of Commodity (000s)

DETAILED MODEL OUTPUT - OCEAN plus RAIL

1161	Shipments per Demand Period	$31,277,628	**Annual Logistics Cost**
33.6	Average Shipment Size		
$0	Perishable Cost/Cont.		**Per Container**
$3	Origin Inventory/Cont.	$676	Interest & Perish Costs
$636	In-Transit Inventory/Cont.	$126	Transportation Costs
$36	Safety Stock/Cont.	**$802**	**Logistics Cost**
$126	Transportation Cost/Cont		

DETAILED MODEL OUTPUT - AIR

39000	Shipments per Demand Period	$29,917,470	**Annual Logistics Cost**
1.0	Average Shipment Size		
$0	Perishable Cost/Cont.		**Per Container**
$0	Origin Inventory/Cont.	$82	Interest & Perish Costs
$64	In-Transit Inventory/Cont.	$685	Transportation Costs
$18	Safety Stock/Cont.	**$767**	**Logistics Cost**
$685	Transportation Cost/Cont		

Exhibit 8.6

Commodity: Company C - Goods Shipped Transpacific by Ocean (1993)

Model Input

$0.40	Value Per Pound
54	Density of Stowage (lb/cu.ft.)
20%	Annual Carrying Charge
365	Demand Period (days)
24,228,000	Period Demand (lb)
999	Shelf Life (days)
100%	Per Cent Salvage Value
6.5	Air to Ocean Freight Price Ratio
6	Perish/Decay parameter

Ocean

$3,215	Transport Cost/Container
40	Average Trip Time (days)
2	Std. Dev. of Trip Time (days)
2	Std. Deviations for Safety Stock
52	Shipments per Demand Period

Air

$20,898	Transportation Cost/Container
6	Average Trip Time (days)
0.5	Std. Dev. of Trip Time (days)
2	Std. Deviations for Safety Stock
52	Shipments per Demand Period

Container

85%	Container Space Used
40	Container Length (ft)
8	Container Width (ft)
8	Container Height (ft)

Per Cont.	Air	Ocean	Difference
	$21,033	$3,829	($17,204.03)

Calculated Container Requirement

448,667	Cubic ft. Annual Demand
2,176.00	Cubic ft. Used per Container
59,000	Cargo Wght. per Cont. (lb)

206	Containers Demand In Period
$23,600	Value per Container
$4,866	Period Value of Commodity (000s)

DETAILED MODEL OUTPUT - OCEAN plus RAIL

52	Shipments per Demand Period
4.0	Average Shipment Size
$0	Perishable Cost/Cont.
$45	Origin Inventory/Cont.
$517	In-Transit Inventory/Cont.
$52	Safety Stock/Cont.
$3,215	Transportation Cost/Cont

$789,573	**Annual Logistics Cost**

Per Container

$614	Interest & Perish Costs
$3,215	Transportation Costs
$3,829	**Logistics Cost**

DETAILED MODEL OUTPUT - AIR

52	Shipments per Demand Period
4.0	Average Shipment Size
$0	Perishable Cost/Cont.
$45	Origin Inventory/Cont.
$78	In-Transit Inventory/Cont.
$13	Safety Stock/Cont.
$20,898	Transportation Cost/Cont

$4,336,851	**Annual Logistics Cost**

Per Container

$136	Interest & Perish Costs
$20,898	Transportation Costs
$21,033	**Logistics Cost**

Exhibit 8.7

Company C

Comparison of each products cubic value density to its likelihood of air transport usage, as indicated by indifference point.

0	**Minimum Demand**

235	Total Records Examined
110,094	Total Demand All Records
100%	Records Over Minimum

235	Records Exceeding Minimum
110,094	Total Demand These Records
468	Mean Demand These Records
100%	Total Demand,These Records

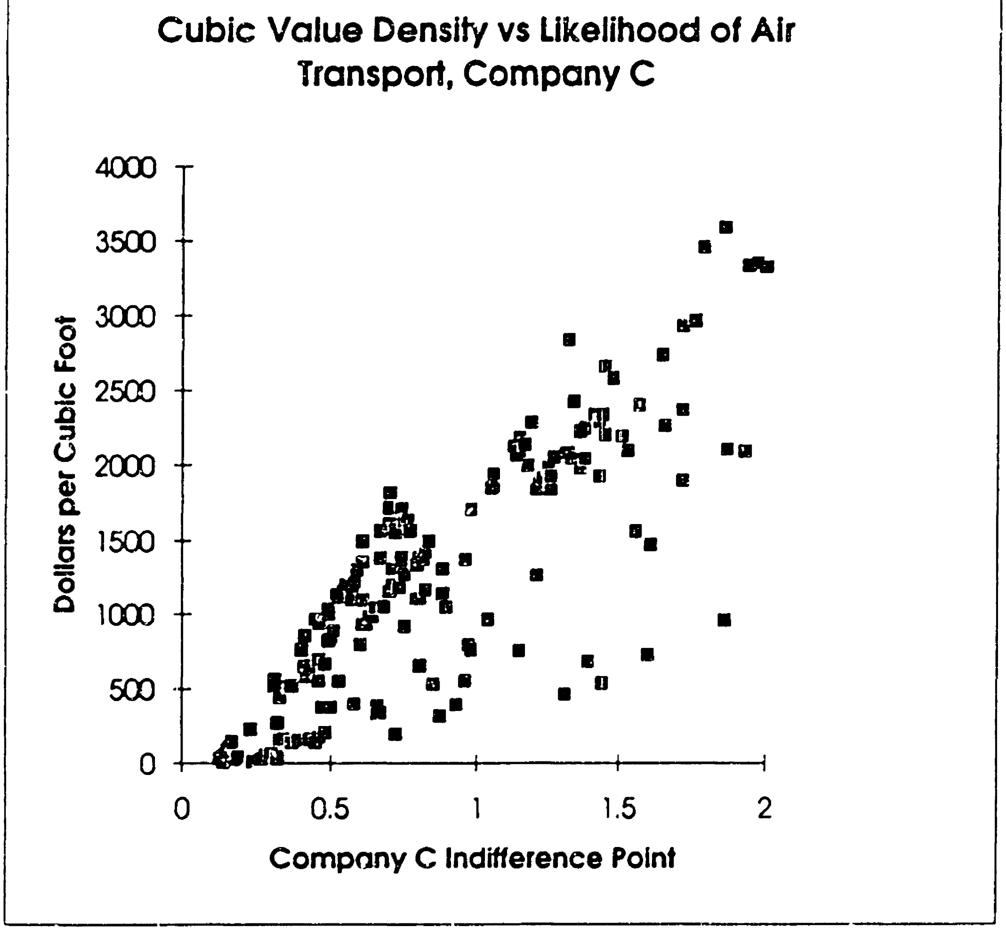

Exhibit 8.8

Company C

Comparison of each products cubic value density to its likelihood of air transport usage, as indicated by indifference point.

40	**Minimum Demand**

235	Total Records Examined
110,094	Total Demand All Records
40%	Records Over Minimum

93	Records Exceeding Minimum
108,445	Total Demand These Records
1,166	Mean Demand These Records
99%	Total Demand,These Records

Cubic Value Density vs Likelihood of Air Transport, Company C

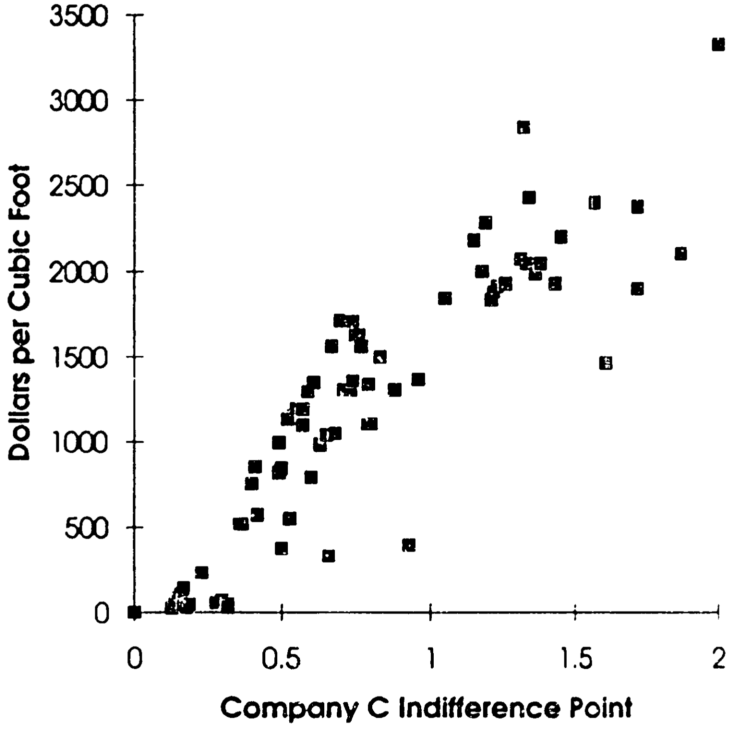

Exhibit 8.9

Company C

Comparison of each products cubic value density to its likelihood of air transport usage, as indicated by indifference point.

200	**Minimum Demand**

235	Total Records Examined
110,094	Total Demand All Records
19%	Records Over Minimum

45	Records Exceeding Minimum
104,386	Total Demand These Records
2,320	Mean Demand These Records
95%	Total Demand,These Records

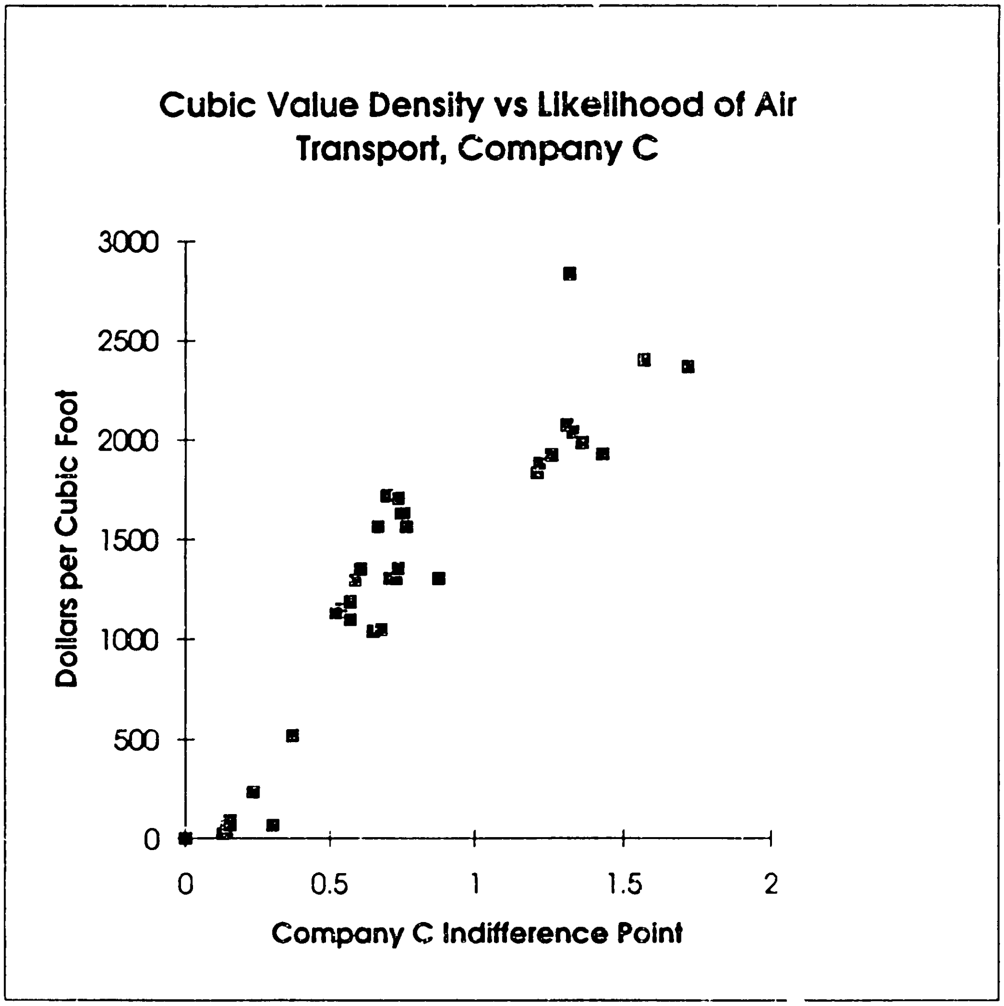

Exhibit 8.10

Company C

Comparison of each products cubic value density to its likelihood of air transport usage, as indicated by indifference point.

550	**Minimum Demand**

235	Total Records Examined
110,094	Total Demand All Records
12%	Records Over Minimum

29	Records Exceeding Minimum
99,168	Total Demand These Records
3,420	Mean Demand These Records
90%	Total Demand,These Records

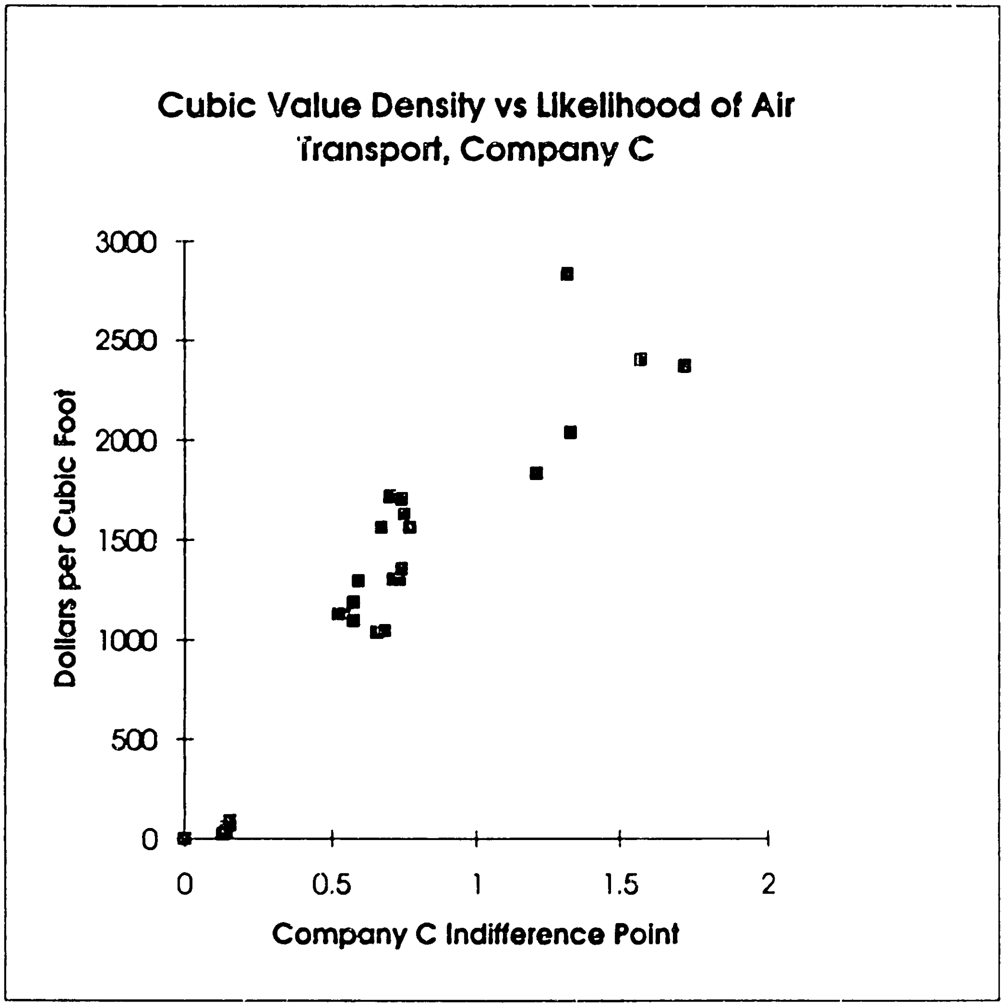

Exhibit 8.11

Company C

Comparison of each products cubic value density to its likelihood of air transport usage, as indicated by indifference point.

1070	**Minimum Demand**

235	Total Records Examined
110,094	Total Demand All Records
7%	Records Over Minimum

16	Records Exceeding Minimum
88,180	Total Demand These Records
5,511	Mean Demand These Records
80%	Total Demand,These Records

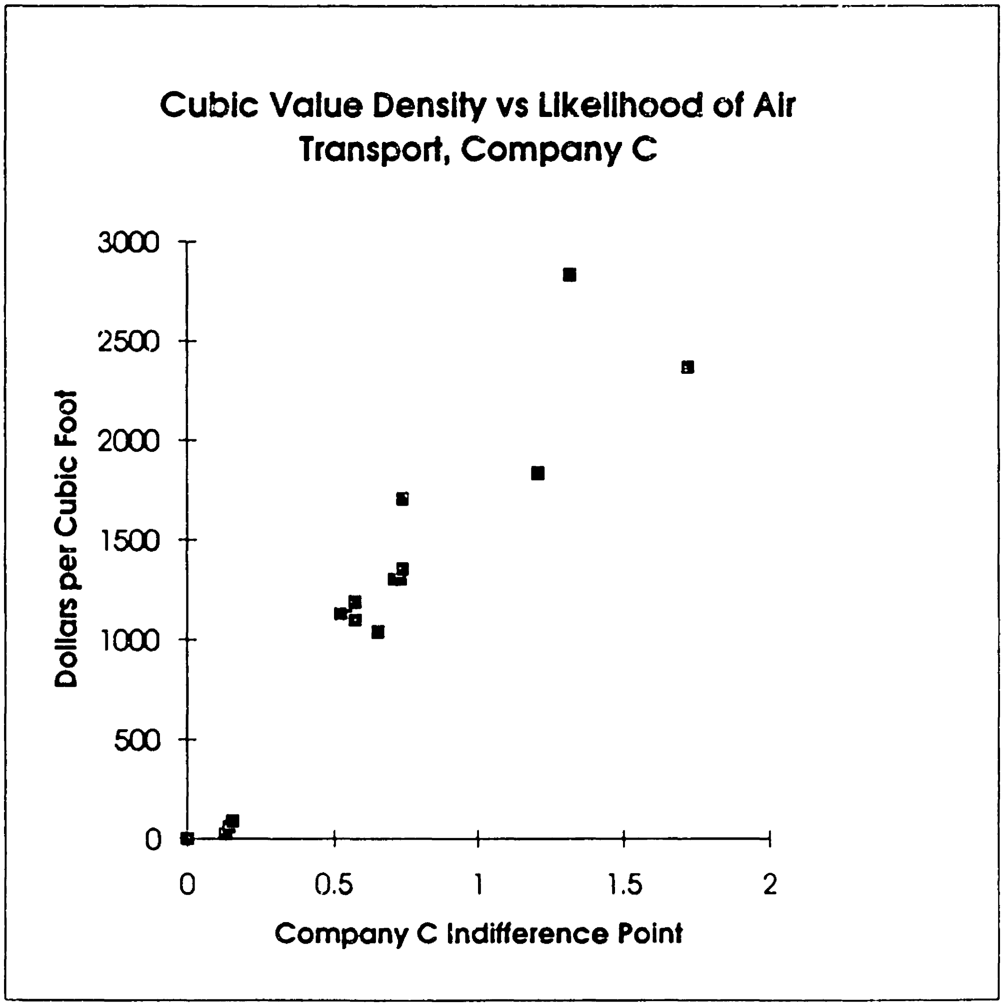

Exhibit 8.12

Mode Choice Data for Company C

Item	$/lb.	lb./cu.ft.	Demand	Ind. Pt.
159	0.3966	54.3026	114	0.13
70	0.9239	45.045	1011	0.14
172	2.963	48.2308	72	0.17
155	4.2728	9.5382	65	0.19
61	9.3458	1.8277	1	0.26
45	12.9032	43.3037	5	0.31
203	13	21.0989	5	0.32
119	15.9124	32.8479	69	0.36
46	19.6078	43.5831	45	0.41
73	20.4055	32.1149	25	0.43
217	22.8694	41.0743	10	0.46
7	24.6873	40.376	65	0.49
85	27.4193	20.0104	53	0.53
221	30.9386	39.2457	22	0.58
137	32.985	33.2115	16	0.61
130	36.8353	42.4507	1000	0.67
132	39.3898	30.4408	21	0.71
138	40.0735	4.81	3	0.72
96	41.8734	40.739	4620	0.74
68	43.7902	35.7086	1020	0.77
225	45.4545	14.385	6	0.8
66	47.8797	31.2451	64	0.83
67	51.6129	20.2698	5	0.89
38	57.5269	29.5935	25	0.98
57	62.0567	15.5964	1	1.04
103	63.4865	30.4408	8	1.06
15	67.9842	31.2451	5	1.13
36	73.6196	17.1705	2	1.21
21	77.4054	26.4951	17	1.27
20	81.9615	29.5935	145	1.34
22	84.9253	24.0186	120	1.38
222	88.7443	26.3466	2	1.44
206	94.88	22.1134	4	1.53
211	100	7.2695	32	1.6
227	110.3263	26.8618	24	1.76
185	122.016	17.1226	16	1.93
183	130.375	18.2208	640	2.05
106	142.8571	8.1661	3	2.24
133	172.1471	8.6928	28	2.67
232	341.1763	5.5795	59	5.17
16	708.8411	7.2681	14	10.62

Supplied by Company C

Chapter 9

Conversion of Ocean Cargo to Air Cargo

In Chapter One, the shipment of goods by ocean was characterized as involving larger lot sizes, less shipment frequency, much longer in-transit times and less reliability than shipment by air. We will now consider how these characteristics may be translated into the *transportation cost premium* that could be supported by using air transport.

Additionally, we will convert the tonnage volumes of cargoes now travelling by ocean container into teu volumes. We will separate U.S. containerized trade into European and Far Eastern zones and then estimate the number of aircraft required to transport cargoes converted from ocean to air travel for a range of cargo values and volumes.

Premiums Supported by Reduced Travel Time - Atlantic Trade

As is shown in exhibit 9.1, there is approximately a 16-day difference in transatlantic travel between air and ocean travel time for cargo originating from ports in the Middle Atlantic States of the United States. When considering the difference in inventory costs between air and ocean, we will assume the following characteristics for the two modes.

Exhibit 9.1

Atlantic Trade Comparison		
(Time in Days)	**Ocean**	**Air**
Std Dev Trip Time	2	0.5
Std Dev for Safety Stk	1.7	1.7
Shipments/Year	52	104
Trip Time	19	3
Carrying Charge	20%	20%
Container Space	85%	85%
Container Length	20	20
Container Width	8	8
Container Length	8	8

Exhibit 9.2

Time Difference, Air compared to Ocean

	Ocean		Air		
	Atlantic	Pacific	Atlantic	Pacific	
Dray	1	1	1	1	Dray
In Port	1	1			
Loading	1	1		1	
Ocean	10	14	1	1	Air
Unloading	1	1			
In Port	1	1			
Dray		1			
Rail	2	4			
Truck	2	1	1	1	Truck
TOTAL	19	25	3	4	TOTAL

Ocean times are based on cargo joining the vessel, then the vessel stopping at three additional ports before sailing across the ocean.

Using the same logistics cost model shown in Chapter 7, we set the transportation costs for the two modes equal to zero and compute the difference in inventory costs per teu for the transatlantic trade. This difference in inventory costs is the *transportation premium* supportable by changing mode from ocean to air.

As was seen in the discussion of cubic value density for commodities shipped through the port of New York in Chapter 6, both the value per pound and stowage density (pounds per square foot) must be considered when calculating the cost for shipping each teu of product. Exhibit 9.3 shows the inventory cost savings per teu (transportation premiums) that are possible for transatlantic cargoes with values ranging from \$1 to \$100 per pound and stowage densities ranging from 5 to 35 pounds per cubic foot.

Appendix D-3 showed that a 251,000 ton sample of New York export air cargo has an average value of \$46.24 per pound and a density of 20 pounds per cubic foot. This combination gives us a cubic value density of \$924 per cubic foot. Examination of Exhibit 10.3 shows that cargo with the combination of \$45 per pound and 20 pounds per cubic foot (cubic value density = \$900) can support an air transportation premium of \$9,983 per teu for transatlantic trade. The shaded area in the lower right section of Exhibit 9.3 shows the transatlantic air transportation premiums supported by those cargoes with cubic value densities greater than or equal to the average value for New York's export air cargo

Exhibit 9.3

Air Transport Premium Possible per TEU for Transatlantic Trade

Based on 16 day difference, 20% annual carrying charge.

Value per Pound	Pounds per Cubic Foot for Stowage						
	5	10	15	20	25	30	35
$1	$55	$111	$166	$222	$277	$333	$388
$2	$111	$222	$333	$444	$555	$666	$776
$3	$166	$333	$499	$666	$832	$998	$1,165
$4	$222	$444	$666	$887	$1,109	$1,331	$1,553
$5	$277	$555	$832	$1,109	$1,387	$1,664	$1,941
$6	$333	$666	$998	$1,331	$1,664	$1,997	$2,329
$7	$388	$776	$1,165	$1,553	$1,941	$2,329	$2,718
$8	$444	$887	$1,331	$1,775	$2,218	$2,662	$3,106
$9	$499	$998	$1,497	$1,997	$2,496	$2,995	$3,494
$10	$555	$1,109	$1,664	**$2,218**	$2,773	$3,328	$3,882
$11	$610	$1,220	$1,830	$2,440	$3,050	$3,660	$4,270
$12	$666	$1,331	$1,997	$2,662	$3,328	$3,993	$4,659
$13	$721	$1,442	$2,163	$2,884	$3,605	$4,326	$5,047
$14	$776	**$1,553**	$2,329	$3,106	$3,882	$4,659	$5,435
$15	$832	$1,664	$2,496	$3,328	$4,160	$4,991	$5,823
$16	$887	$1,775	$2,662	$3,549	$4,437	$5,324	$6,212
$17	$943	$1,886	$2,828	$3,771	$4,714	$5,657	$6,600
$18	$998	$1,997	$2,995	$3,993	$4,991	$5,990	$6,988
$19	$1,054	$2,107	$3,161	$4,215	$5,269	$6,322	$7,376
$20	$1,109	$2,218	$3,328	$4,437	$5,546	$6,655	$7,764
$25	$1,387	$2,773	$4,160	$5,546	$6,933	$8,319	$9,706
$30	$1,664	$3,328	$4,991	$6,655	$8,319	$9.983	$11,647
$35	$1,941	$3,882	$5,823	$7,764	$9,706	$11,647	$13,508
$40	$2,218	$4,437	$6,655	$8,874	$11,092	$13,310	$15,529
$45	$2,496	$4,991	$7,487	$9,983	$12,479	$14,974	$17,470
$50	$2,773	$5,546	$8,319	$11,092	$13,865	$16,638	$19,411
$55	$3,050	$6,101	$9,151	$12,201	$15,252	$18,302	$21,352
$60	$3,328	$6,655	$9,983	$13,310	$16,638	$19,966	$23,293
$65	$3,605	$7,210	$10,815	$14,420	$18,025	$21,629	$25,234
$70	$3,882	$7,764	$11,647	$15,529	$19,411	$23,293	$27,175
$75	$4,160	$8,319	$12,479	$16,638	$20,798	$24,957	$29,117
$80	$4,437	$8,874	$13,310	$17,747	$22,184	$26,621	$31,058
$85	$4,714	$9,428	$14,142	$18,856	$23,571	$28,285	$32,999
$90	$4,991	$9,983	$14,974	$19,966	$24.957	$29.948	$34,940
$95	$5,269	$10,537	$15,806	$21,075	$26,344	$31,612	$36,881
$100	$5,546	$11.092	$16,638	$22.184	$27,730	$33.276	$38.822

Based on Comparative Logistics Cost Model, D.B. Lewis, 1994.

Pacific Trade

The travel times for the Pacific Ocean Trade shown in Exhibit 9.2 are based on cargoes that originate or terminate in the midwestern United States and pass through a port on the United States Pacific Coast. Four days of the "Ocean" time shown in Exhibit 9.2 are spent in travelling between ports along a coast (either a U.S. or Far Eastern coast) and the remaining nine days are spent in sailing across the Pacific.

When considering the difference in inventory costs between air and ocean, we will assume the following characteristics for the two modes.

Exhibit 9.4

Pacific Trade Comparison		
(Time In Days)	Ocean	Air
Std Dev Trip Time	2	0.5
Std Dev for Safety Stk	1.7	1.7
Shipments/Year	52	104
Trip Time	25	4
Carrying Charge	20%	20%
Container Space	85%	85%
Container Length	20	20
Container Width	8	8
Container Length	8	8

Referring again to the average cubic value density found for air cargoes out of New York, ($45/lb x 20lb/cu. ft. = $900/cu.ft.), we find in Exhibit 10.5 that the inventory savings for these cargoes during a Pacific crossing can support a transportation premium of $12,665 per teu. The shaded area in the lower right section of Exhibit 9.5 shows the transpacific air transportation premiums supported by those cargoes with cubic value densities greater than or equal to New York's export air cargo.

Cargo Volumes at Specific Value Densities

MARAD's Review of U.S. Liner Trades shows that in 1992 the ratio of loaded import containers to loaded export containers for the Far East was 1.33 to 1. It also shows that the ratio of loaded import and export containers for the European trade is 1.02 to 1. These numbers indicate a reasonably balanced trade on an overall teu basis.

In Chapter 5 the containerized cargo *tonnages* for the European and Far Eastern trades were estimated, based on a sample that captured 100% of the loaded container movements through the ports of Los Angeles, Long Beach, Seattle, Tacoma and New York/New Jersey for 1992. This sample captured over 60% of all the loaded container movements for the United States for the year.

Exhibit 9.5

Air Transport Premium Possible per TEU for TranspacificTrade
Based on 21 day difference, 20% annual carrying charge.

Value per Pound	Pounds per Cubic Foot for Stowage						
	5	10	15	20	25	30	35
$1	$70	$141	$211	$281	$352	$422	$493
$2	$141	$281	$422	$563	$704	$844	$985
$3	$211	$422	$633	$844	$1,055	$1,266	$1,478
$4	$281	$563	$844	$1,126	$1,407	$1,689	$1,970
$5	$352	$704	$1,055	$1,407	$1,759	$2,111	$2,463
$6	$422	$844	$1,266	$1,689	$2,111	$2,533	$2,955
$7	$493	$985	$1,478	$1,970	$2,463	$2,955	$3,448
$8	$563	$1,126	$1,689	$2,252	$2,814	$3,377	$3,940
$9	$633	$1,266	$1,900	$2,533	$3,166	$3,799	$4,433
$10	$704	$1,407	$2,111	$2,814	$3,518	$4,222	$4,925
$11	$774	$1,548	$2,322	$3,096	$3,870	$4,644	$5,418
$12	$844	$1,689	$2,533	$3,377	$4,222	$5,066	$5,910
$13	$915	$1,829	$2,744	$3,659	$4,573	$5,488	$6,403
$14	$985	$1,970	$2,955	$3,940	$4,925	$5,910	$6,895
$15	$1,055	$2,111	$3,166	$4,222	$5,277	$6,332	$7,388
$16	$1,126	$2,252	$3,377	$4,503	$5,629	$6,755	$7,880
$17	$1,196	**$2,392**	$3,588	$4,784	$5,981	$7,177	$8,373
$18	$1,266	$2,533	$3,799	$5,066	$6,332	$7,599	$8,865
$19	$1,337	$2,674	**$4,011**	$5,347	$6,684	$8,021	$9,358
$20	$1,407	$2,814	$4,222	$5,629	$7,036	$8,443	$9,850
$25	$1,759	$3,518	$5,277	$7,036	$8,795	$10,554	$12,313
$30	$2,111	$4,222	$6,332	$8,443	$10,554	$12,665	$14,776
$35	$2,463	$4,925	$7,388	$9,850	$12,313	$14,776	$17,238
$40	$2,814	$5,629	$8,443	$11,258	$14,072	$16,886	$19,701
$45	$3,166	$6,332	$9,499	$12,665	$15,831	$18,997	$22,163
$50	$3,518	$7,036	$10,554	$14,072	$17,590	$21,108	$24,626
$55	$3,870	$7,740	$11,609	$15,479	$19,349	$23,219	$27,089
$60	$4,222	$8,443	$12,665	$16,886	$21,108	$25,330	$29,551
$65	$4,573	$9,147	$13,720	$18,294	$22,867	$27,440	$32,014
$70	$4,925	$9,850	$14,776	$19,701	$24,626	$29,551	$34,476
$75	$5,277	$10,554	$15,831	$21,108	$26,385	$31,662	$36,939
$80	$5,629	$11,258	$16,886	$22,515	$28,144	$33,773	$39,402
$85	$5,981	$11,961	$17,942	$23,922	$29,903	$35,884	$41,864
$90	$6,332	$12,665	$18,997	$25,330	$31,662	$37,994	$44,327
$95	$6,684	$13,368	$20,053	$26,737	$33,421	$40,105	$46,789
$100	$7,036	$14,072	$21,108	$28,144	$35,180	$42,216	$49,252

Based on Comparative Logistics Cost Model, D.B. Lewis, 1994.

When the teu volumes are segmented by the value of their contents, the imbalance between imports and exports of high-value goods becomes apparent.

Exhibit 9.6, Repeated from Chapter 5

1992 Stratified Balance of United States Containerized Trade Volumes

Far East	Export TEU	Import TEU
Over $5/lb	63,762	603,531
Over $10/lb	12,525	88,484
Over $15/lb	4,926	12,845
Over $20/lb	3,135	8,817
Over $25/lb	2,261	6,333
Over $30/lb	2,040	6,287
Over $0/lb	2,569,114	3,424,740

Europe	Export TEU	Import TEU
Over $5/lb	79,429	118,087
Over $10/lb	18,084	19,510
Over $15/lb	9,036	9,707
Over $20/lb	3,060	5,424
Over $25/lb	1,975	3,209
Over $30/lb	1,556	996
Over $0/lb	1,274,167	1,310,576

Derived from unpublished MARAD sample data for 1992.

Balanced Flow for Cargo Diverted to Air - Pacific Trade

In order for there to be a reasonably balanced flow between eastbound and westbound container volumes, it appears from Exhibit 9.6 that an air transport operator would have to carry exports to the Far East that were worth over $10/lb (12,525 teu) and return with imports having values of over $15/lb (12,845 teu). The assumption would naturally be that the $15/lb cargo could support a substantially higher transportation charge than the $10/lb cargo.

Exhibit 9.7 shows that this is the case. There is a great difference in the cubic value density of $10/lb. Far Eastern Exports (C.V.D = $170) and $15/lb. Far Eastern Imports (C.V.D.= $281). Therefore, the Far Eastern Imports can support a higher transportation premium.

Refer for a moment to Exhibit 9.5, which lists the air transportation premiums supportable by cargoes in the transpacific trade. Exhibit 9.5 shows that a commodity with a cubic value density of $281 (15 x 19) can support an air premium of $4,011 per teu. Note also that a commodity with a cubic value density of $170 (10 x 17) can support an air premium of $2,392 per teu.

Exhibit 9.7

Cubic Value Densities for 1992 Containerized Trade

Far East	Export	Import
Space Used	1088	1088
Tons/Teu	9.3	10.2
Lb/cu.ft.	17	19

Europe	Export	Import
Space Used	1088	1088
Tons/Teu	11.9	7.58
Lb/cu.ft.	22	13.93

Value	C.V.D.	C.V.D.
$5	$85	$94
$10	$170	$188
$15	$255	$281
$20	$341	$375
$25	$426	$469
$30	$512	$562

Value	C.V.D.	C.V.D.
$5	$109	$69
$10	$219	$138
$15	$328	$207
$20	$438	$275
$25	$547	$344
$30	$656	$414

Derived from unpublished MARAD sample data for 1992.

It was shown earlier in this chapter that the average air premium supported by air cargoes out of the port of New York was $12,665. The difference between this premium, which shippers are now paying, and the *one-way premium* that can be supported by $10 to $15 per pound commodities in the transpacific container trade is $9,463.50

[($12,665 + $12,665) - ($4,011 + $2,392)] / 2 = $9,463.50

In other words, the cost of air transport must be reduced by over $9,400 per teu for a Pacific transit in order to convert these commodities from ocean to air transport.

Atlantic Trade

The Atlantic trade air transport premiums may be applied in the same manner. Exhibits 9.3 and 9.7 show that:

1. New York cargoes with $900 C.V.D. (20 x $45) support a premium of $9,983.
2. $10/lb. exports with $200 C.V.D. support premiums of $2,218 and
3. $10/lb. imports with $140 C.V.D. support premiums of $1,553.

[($9,983 + $9,983) - ($2,218 + $1,553)] / 2 = $8,097

The cost of air transport must be reduced by over $8,000 per teu for each Atlantic crossing to convert these commodities from ocean to air transport, based strictly on the transportation cost/inventory cost tradeoff.

Future Growth

The teu volumes for 1992 are adjusted for growth in Appendix F. Growth is shown at four different levels: 3%, 6% or 9% per year for the peiod from 1992 to 2040 and also at 9% until the year 2000, after which it falls to 5%. Two things should be noted about the growth projections.

1. By the year 2030, using either the straight 6% growth or the stepped 9% to 5% growth yields very similar results.
2. The strong historical growth in container volume, as was shown in exhibit 5.8, has been due in part to increased penetration of the general cargo trade by container transport companies. That penetration is now nearly 50%. It obviously cannot exceed 100%, so this component of container volume growth is likely to become less powerful in the next 6 years.

Aircraft Required

For the estimation of the number of aircraft required to transport cargo diverted from ocean container ships, the following assumptions are made.

1. Aircraft carries 36 teu.
2. Aircraft flies 7 days per week.
3. Aircraft can lift 324 short tons (628,000 pounds).
4. Aircraft may be deployed anywhere within the trade zone that demand is sufficient.
5. Growth will occur at 9% until the year 2000 and at 5% after that.

For each trade zone and cargo value level, the figure shown in Exhibit 9.8 is the number of flights that need to be made each day, 365 days per year, in order to serve that trade.

For example, in the year 2030 there will need to be 58 flights made per day from the Far East to the United States, if all cargoes above $10 per pound are diverted from ocean to air transport. The distance involved precludes any aircraft from making more than one flight per day, so 58 aircraft will be required. (See Appendix F for projected aircraft requirements at various trade growth rates.)

Total Aircraft

This report has focused on U.S. containerized trades with the Far East and Europe. There is a third trade that must be considered. The container volumes between Northern Europe and the Far East are within 4% of the volumes between the U.S. and Europe.[30] The assumption will be made that similar types of goods are transported in this trade and that, whatever the number of planes are that are required for the trade between the U.S. and Europe, the same number will be required to handle trade between Europe and the Far East.

Exhibit 9.8

The Year 2030
Aircraft Required at Various Trade Growth Rates
For Mode-Converted Cargoes over $10 per Pound

Growth Rate	**3%**	**6%**	**9% to 5%**	**9%**
Far East Exports	3	9	8	25
Far East Imports	21	62	58	178
European Exports	4	13	12	36
European Imports	5	14	13	39
Eur. /F. East Exp.	4	13	12	36
Eur. / F. East Imp	5	14	13	39

Total Fleet	31	90	84	256

Based on a 36-teu aircraft.

Maximum Air Transportation Cost

Air transport companies must compete against the modally-integrated system that marine container transport companies provide. The service they provide must be door-to-door and the price charged for transportation must include all modes and all mode transfers. In the case of the examples we have used to this point, this means that the air transport charge must include:

1. Truck cost from 500 miles away to the airport.
2. Transfers from truck to temporary storage to aircraft.
3. Air transportation.
4. Transfer from aircraft to truck.
5. Truck delivery within 500 miles to a customer.

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[30] Drewry Shipping Consultants, *Container Market Profitability to 1997*, Section 1.54, 1992.

In Chapter 4 we saw the average cost per teu for a medium-cost containership operator. We may add this to the air transport premium supportable by the goods in the European and Far Eastern trades to find the maximum air transport cost for goods valued at $10 per pound in each trade.

Exhibit 9.9

Trade Zone	Ocean Cost	Air Premium	Per Teu TOTAL
Far East Export	$1,733	$2,392	$4,125
Far East Import	$1,733	$2,674	$4,407
Europe Export	$1,350	$2,218	$3,568
Europe Import	$1,350	$1,553	$2,903

These are the cost premiums per teu that are chargeable strictly on the basis of reduced inventory *interest* costs for shippers.[31] Shippers will consider paying even higher premiums when the speed of air transport insures that their products will reach market with a higher probability of being sold at their full value, provided that the air premium is more than offset by the gain in product sales.[32]

Summary

The speed and reliability of air transport offers the shipper substantial inventory cost savings. These savings come from reduced origin inventory costs, reduced in-transit inventory costs and reduced safety stock costs. The value of a product per cubic foot, not just the value per pound, drives these savings.

The speed of air transport also offers shippers the opportunity to wait later to produce their products, receive more accurate forecasts and then initiate production with a much higher degree of certainty about demand. The most easily measured savings here is in reduced costs for obsolete or otherwise unsaleable products. However, we have seen that an increase in service frequency directly translates into a savings on origin inventory and can reasonably state that there should also be a reduction of direct warehousing costs as the volume of goods to be stored between shipments declines. The extension of this argument would be that the speed and reliablity of reduced-cost air transport would make it possible to eliminate whole levels of inventory, causing the closing of regional distribution centers and the consolidation of inventory at central locations. The effect of a

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[31] As was stated in Chapter One, the direct cost of warehousing has not been considered as part of the cost savings shown. For each commodity, season and region, this savings will vary.

[32] Company B interviews.

reduction in air transport rates at this level, where the structure of distribtution systems might be changed, should be investigated more fully.

Air transport also makes it possible to ship items to markets that otherwise would not exist. For example, fresh fish shipped from New York to Europe and cut flowers shipped from South America to Florida would be limited to their home markets without the speed of air transport. It is important to note that the potential exists for other markets and industries to develop as a consequence of reduced air transport costs. There has been no attempt to model this type of economic growth in this report.

The non-perishable products that are currently shipped by air on a routine basis are generally found to have values of $45 per pound and stowage densities of about 20 pounds per cubic foot. These two characteristics combine to give a cubic value density of $900 per cubic foot. In contrast, over 85% of the United States' containerized oceanborne imports and over 95% of the exports are worth less than $5 per pound. With stowage densities varying between 12 pounds per cubic foot for Far Eastern imports to over 21 pounds per cubic foot for low value exports to the Far East, most containerized cargoes may be characterized as having cubic value densities of less than $60 per cubic foot.

This fifteen to one ratio, $900 to $60, means that based strictly on inventory interest cost savings, transoceanic air cargoes are, on average, able to support transportation charges that are $9,000 to $12,000 more per teu than cargoes we find travelling by ocean container.

However, there *is* a small percentage of containerized products that have values over $10 per pound. These products are capable of supporting air transportation premiums of $1,500 to $2,700. Today, there is enough of this cargo moving in the major trade lanes to employ ten aircraft capable of lifting 324 tons each. With moderate growth in world trade over the next 35 years, there should be enough cargo with value over $10 per pound (in 1994 dollars) to employ 80 to 90 aircraft on a daily basis, provided that the technology then exists to provide air transport at greatly reduced rates.

The cost categories include the following expense items:

Fixed Costs

Bunkers - Fuel for the ship's engines.

Ports - Pilotage, towage, dockage fees, port dues, etc;

Capital - Payments toward equity in the vessel, including interest charges.

Operating - Stores and lubes, ship repairs and maintenance, insurance and managing the ship.

Administration - Managing the movement of cargo through the service network.

Direct Costs

Terminals - Moving containers on and off the vessel, including terminal gate charges, crane usage, transfers, removal of hatch covers and all other in-terminal cargo expenses.

Transport - Cargo movement by rail, truck or barge from the port to an inland destination.

Depots - Costs for consolidating cargo into full container loads (stuffing/stripping) at container freight stations.

Refrigeration - Cost for provision of refrigeration facilities and monitoring the temperature of frozen cargo.

Indirect Costs

Empty Containers - Cost for restowage, transportation and loading of empties. Does not include opportunity cost of not carrying full containers.

Equipment Provision - Cost for containers and trailers, includes both leasing and purchasing costs.

Maint. & Repair - Costs for maintaining containers and trailers.

Cargo Insurance - Covers the cargo on both the land and sea portions of the trip.

Drewry Shipping Consultants
Pacific Trade

Appendix A-2

ROUNDTRIP VOYAGE COSTS

FIXED COSTS	$'000	%
Bunkers	249	3.5
Ports	258	3.6
Capital	693	9.7
Operating	545	7.7
Administration	1155	16.2
Subtotal	2900	40.8
DIRECT COSTS		
Terminals	1177	16.5
Transport	1927	27.1
Depots	27	0.4
Refrigeration	27	0.4
Subtotal	3158	44.4
INDIRECT COSTS		
Empty Containers	350	4.9
Equipment Provision	364	5.1
Maint. & Repair	280	3.9
Cargo Insurance	62	0.9
Subtotal	1056	14.8
TOTAL COSTS	7114	100

COSTS PER TEU*	$1,733

VOYAGE/VESSEL DESCRIPTION

SIZE

2800 Ship Size in TEU

TIME

33 Days at sea
0 Canal Days
9 Port Days
42 Roundtrip days

SPEED

21 knots ship speed

FUEL

105 tons/day MFO (steaming
71 $/ton
3 tons/day MDO (in port)
161 $/ton MDO

OPERATE

13,030 $/day

LOAD FACTORS

81.70% Eastbound
64.50% Westbound
73.30% Average

Drewry Shipping Consultants
Atlantic Trade

Appendix A-3

ROUNDTRIP VOYAGE COSTS

FIXED COSTS	$'000	%
Bunkers	85	2.8
Ports	161	5.3
Capital	326	10.8
Operating	309	10.2
Administration	576	19.1
Subtotal	1458	48.2
DIRECT COSTS		
Terminals	726	24
Transport	314	10.4
Depots	50	1.7
Refrigeration	16	0.5
Subtotal	1105	36.6
INDIRECT COSTS		
Empty Containers	95	3.1
Equipment Provision	198	6.5
Maint. & Repair	134	4.4
Cargo Insurance	34	1.1
Subtotal	460	15.2
TOTAL COSTS	3023	100

COSTS PER TEU	$1,350

VOYAGE/VESSEL DESCRIPTION

SIZE

1600 Ship Size in TEU
3456 (Maximum ship size)

TIME

20 Days at sea
0 Canal Days
8 Port Days
28 Roundtrip days

SPEED

19.5 knots ship speed

FUEL

55 tons/day MFO (steaming
75 $/ton
2 tons/day MDO (in port)
160 $/ton MDO

OPERATING

11,030 $/day

LOAD FACTORS

75.00% Eastbound
65.00% Westbound
70.00% Average

Seok-Min Lim Appendix B-1

The costs categories are setup so that:

Variable Operating Costs = Cargo Related Expense + Navigation Expense

Fixed Costs = Ship Expense + Administrative Expense.

Cargo Related Expenses are described as follows:

Cargo Expense - include cargo stuffing and stripping at a container freight station, customs examination, documentation, pre-cooling and reefer monitoring.

Stevedorage - loading and unloading cargo, storage of equipment, movement to or from the stacking area, transshipment and labor costs.

Haulage - railroad charges, rail ramp fee, inland depot charges, local drayage or any shuttle charges.

Agency Fee - charged by ship's agent to process ship's documents and arrange for port services.

Navigation Expenses are:

Port Charges - pilotage, towage, dockage, wharfage, mooring and unmooring, watchmen and any canal fees.

Bunker Expense - Ship's fuel and marine diesel oil.

Ship Expenses are:

Crew Expense - wages, overtime, pensions, accident/sickness insurance, provisions, food and cabin stores.

Ship Expense - stores and spares, lubricants, maintenance/minor repair, annual survey and potable water.

Insurance - hull and machinery, war risks, freight/demurrage defence, P & I, other marine risks.

Depreciation - on ships, containers, chassis and trailers, on leasehold improvements.

Administrative Expenses are:

Overhead - compensation of officers and directors, employee salaries, office expenses, advertising, legal fees and taxes.

Non Operating Expenses are:

Interest payments on vessels and equipment, foreign exchange losses, miscellaneous losses.

Annual Operating Costs

Vessel Characteristics	A-1	A-2
Type (TEU)	1200	1700
Capacity (TEU)	1150	1662
Built	79-08	81-03
Purchase Price	$19,377,000.00	$25,607,000.00
per TEU	$16,580.00	$15,063.00
Speed (knots)	17	18.6
Bunker (MT/day)	45.1	145.6
Crew number	20	22
Distance (mile)	12001	12001
Duration (days)	35	35
Operation days	350	350
Voyages (O/I)	20	20
Navigated Miles	120010	120010
Supplied (TEU)	23000	33240
Carried (TEU)	19114	27556
Load Factor	0.831	0.829
Freight Revenue	$22,322,000.00	$32,260,000.00
per TEU	$1,168.00	$1,170.00

CARGO RELATED	$14,535,000.00	$21,006,000.00
Cargo Expense	$829,000.00	$1,197,000.00
Stevedorage	$4,724,000.00	$6,827,000.00
Haulage	$8,445,000.00	$12,204,000.00
Agency Fee	$538,000.00	$777,000.00

NAVIGATION EXPENSE	$2,066,000.00	$2,194,000.00
Port Charge	$612,000.00	$649,000.00
Bunker Expense	$1,444,000.00	$1,534,000.00

SHIP EXPENSE	$2,539,000.00	$3,077,000.00
Crew Expense	$627,000.00	$632,000.00
Ship Expense	$769,000.00	$966,000.00
Insurance	$199,000.00	$236,000.00
Depreciation	$944,000.00	$1,243,000.00

ADMINISTRATIVE EXPNSE	$1,491,000.00	$2,207,000.00
NON-OPERATION EXPNSE	$550,000.00	$632,000.00

Appendix B-3

Annual Operating Costs

Vessel Characteristics	**A-3**	**A-4**	**A-5**
Type (TEU)	2700	2700	4000
Capacity (TEU)	2668	2678	3730
Built	87-06	88-12	93-01
Purchase Price	$28,356,000.00	$31,931,000.00	$73,900,000.00
per TEU	$10,628.00	$11,923.00	$19,812.00
Speed (knots)	22	22	24
Bunker (MT/day)	97	97	140
Crew number	17	18	18
Distance (mile)	23674	33953	13788
Duration (days)	63	91	35
Operation days	358	364	350
Voyages (O/I)	12	8	20
Navigated Miles	134528	135812	137880
Supplied (TEU)	30332	42848	74600
Carried (TEU)	23924	34610	59012
Load Factor	0.789	0.808	0.783
Freight Revenue	$30,500,000.00	$42,540,000.00	$68,261,000.00
per TEU	$1,275.00	$1,229.00	$1,157.00

CARGO RELATED	$14,560,000.00	$22,419,000.00	$39,493,000.00
Cargo Expense	$1,704,000.00	$1,794,000.00	$2,765,000.00
Stevedorage	$8,226,000.00	$10,828,000.00	$19,273,000.00
Haulage	$3,669,000.00	$8,250,000.00	$15,560,000.00
Agency Fee	$961,000.00	$1,524,000.00	$1,777,000.00

NAVIGATION EXPENSE	$3,336,000.00	$4,919,000.00	$4,965,000.00
Port Charge	$1,451,000.00	$2,563,000.00	$1,609,000.00
Bunker Expense	$1,871,000.00	$2,341,000.00	$3,336,000.00

SHIP EXPENSE	$4,813,000.00	$5,481,000.00	$10,692,000.00
Crew Expense	$593,000.00	$613,000.00	$718,000.00
Ship Expense	$2,569,000.00	$3,181,000.00	$5,735,000.00
Insurance	$205,000.00	$227,000.00	$544,000.00
Depreciation	$1,446,000.00	$1,460,000.00	$3,695,000.00

ADMINISTRATIVE EXPNSE	$3,537,000.00	$3,131,000.00	$16,560,000.00
NON-OPERATION EXPNSE	$2,326,000.00	$3,469,000.00	$7,387,000.00

Appendix C - 1

Stratified Volumes and Values for Far Eastern Imports

1992

Total Market	Total Tons	Total Value	Av. Val/lb
from Far East	19,913,995	$130,344,382,782	$2.92

LA. Plus	Sample Tons	Sample % of total	Av. Val/lb
Seattle	13,722,918	69%	
Imports	Sample Value	Sample % of total	
	$102,146,076,197	78%	$3.32

Average Value of trade, excluding LA/LB	$2.03
Scalar	61%

L.A./L. Beach Plus Seattle/Tacoma Sample

Value per lb.	Long Tons	Value	% Tons	% Value
LA + Seattle	13,722,918	$102,146,076,197	100	100
Over $5/lb	2,749,107	$53,106,731,306	20.0	52.0
Over $10/lb	631,502	$20,049,152,313	4.6	19.6
Over $15/lb	91,676	$5,639,610,661	0.7	5.5
Over $20/lb	62,925	$4,568,717,682	0.5	4.5
Over $25/lb	45,197	$3,682,332,490	0.3	3.6
Over $30/lb	44,867	$3,660,436,798	0.3	3.6

Balance of Far Eastern Market, adjusted by scalar

Value per lb.	Long Tons	Value	% Tons	% Value
Other Ports	6,191,077	$28,198,306,585	100	100
Over $5/lb	758,915	$8,970,827,664	12.3	31.8
Over $10/lb	174,332	$3,386,717,386	2.8	12.0
Over $15/lb	25,308	$952,647,133	0.4	3.4
Over $20/lb	17,371	$771,751,113	0.3	2.7
Over $25/lb	12,477	$622,022,281	0.2	2.2
Over $30/lb	12,386	$618,323,645	0.2	2.2

Total Far Eastern Imports, Including L.A./ Long Beach + Seattle

Value per lb.	Long Tons	Value	% Tons	% Value
Total	19,913,995	$130,344,382,782	% Tons	% Value
Over $5/lb	3,508,022	$62,077,558,970	17.6	47.6
Over $10/lb	805,834	$23,435,869,699	4.0	18.0
Over $15/lb	116,984	$6,592,257,794	0.6	5.1
Over $20/lb	80,296	$5,340,468,795	0.4	4.1
Over $25/lb	57,674	$4,304,354,771	0.3	3.3
Over $30/lb	57,253	$4,278,760,443	0.3	3.3

Derived from unpublished MARAD data.

Appendix C - 2

Stratified Volumes and Values for Far Eastern Exports
1992

Total Market **to Far East**	Total Tons	Total Value	Av. Val/lb
	25,426,080	$42,878,188,554	$0.75

LA. Plus	Sample Tons	Sample % of total	Av. Val/lb
Seattle	13,277,878	52%	
Exports	Sample Value	Sample % of total	
	$22,884,027,473	53%	$0.77

Average Value of trade, excluding LA/LB	$0.73
Scalar	95%

L.A./L Beach Plus Long Beach Sample

Value per lb.	Long Tons	Value	% Tons	% Value
LA + Seattle	13,277,878	$22,884,027,473	100	100
Over $5/lb	336,653	$6,311,658,598	2.5	27.6
Over $10/lb	55,385	$2,187,532,654	0.4	9.6
Over $15/lb	21,783	$1,326,871,297	0.2	5.8
Over $20/lb	13,864	$1,027,904,113	0.1	4.5
Over $25/lb	9,998	$827,613,575	0.1	3.6
Over $30/lb	9,019	$767,160,371	0.1	3.4

Balance of Far Eastern Market, adjusted by scalar

Value per lb.	Long Tons	Value	% Tons	% Value
Other Ports	12,148,202	$19,994,161,081	100	100
Over $5/lb	294,139	$5,266,251,806	2.4	26.3
Over $10/lb	48,391	$1,825,209,271	0.4	9.1
Over $15/lb	19,032	$1,107,100,179	0.2	5.5
Over $20/lb	12,113	$857,651,251	0.1	4.3
Over $25/lb	8,735	$690,535,050	0.1	3.5
Over $30/lb	7,880	$640,094,775	0.1	3.2

Total Far Eastern Exports, Including L.A./ Long Beach + Seattle

Value per lb.	Long Tons	Value	% Tons	% Value
Total	25,426,080	$42,878,188,554	100	100
Over $5/lb	630,792	$11,577,910,404	2.5	27.0
Over $10/lb	103,776	$4,012,741,925	0.4	9.4
Over $15/lb	40,815	$2,433,971,476	0.2	5.7
Over $20/lb	25,977	$1,885,555,364	0.1	4.4
Over $25/lb	18,733	$1,518,148,625	0.1	3.5
Over $30/lb	16,899	$1,407,255,146	0.1	3.3

Derived from unpublished MARAD data.

Appendix C - 3

Stratified Volumes and Values for European Imports
1992

Total Market from Europe	Total Tons	Total Value	Av. Val/lb
	8,865,608	$35,344,578,860	$1.78

N.Y. Import	Sample Tons	Sample % of total	Av. Val/lb
	2,424,509	27%	
	Sample Value	Sample % of total	
	$11,719,237,738	33%	$2.16

Average Value of trade, excluding N.Y.	$1.64
Scalar	76%

New York Sample

Value per lb.	Long Tons	Value	% Tons	% Value
NY Import	2,424,509	$11,719,237,738	100	100
Over $5/lb	264,991	$5,292,685,983	10.9	45.2
Over $10/lb	42,670	$1,788,233,421	1.8	15.3
Over $15/lb	21,011	$1,208,828,863	0.9	10.3
Over $20/lb	11,886	$863,342,509	0.5	7.4
Over $25/lb	6,823	$606,035,378	0.3	5.2
Over $30/lb	1,780	$279,943,408	0.1	2.4

Balance of European Market, adjusted by scalar

Value per lb.	Long Tons	Value	% Tons	% Value
Other Ports	6,441,099	$23,625,341,122	100	100
Over $5/lb	534,207	$8,096,501,506	8.3	34.3
Over $10/lb	87,978	$2,742,913,225	1.4	11.6
Over $15/lb	43,989	$1,846,536,354	0.7	7.8
Over $20/lb	24,438	$1,326,637,769	0.4	5.6
Over $25/lb	14,663	$932,231,946	0.2	3.9
Over $30/lb	4,888	$430,260,898	0.1	1.8

Total European Imports, Including N.Y.

Value per lb.	Long Tons	Value	% Tons	% Value
Total	8,865,608	$35,344,578,860	100	100
Over $5/lb	799,198	$13,389,187,489	9.0	37.9
Over $10/lb	130,648	$4,531,146,646	1.5	12.8
Over $15/lb	65,000	$3,055,365,217	0.7	8.6
Over $20/lb	36,324	$2,189,980,278	0.4	6.2
Over $25/lb	21,486	$1,538,267,324	0.2	4.4
Over $30/lb	6,668	$710,204,306	0.1	2.0

Derived from unpublished MARAD data.

Appendix C - 4

Stratified Volumes and Values for European Exports

1992

Total Market	Total Tons	Total Value	Av. Val/lb
to Europe	10,378,253	$28,583,803,220	$1.23

N.Y. Export	Sample Tons	Sample % of total	Av. Val/lb
	1,185,773	11%	
	Sample Value	Sample % of total	
	$6,335,378,752	22%	$2.39

Average Value of trade, excluding N.Y.	$1.08
Scalar	45%

New York Sample

Value per lb.	Long Tons	Value	% Tons	% Value
NY Export	1,185,773	$6,335,378,752	100	100
Over $5/lb	143,353	$3,198,083,618	12.1	50.5
Over $10/lb	42,237	$1,710,862,558	3.6	27
Over $15/lb	21,070	$1,174,737,727	1.8	18.5
Over $20/lb	7,527	$614,709,746	0.6	9.7
Over $25/lb	4,330	$454,184,063	0.4	7.2
Over $30/lb	4,036	$435,509,347	0.3	6.7

Balance of European Market, adjusted by scalar

Value per lb.	Long Tons	Value	% Tons	% Value
Other Ports	9,192,480	$22,248,424,468	100	100
Over $5/lb	503,423	$5,087,589,171	5.5	22.9
Over $10/lb	149,910	$2,721,188,127	1.6	12.2
Over $15/lb	74,955	$1,864,517,791	0.8	8.4
Over $20/lb	24,985	$977,612,031	0.3	4.4
Over $25/lb	16,657	$725,650,167	0.2	3.3
Over $30/lb	12,493	$675,257,794	0.1	3.0

Total European Exports, Including N.Y.

Value per lb.	Long Tons	Value	% Tons	% Value
Total	10,378,253	$28,583,803,220	100	100
Over $5/lb	646,776	$8,285,672,789	6.2	29.0
Over $10/lb	192,147	$4,432,050,685	1.9	15.5
Over $15/lb	96,025	$3,039,255,518	0.9	10.6
Over $20/lb	32,512	$1,592,321,777	0.3	5.6
Over $25/lb	20,987	$1,179,834,230	0.2	4.1
Over $30/lb	16,529	$1,110,767,141	0.2	3.9

Derived from unpublished MARAD data.

Commodity Codes, Descriptions, Tonnages and Gross Values are from unpublished MARAD data.

All Commodities shown were transported by ship and have values of at least $10 per pound.

Density = D = (Lb./Cu.Ft.)

1992 HIGH VALUE CONTAINERIZED IMPORT COMMODITIES for LA/Long Beach, Seattle/Tacoma, New York/New Jersey.

PORT	CODE	COMMODITY DESCRIPTION	D	L TONS	VALUE	Per lb
LA_MPT	8471	AUTOMATIC DATA PROCESS MACHINES; MAGN. READER, ETC.	20	180947	$4,387,452,414.00	$10.82
LA_MPT	8525	TRANS APPAR. FOR RADIOTELEPHONY, ETC.; TV CAMERAS	20	21102	$1,775,742,324.00	$37.57
LA_MPT	8521	VIDEO RECORDING OR REPRODUCING APPARATUS	23	52229	$1,639,692,488.00	$14.02
LA_MPT	8517	ELECTRIC APPARATUS FOR LINE TELEPHONY, ETC., PARTS	22	37885	$987,069,000.00	$11.63
LA_MPT	8519	TURNTABLES, RECORD & CASSETTE PLAYERS, ETC.	19	33679	$940,460,400.00	$12.47
LA_MPT	9006	PHOTOGRAPHIC STILL CAMERAS, FLASH APPARATUS, ETC.	23	6614	$480,349,380.00	$32.42
LA_MPT	8470	CALCULATING & ACCOUNT MACHINES, CASH REGISTERS, ETC.	20	16599	$424,689,700.00	$11.42
LA_MPT	8520	MAGNETIC TAPE & OTHER SOUND RECORDERS	19	14258	$342,620,800.00	$10.73
LA_MPT	6206	WOMEN'S OR GIRL'S BLOUSES, SHIRTS, ETC. NOT KNIT, ETC.	18	11897	$339,368,434.00	$12.73
LA_MPT	8531	ELECTRIC SOUND OR VISUAL SIGNALING APPARATUS, PT.S	26	9113	$212,368,607.00	$10.40
LA_MPT	8479	MACHINES, ETC. HAVING INDIVIDUAL FUNCTIONS NESOI, PT.S	20	7646	$212,128,487.00	$12.39
LA_MPT	9018	MEDICAL, SURGICAL, DENTAL OR VET. INST., NO ELEC., PT.S	18	6423	$193,177,672.00	$13.43
LA_MPT	9102	WATCHES, WRIST, POCKET, ETC., CASE NOT PREC. NOR CLAD	21	3905	$169,671,130.00	$19.40
LA_MPT	8472	OFFICE MACHINES NESOI (HECTOGRAPH, ADDRESSING, ETC.	20	5162	$142,548,274.00	$12.33
LA_MPT	3702	PHOTO FILM IN ROLLS SENSITIZED, UNEXPOSED	29	4965	$141,228,380.00	$12.70
LA_MPT	8532	ELECTRIC CAPACITORS, FIXED, VAR. OR ADJ. (PRESET) PT.S	12	4573	$130,513,084.00	$12.74
LA_MPT	8803	PARTS OF BALLOONS, ETC., AIRCRAFT, SPACECRAFT, ETC.	17	1069	$124,646,465.00	$52.05
LA_MPT	9010	APPARATUS, ETC. FOR PHOTO LABS, ETC. NESOI; PARTS, ETC.	27	2926	$93,891,477.00	$14.33
LA_MPT	8480	MOLDING BOXES FOR METAL FOUNDREY; MOLD BASES, ETC.	20	2877	$93,611,466.00	$14.53
LA_MPT	9002	OPTICAL ELEMENTS, MOUNTED; PARTS & ACCESSORIES	23	1192	$90,036,250.00	$33.72
LA_MPT	8537	BOARDS, PANELS, ETC. WITH ELEC. SWITCH APPAR., ETC.	32	2341	$80,500,123.00	$15.35
LA_MPT	8533	ELECTRICAL RESISTORS EXCEPT HEATING RESISTORS, PT.S	12	2765	$78,697,038.00	$12.71
LA_MPT	8541	SEMICONDUCTOR DEVICES; LIGHT-EMIT DIODES, ETC., PT.S	9	1934	$70,522,124.00	$16.28
LA_MPT	9612	TYPEWRITER, ETC. RIBBONS, INKED OR PREP.; INK PADS	9	520	$67,583,545.00	$58.02
LA_MPT	9031	MACHINES, NESOI IN CHAPTER 90; PROFILE PROJECT, PT.S	34	2050	$64,637,162.00	$14.08
LA_MPT	9005	OPTICAL TELESCOPES & MOUNT; ASTRO. INST. & MOUNT, PT.S	23	2003	$64,387,927.00	$14.35
LA_MPT	9027	INST. ETC. FOR PHYSICAL, ETC. ANAL., ETC.; MICROTOME; PT.S	9	917	$63,396,997.00	$30.86

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PORT	CODE	COMMODITY DESCRIPTION	D	L. TONS	VALUE	Per lb.
LA_XPT	8803	PARTS OF BALLOONS, ETC., AIRCRAFT, SPACECRAFT, ETC.	17	6102	$428,796,573.00	$31.37
LA_XPT	8421	CENTRIFUGES; FILTER, ETC. MACH. FOR LIQ. OR GASES; PT.S	17	9099	$206,012,768.00	$10.11
LA_XPT	8471	AUTOMATIC DATA PROCESS. MACHINES; MAGN. READER, ETC.	20	2164	$115,320,239.00	$23.79
LA_XPT	8411	TURBOJETS, TURBOPROPELLORS & OTH. GAS TURBINES, PT.S	21	981	$98,261,623.00	$44.72
LA_XPT	8529	PARTS FOR TELEVISION, RADIO AND RADAR APPARATUS	26	2049	$67,012,469.00	$14.60
LA_XPT	8525	TRANS. APPAR. FOR RADIOTELEPHONY, ETC.; TV CAMERAS	20	1924	$66,426,706.00	$15.41
LA_XPT	8517	ELECTRIC APPARATUS FOR LINE TELEPHONY, ETC., PARTS	22	767	$32,578,714.00	$18.96
LA_XPT	2844	RADIOACTIVE CHEMICAL ELEMENTS & ISOTOPES, ETC.	200	205	$31,272,017.00	$68.10
LA_XPT	8485	MACHINERY PT.S, NO ELEC. CONNECTORS, ETC. NESOI	30	1309	$30,218,743.00	$10.31
LA_XPT	6103	MEN'S OR BOY'S SUITS, ENSEMBLES, ETC., KNIT OR CROCHET	18	1022	$28,257,597.00	$12.34
LA_XPT	8422	MACHINES, DISHWASH, CLEAN, ETC. CONT. & FILL, PAK., ETC.	11	969	$27,733,987.00	$12.78
LA_XPT	8473	PARTS, ETC. FOR TYPEWRITERS & OTHER OFFICE MACHINES	21	831	$27,698,991.00	$14.88
LA_XPT	8805	AIRCRAFT LAUNCH GEAR; DECK-ARREST; GR. FL. TRAIN; PT.S	28	98	$25,240,199.00	$114.98
LA_XPT	7115	ARTICLES OF OR CLAD WITH PRECIOUS METAL, NESOI		343	$24,861,223.00	$32.36
LA_XPT	9031	MACHINES, NESOI IN CHAPTER 90; PROFILE PROJECT, PT.S	34	692	$24,806,478.00	$16.00
LA_XPT	9030	OSCILLOSCOPES, SPECTRUM ANALYZERS, ETC., PARTS, ETC.	13	308	$23,740,152.00	$34.41
LA_XPT	9006	PHOTOGRAPHIC STILL CAMERAS, FLASH APPARATUS, ETC.	23	365	$20,333,946.00	$24.87
LA_XPT	9032	AUTOMATIC REGULATING OR CONTROL INSTRUMENTS; PARTS	29	792	$19,357,520.00	$10.91
LA_XPT	8543	ELECTRICAL MACH., ETC., WITH IND. FUNCTIONS NESOI, PT.S	30	704	$19,037,487.00	$12.07
LA_XPT	9014	DIRECTION FINDING COMPASSES & NAVIG. INST., ETC., PT.S	8	284	$18,589,724.00	$29.22
LA_XPT	8461	MACHINE TOOLS FOR SHAPING, SLOTTING, GEAR CUT, ETC.	33	556	$15,695,658.00	$12.60
LA_XPT	9803	MILITARY WEARING APPAREL; MILITARY EQUIP. NOT IDENT.	18	540	$15,542,168.00	$12.85
LA_XPT	9019	MECH-THER., MASSAGE, PSYCH. TEST, OZONE APP., ETC. PT.S	18	564	$14,426,870.00	$11.42
LA_XPT	8412	ENGINES AND MOTORS NESOI, AND PARTS THEREOF	21	459	$13,883,189.00	$13.50
LA_XPT	8527	RECEPTION APPARATUS FOR RADIOTELEPHONY, ETC.	19	306	$13,877,603.00	$20.25
LA_XPT	8401	NUCLEAR REACTORS; FUEL ELM. (N-I); MACH. ISOTOP. SEP.	50	210	$13,817,401.00	$29.37
LA_XPT	8109	ZIRCONIUM & ARTICLES THEREOF, INCL. WASTE & SCRAP	9	185	$12,913,304.00	$31.16
LA_XPT	8212	RAZORS & RAZOR BLADES (INCL. BLADE BLANKS), B. MT. PT.	25	296	$12,822,761.00	$19.34
LA_XPT	8526	RADAR APPARATUS, RADIO NAVIG. AID & REMOTE CONT. APP	20	217	$12,480,837.00	$25.68
LA_XPT	8524	RECORDS, TAPES & OTHER RECORDED SOUND MEDIA, ETC.	19	531	$12,472,235.00	$10.49
LA_XPT	9010	APPARATUS, ETC. FOR PHOTO LABS, ETC. NESOI; PARTS, ETC.	27	451	$12,142,789.00	$12.02
LA_XPT	9026	INST., ETC. MEASURE OR CHECK FLOW, LEVEL, ETC.,PT.S, ETC.	9	402	$11,787,180.00	$13.09

PORT	CODE	COMMODITY DESCRIPTION	D	L. TONS	VALUE	Per lb.
SE_MPT	9504	ARTICLES FOR ARCADE, TABLE OR PARLOR GAMES	12	48354	$1,373,211,895.00	$12.68
SE_MPT	8525	TRANS. APPAR. FOR RADIOTELEPHONY, ETC.; TV CAMERAS	20	11101	$797,865,521.00	$32.09
SE_MPT	8521	VIDEO RECORDING OR REPRODUCING APPARATUS	23	13178	$463,004,554.00	$15.69
SE_MPT	8517	ELECTRIC APPARATUS FOR LINE TELEPHONY, ETC., PARTS	22	13716	$431,292,522.00	$14.04
SE_MPT	4203	ARTICLES OF APPAREL & ACCESS., LEATH & COMP. LEATHER	23	15932	$428,267,799.00	$12.00
SE_MPT	8803	PARTS OF BALLOONS, ETC., AIRCRAFT, SPACECRAFT, ETC.	17	7834	$382,971,414.00	$21.82
SE_MPT	8479	MACHINES, ETC. HAVING INDIVIDUAL FUNCTIONS NESOI, PT.S	20	7352	$180,771,549.00	$10.98
SE_MPT	9006	PHOTOGRAPHIC STILL CAMERAS, FLASH APPARATUS, ETC.	23	3144	$170,480,890.00	$24.21
SE_MPT	6206	WOMEN'S OR GIRL'S BLOUSES, SHIRTS, ETC. NOT KNIT OR CHRO.	18	5733	$163,448,085.00	$12.73
SE_MPT	9018	MEDICAL, SURGICAL, DENTAL OR VET INST., NO ELEC., PT.S	18	3903	$102,926,638.00	$11.77
SE_MPT	9032	AUTOMATIC REGULATING OR CONTROL INSTRUMENTS; PARTS	29	4072	$95,402,367.00	$10.46
SE_MPT	8520	MAGNETIC TAPE & OTHER SOUND RECORDERS	19	3740	$93,514,791.00	$11.16
SE_MPT	9102	WATCHES, WRIST, POCKET, ETC., CASE NOT PREC. NOR CLAD	21	1448	$69,663,446.00	$21.48
SE_MPT	8538	PARTS FOR ELEC. APPAR., ETC. OF HEAD 8535, 8536 & 8537	32	2111	$59,350,267.00	$12.55
SE_MPT	8532	ELECTRIC CAPACITORS, FIXED, VAR. OR ADJ. (PRESET), PT.S	12	1798	$49,438,641.00	$12.28
SE_MPT	8537	BOARDS, PANELS, ETC. WITH ELEC. SWITCH. APPAR., ETC.	32	1193	$47,350,415.00	$17.72
SE_MPT	8534	PRINTED CIRCUITS	12	1130	$47,086,897.00	$18.60
SE_MPT	8531	ELECTRIC SOUND OR VISUAL SIGNALING APPARATUS, PT.S	26	2050	$46,212,044.00	$10.06
SE_MPT	9002	OPTICAL ELEMENTS, MOUNTED; PARTS & ACCESSORIES	23	528	$42,171,212.00	$35.66
SE_MPT	6208	WOMEN'S OR GIRL'S SLIPS, ETC., NOT KNIT OR CHROCHETED	18	1554	$39,059,798.00	$11.22
SE_MPT	9013	LIQUID CRYSTAL DEVICES NESOI; LASERS; OPT. APPL.; PT.S	26	1074	$37,838,799.00	$15.73
SE_MPT	9207	MUSICAL INSTRUMENTS WITH SOUND ELECTRIC PROD., ETC.	9	1575	$36,493,558.00	$10.34
SE_MPT	9005	OPTICAL TELESCOPES & MOUNT; ASTRO INST. & MOUNT, PT.S	23	1325	$35,759,869.00	$12.05
SE_MPT	9612	TYPEWRITER, ETC. RIBBONS, INKED OR PREP; INK PADS	9	243	$33,321,968.00	$61.22
SE_MPT	8447	MACHINES, KNITTING, STITCH-BOND, LACE, NET, ETC.	26	1197	$33,265,590.00	$12.41
SE_MPT	8480	MOLDING BOXES FOR METAL FOUNDRY; MOLD BASES, ETC.	20	1065	$33,134,296.00	$13.89
SE_MPT	9008	IMAGE PROJECTORS, STILL; ENLARGERS, ETC., STILL; PT.S	23	1137	$32,944,833.00	$12.94
SE_MPT	9027	INST., ETC. FOR PHYSICAL, ETC. ANAL., ETC.; MICROTOME; PT.S	9	345	$32,828,163.00	$42.48
SE_MPT	9406	PREFABRICATED BUILDINGS	17	126	$31,779,219.00	$112.60
SE_MPT	8533	ELECTRICAL RESISTORS EXCEPT HEATING RESISTORS, PT.S	12	1316	$30,706,149.00	$10.42
SE_MPT	6704	WIGS, ETC. OF HAIR, ETC.; HUMAN HAIR ARTICLES	8	1107	$30,120,600.00	$12.15
SE_MPT	8542	ELECTRONIC INTEGRATED CIRCUITS & MICROASSEMBL., PT.S	12	533	$28,400,638.00	$23.79

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PORT	CODE	COMMODITY DESCRIPTION	D	L. TONS	VALUE	Per lb.
SE_XPT	2844	RADIOACTIVE CHEMICAL ELEMENTS & ISOTOPES, ETC.	200	132	$35,150,792.00	$118.88
SE_XPT	8517	ELECTRIC APPARATUS FOR LINE TELEPHONY, ETC., PARTS	22	945	$32,390,920.00	$15.30
SE_XPT	8518	MICROPHONES; LOUDSPEAKERS; SOUND AMPLIFIER, ETC., PT.S	19	1223	$27,709,066.00	$10.11
SE_XPT	2804	HYDROGEN, RARE GASES AND OTHER NONMETALS		688	$27,547,755.00	$17.88
SE_XPT	3702	PHOTO FILM IN ROLLS SENSITIZED, UNEXPOSED	29	1165	$27,175,030.00	$10.41
SE_XPT	8803	PARTS OF BALLOONS, ETC., AIRCRAFT, SPACECRAFT, ETC.	17	120	$16,670,646.00	$62.02
SE_XPT	8603	SELF-PROPELLED RAILWAY, ETC. COACHES, VANS, ETC. NESOI	17	370	$14,857,160.00	$17.93
SE_XPT	8411	TURBOJETS, TURBOPROPELLERS & OTHER GAS TURBINES, PT.S	21	78	$12,308,969.00	$70.45
SE_XPT	8475	MACHINES FOR ASSEMB. ELEC. TUBES, ETC. & GLASS MFR., PT.S	30	358	$11,313,281.00	$14.11
SE_XPT	8471	AUTOMATIC DATA PROCESS MACHINES; MAGN. READER, ETC.	20	202	$10,397,094.00	$22.98
SE_XPT	9024	MACHINES, ETC. FOR TESTING MECH. PROP. OF MATERIAL, PT.S	39	335	$9,103,618.00	$12.13
SE_XPT	7112	WASTE & SCRAP OF PREC. METAL OR METAL CL. W PREC. METL.		77	$8,092,354.00	$46.92
SE_XPT	8538	PARTS FOR ELEC. APPAR., ETC. OF HEAD. 8535, 8536 & 8537	32	290	$7,247,525.00	$11.16
SE_XPT	8707	BODIES (INCLUDING CABS), FOR SPECIF. MOTOR VEHICLES	4	284	$6,673,157.00	$10.49
SE_XPT	9032	AUTOMATIC REGULATING OR CONTROL INSTRUMENTS; PARTS	29	247	$6,595,691.00	$11.92
SE_XPT	8525	TRANS. APPAR. FOR RADIOTELEPHONY, ETC.; TV CAMERAS	20	142	$6,459,193.00	$20.31
SE_XPT	8535	ELECTRICAL APPARATUS FOR SWITCHING, ETC., OV 1000 V	32	225	$6,347,218.00	$12.59
SE_XPT	505	BIRD SKINS & OTHER FEATHERED PARTS AND DOWN	5	255	$6,283,197.00	$11.00
SE_XPT	9027	INST., ETC. FOR PHYSICAL, ETC., ANAL., ETC.; MICROTOME; PT.S	9	89	$4,877,248.00	$24.46
SE_XPT	8212	RAZORS & RAZOR BLADES (INCL. BLADE BLANKS), B. MT. PT.S	25	96	$4,830,654.00	$22.46
SE_XPT	9703	ORIGINAL SCULPTURES AND STATUARY, IN ANY MATERIAL	20	14	$4,815,911.00	$153.57
SE_XPT	8542	ELECTRONIC INTEGRATED CIRCUITS & MICROASSEMBL., PT.S	12	109	$4,488,636.00	$18.38
SE_XPT	8459	MACHINE TOOLS FOR DRILLING, BORING, MILLING, ETC.	33	139	$3,753,023.00	$12.05
SE_XPT	9030	OSCILLOSCOPES, SPECTRUM ANALYZERS, ETC., PARTS, ETC.	13	123	$3,641,565.00	$13.22
SE_XPT	8710	TANK & OTH. ARMORED FIGHT VEH., MOTORIZED; AND PARTS	51	127	$3,516,228.00	$12.36
SE_XPT	9033	PT.S, NESOI FOR MACHINES, APPLN., INST./APPT.S OF CHAP. 90	34	152	$3,477,057.00	$10.21
SE_XPT	8412	ENGINES AND MOTORS NESOI, AND PARTS THEREOF	21	128	$3,366,476.00	$11.74
SE_XPT	8526	RADAR APPARATUS, RADIO NAVIG. AID & REMOTE CONT. APPA	20	20	$2,959,256.00	$66.05
SE_XPT	9031	MACHINES, NESOI IN CHAPTER 90; PROFILE PROJECT, PT.S	34	83	$2,703,506.00	$14.54
SE_XPT	8609	CONTAINERS FOR ONE OR MORE MODES OF TRANSPORT	3	108	$2,617,230.00	$10.82
SE_XPT	9022	X-RAY, ETC. APPARATUS; TUBES, PANELS, SCREEN, ETC., PT.S	9	83	$2,487,127.00	$13.38
SE_XPT	9017	DRAWING, MATH, MEASURING INST., ETC. NESOI, PARTS	13	14	$2,311,153.00	$73.70

PORT	CODE	COMMODITY DESCRIPTION	D	L. TONS	VALUE	Per lb.
NY_MPT	9022	X-RAY, ETC. APPARATUS; TUBES, PANELS, SCREEN, ETC., PT.	3	3759	$246,213,625.00	$29.24
NY_MPT	8443	PRINTING MACHINERY; MACHINES ANCIL. TO PRINTING, PT.S	27	5895	$150,625,358.00	$11.41
NY_MPT	9018	MEDICAL, SURGICAL, DENTAL OR VET. INST., NO ELEC., PT.S	18	1939	$105,722,313.00	$24.34
NY_MPT	2844	RADIOACTIVE CHEMCAL ELEMENTS & ISOTOPES	200	222	$88,327,023.00	$177.62
NY_MPT	8510	ELECTRIC SHAVERS & HAIR CLIPPERS; PARTS	15	1632	$74,609,565.00	$20.41
NY_MPT	8105	COBALT MATTES, ETC., COBALT & ART., INCL. WASTE & SCRP.	30	1686	$72,093,016.00	$19.09
NY_MPT	3006	PHARMACEUTICAL GOODS (SPECIFIED STERILE PROD., ETC.	20	330	$52,141,800.00	$70.54
NY_MPT	8422	MACHINES, DISHWASH, CLEAN, ETC. CONT. & FILL, PAK, ETC.	11	1521	$51,273,354.00	$15.05
NY_MPT	2939	VEG. ALKALOIDS, NAT. OR SYNTH. & SALTS		1327	$51,195,810.00	$17.22
NY_MPT	8441	MACH. FOR MAKING UP PULP & PAPER, INCL. CUTTERS, PT.S	41	2055	$48,597,995.00	$10.56
NY_MPT	8803	PARTS OF BALLOONS, ETC., AIRCRAFT, SPACECRAFT, ETC.	17	427	$45,908,915.00	$48.00
NY_MPT	8211	KNIVES WITH BLADES & BLADES FOR KNIVES NESOI, BMPT.	23	751	$45,442,526.00	$27.01
NY_MPT	8505	ELECTROMAGNETS, PERMANENT MAGNETS, ETC. & PARTS	155	1372	$44,358,859.00	$14.43
NY_MPT	6203	MEN'S OR BOY'S SUITS, ENSEMBLES, ETC., NOT KNIT, ETC.	18	1464	$43,791,976.00	$13.35
NY_MPT	8805	AIRCRAFT LAUNCH GEAR; DECK-ARREST; GR. FL. TRAIN; PT.	28	228	$39,025,404.00	$76.41
NY_MPT	8471	AUTOMATIC DATA PROCESS MACHINES; MAGN. READER, ETC.	20	940	$38,936,585.00	$18.49
NY_MPT	8411	TURBOJETS, TURBOPROPELLERS & OTH. GAS TURBINES	21	659	$34,353,152.00	$23.27
NY_MPT	905	VANILLA BEANS	35	494	$32,015,614.00	$28.93
NY_MPT	8473	PARTS, ETC. FOR TYPEWRITTERS & OTHER OFFICE MACH.S	21	1011	$29,534,306.00	$13.04
NY_MPT	8502	ELECTRIC GENERATING SETS & ROTARY CONVERTERS	30	1003	$29,288,131.00	$13.04
NY_MPT	8517	ELECTRIC APPARATUS FOR LINE TELEPHONY, ETC., PARTS	22	710	$24,432,071.00	$15.36
NY_MPT	8470	CALCULATING & ACCOUNT MACHINES, CASH REGISTERS, ETC	20	216	$20,832,145.00	$43.06
NY_MPT	5207	COTTON YARN (NOT SEWING THREAD) RETAIL PACKED	20	398	$20,676,468.00	$23.19
NY_MPT	8529	PARTS FOR TELEVISION, RADIO AND RADAR APPARATUS	26	689	$18,813,813.00	$12.19
NY_MPT	8461	MACHINE TOOLS FOR SHAPING, SLOTTING, GEAR CUT, ETC.	33	658	$18,353,234.00	$12.45
NY_MPT	9010	APPARATUS, ETC. FOR PHOTO LABS, ETC. NESOI	27	739	$16,908,671.00	$10.21
NY_MPT	8475	MACHINES FOR ASSEMB. ELEC. TUBES, ETC. & GLASS MFR.	30	486	$16,659,757.00	$15.30
NY_MPT	8460	MACHINE TOOLS FOR HONING OR FINISHING METAL, ETC.	33	586	$16,552,303.00	$12.61
NY_MPT	8456	MACHINE TOOLS FOR MATERIAL REMOVAL BY LASER, ETC.	30	432	$15,345,442.00	$15.86
NY_MPT	9507	FISHING RODS & TACKLE; NETS; DECOYS, ETC.; PARTS, ETC	11	612	$14,166,867.00	$10.33
NY_MPT	9031	MACHINES, NESOI IN CHAPTER 90; PROFILE PROJECT, PT.S	34	408	$12,578,662.00	$13.76
NY_MPT	8452	SEWING MACHINES, (NOT BOOK-SEW), COVER ETC., NEEDLES	30	254	$12,486,997.00	$21.95

Appendix C-10

PORT	CODE	COMMODITY DESCRIPTION	D	L. TONS	VALUE	Per lb.
NY_XPT	9009	PHOTOCOPY APPARATUS & THERMOCOPY APPARATUS	23	9385	$215,615,481.00	$10.26
NY_XPT	8471	AUTOMATIC DATA PROCESS MACHINES; MAGN RE	20	4110	$174,284,207.00	$18.93
NY_XPT	3702	PHOTO FILM IN ROLLS SENSITIZED, UNEXPOSED	29	4322	$172,530,221.00	$17.82
NY_XPT	3701	PHOTO PLATES & FILM, FLAT, SENSITIZED, UNEXP.	29	5107	$134,636,225.00	$11.77
NY_XPT	3815	REACTION INITIATORS & ACCELER. & CATALYT.	47	1451	$130,591,759.00	$40.18
NY_XPT	9006	PHOTOGRAPHIC STILL CAMERAS, FLASH APPARATUS	23	2093	$90,821,412.00	$19.37
NY_XPT	8473	PARTS, ETC. FOR TYPEWRITERS & OTHER OFFICE	21	1493	$78,298,228.00	$23.41
NY_XPT	7112	WASTE & SCRAP OF PREC. METAL OR METAL CLAD		184	$74,480,700.00	$180.71
NY_XPT	2712	PETROLEUM JELLY; MINERAL WAXES & SIMILAR		1852	$55,828,592.00	$13.46
NY_XPT	2844	RADIOACTIVE CHEMICAL ELEMENTS & ISOTOPES	200	447	$52,489,587.00	$52.42
NY_XPT	9306	BOMBS, GRENADES, ETC.; CARTRIDGES, ETC. AND	36	1064	$50,631,916.00	$21.24
NY_XPT	9022	X-RAY, ETC. APPARATUS; TUBES, PANELS, SCREENS	3	451	$49,996,595.00	$49.49
NY_XPT	8803	PARTS OF BALLOONS, ETC., AIRCRAFT, SPACECRAFT, ETC.	17	528	$40,541,578.00	$34.28
NY_XPT	8411	TURBOJETS, TURBOPROPELLORS & OTH. GAS TURB.S	21	559	$38,885,889.00	$31.08
NY_XPT	8503	PARTS FOR ELECTRIC MOTORS AND GENERATORS	30	797	$34,079,417.00	$19.09
NY_XPT	8443	PRINTING MACHINERY; MACHINES ANCIL. TO PRINTING	27	706	$17,891,120.00	$11.31
NY_XPT	8531	ELECTRIC SOUND OR VISUAL SIGNALLING APPARATUS	26	346	$15,399,569.00	$19.87
NY_XPT	7106	SILVER (INCL. PREC. PLATED), UNWR., SEMIMFR.	111	111	$14,242,631.00	$57.28
NY_XPT	8548	ELECTRICAL PARTS OF MACHINERY NESOI	26	382	$13,669,248.00	$15.97
NY_XPT	2934	HETEROCYCLIC COMPOUNDS NESOI		356	$12,518,610.00	$15.70
NY_XPT	8422	MACHINES, DISHWASH., CLEAN, ETC., CONT. & FIL.	11	428	$11,177,294.00	$11.66
NY_XPT	9015	SURVEY, HYDROGR., METEORO., ETC. INSTR.; RANGE	13	76	$10,033,426.00	$58.94
NY_XPT	8534	PRINTED CIRCUITS	12	205	$10,024,281.00	$21.83
NY_XPT	2941	ANTIBIOTICS	20	352	$9,192,957.00	$11.66
NY_XPT	9027	INST., ETC. FOR PHYSICAL, ETC., ANAL., ETC., MICRO.	9	196	$8,138,284.00	$18.54
NY_XPT	8440	BOOKBINDING MACHINERY, INCL. BOOK-SEWING	27	281	$8,066,425.00	$12.82
NY_XPT	9613	CIGARETTE LIGHTERS & OTHER LIGHTERS	21	175	$7,749,979.00	$19.77
NY_XPT	8475	MACHINES FOR ASSEMB. ELEC. TUBES, ETC.	30	181	$7,252,445.00	$17.89
NY_XPT	9703	ORIGINAL SCULPTURES AND STATUARY, IN ANY MATERIAL	20	99	$7,132,089.00	$32.16
NY_XPT	9031	MACHINES, NESOI IN CHAPTER 90; PROFILE	34	217	$6,913,995.00	$14.22
NY_XPT	8406	STEAM TURBINES & OTHER VAPOR TURBINES	28	230	$6,801,169.00	$13.20
NY_XPT	8525	TRANS. APPARATUS FOR RADIOTELEPHONY, ETC.	20	93	$6,104,719.00	$29.30

Appendix D-1

1992 Leading Ocean Exports, Port of New York

			Ocean			Air			Cubic Value Density	
									Ocean	Air
U.N. Class	Density Pounds per foot	Commodity	Tons (000s)	Value Dollars (Millions)	Value Dollars per lb.	Tons (000s)	Value Dollars (Millions)	Value Dollars per lb.	Value Dollars per cu.ft.	Value Dollars per cu.ft.
		Leading Ocean Exports								
73	6	Road Motor Vehicles	182	$1,501	$3.70	6	$148	$11.10	$22.20	$66.60
71	33	Machinery General	108	$1,397	$5.80	26	$1,310	$22.50	$191.40	$742.50
57	36	War Material	17	$675	$17.20	2	$272	$66.70	$619.20	$2,401.20
86	27	Photo Supplies	33	$670	$8.90	4	$181	$19.50	$240.30	$526.50
71	20	Office Machinery	21	$635	$13.30	32	$4,899	$68.00	$266.00	$1,360.00
73	17	Scientific Instruments	18	$502	$12.70	17	$2,508	$65.30	$215.90	$1,110.10
71	33	Machinery for Special Ind.	37	$453	$5.50	6	$313	$23.10	$181.50	$762.30
72	21	Electrical Machinery	40	$424	$4.70	15	$3,066	$90.20	$98.70	$1,894.20
73	32	Gas Engines and Diesels	40	$374	$4.20	4	$315	$31.60	$134.40	$1,011.20
73	8	Aircraft and Parts	4	$346	$38.60	10	$2,805	$127.00	$308.80	$1,016.00
71	33	Metal Working Machinery	22	$345	$7.00	4	$229	$26.90	$231.00	$887.70
72	36	Electric Motors and Generators	19	$298	$6.90	12	$1,118	$39.90	$248.40	$1,436.40
89	33	Printed Matter	36	$245	$3.00	18	$602	$23.60	$99.00	$778.80
72	22	Telecommunications Apparatus	9	$239	$11.20	10	$1,659	$71.10	$246.40	$1,564.20
		TOTALS	**586**	**$8,104**		**166**	**$19,425**			

U.N. =United Nations Standard International Trade Classification Index

Density is drawn from the U.N. table

Appendix D - 2

1992 Leading Air Exports Not on Leading Ocean List, Port of New York

			Ocean			Air			Cubic Value Density	
									Ocean	Air
U.N. Class	Density lb / cu.ft	Commodity	Tons (000s)	Value Dollars (Millions)	Value Dollars per lb.	Tons (000s)	Value Dollars (Millions)	Value Dollars per lb.	Value Dollars per cu.ft.	Value Dollars per cu.ft.
		Leading Air Exports								
3	30	Fish and Fish Products	42	$111	$1.20	13	$92	$3.00	$36.00	$90.00
58	13	Plastic Materials	267	$708	$1.20	11	$139	$5.90	$15.60	$76.70
84	18	Clothing	20	$188	$4.20	9	$307	$14.50	$75.60	$261.00
54	21	Pharmaceuticals	16	$201	$5.40	9	$1,572	$80.30	$113.40	$1,686.30
64	20	Paper and Paperboard Mfgs.	40	$99	$1.10	9	$33	$1.70	$22.00	$34.00
65	16	Woven Fabrics (except cotton)	22	$157	$3.10	9	$127	$6.70	$49.60	$107.20
86	20	Sound Recorders	14	$157	$4.90	7	$569	$37.30	$98.00	$746.00
86	20	Electro-Medical Apparatus	2	$102	$18.30	6	$1,350	$76.00	$366.00	$1,520.00
64	32	Paper and Paperboard	100	$159	$0.70	6	$13	$1.00	$22.40	$32.00
73	32	Internal Combustion Engines	10	$185	$8.60	6	$2,373	$189.00	$275.20	$6,048.00
		TOTALS	**533**	**$2,067**		**85**	**$6,575**			

U.N. =United Nations Standard International Trade Classification Index

Density is drawn from the U.N. table

Appendix D-3

1992 Leading Air Exports, Port of New York, Ordered by Dollar Value

U.N. Class	Density lb/cu.ft.		Tons (000s)	Value Dollars (Millions)	Value Dollars per lb.	Cubic Feet (000s)	Pounds (000s)	**Cubic Value Density**
71	20	Office Machinery	32	$4,899	$68.00	3,584	71,680	**$1,360**
72	21	Electrical Machinery	15	$3,066	$90.20	1,600	33,600	**$1,894**
73	8	Aircraft and Parts	10	$2,805	$127.00	2,800	22,400	**$1,016**
73	17	Scientific Instruments	17	$2,508	$65.30	2,240	38,080	**$1,110**
73	32	Internal Combustion Engines	6	$2,373	$189.00	420	13,440	**$6,048**
72	22	Telecommunications Apparatus	10	$1,659	$71.10	1,018	22,400	**$1,564**
54	21	Pharmaceuticals	9	$1,572	$80.30	960	20,160	**$1,686**
86	20	Electro-Medical Apparatus	6	$1,350	$76.00	672	13,440	**$1,520**
71	33	Machinery General	26	$1,310	$22.50	1,765	58,240	**$743**
72	36	Electric Motors and Generators	12	$1,118	$39.90	747	26,880	**$1,436**
89	33	Printed Matter	18	$602	$23.60	1,222	40,320	**$779**
86	20	Sound Recorders	7	$569	$37.30	784	15,680	**$746**
73	32	Gas Engines and Diesels	4	$315	$31.60	280	8,960	**$1,011**
71	33	Machinery for Special Ind.	6	$313	$23.10	407	13,440	**$762**
84	18	Clothing	9	$307	$14.50	1,120	20,160	**$261**
57	36	War Material	2	$272	$66.70	124	4,480	**$2,401**
71	33	Metal Working Machinery	4	$229	$26.90	272	8,960	**$888**
86	27	Photo Supplies	4	$181	$19.50	332	8,960	**$527**
73	6	Road Motor Vehicles	6	$148	$11.10	2,240	13,440	**$67**
58	13	Plastic Materials	11	$139	$5.90	1,895	24,640	**$77**
65	16	Woven Fabrics (except cotton)	9	$127	$6.70	1,260	20,160	**$107**
3	30	Fish and Fish Products	13	$92	$3.00	971	29,120	**$90**
64	20	Paper and Paperboard Mfgs.	9	$33	$1.70	1,008	20,160	**$34**
64	32	Paper and Paperboard	6	$13	$1.00	420	13,440	**$32**
			251	$26,000		28,141	562,240	

$46.24 per Pound Average

19.98 Pounds per Cubic Feet Average for these commodities

Appendix E-1

Perishable Cost = $\left[(1 - Sal) * (V * S) * \left(\frac{T}{L}\right)^{d}\right]$

Perishable Cost = (Per Cent Loss in Value) * (Value of Product Shipped) * (Per Cent of Shelf Life spent InTransit)

Origin Cost = $\left[\left(i * \frac{P}{365}\right) * (V) * \left(\frac{X}{2}\right)\right]$

Origin Cost = (Interest Rate per Period) * (Value per Container) * (One Half the Number of Containers per Shipment)

InTransit Cost = $\left[(S * V) * \left(i * \frac{P}{365}\right) * \left(\frac{T}{P}\right)\right]$

InTransit Cost = (Value of Product Shipped) * (Interest Rate per Period) * (Trip Time in Days / Period Length)

SafetyStock Cost = $\left[\left(i * \frac{P}{365}\right) * (V) * (k * \sigma) * \left(\frac{S}{P}\right)\right]$

Safety Stock Cost = (Interest Rate per Period) * (Value per Container) * (Protected Time) * (Containers Shipped per Day)

Transport Cost = Quote from Transportation Provider

Logistics Cost = Origin + InTransit + Safety Stock + Perishable Cost + TransportCost

X = Shipment Size in Containers
V = Value per Container
i = Annual Inventory Interest Rate
S = Period Demand in Containers
T = Average Trip Time
L = Shelf Life of Product
σ = Standard Deviation of Trip Time in Days
k = Constant, multiplier for σ
Sal = Salvage Value of Product in Per Cent
P = Demand Period in Days
d = Industry or Commodity - specific decay parameter

Adapted From
C.D. Martland, 1992

Appendix F-1

TEU Projection	9.0% Annual Growth Rate to 2000 5.0% Annual Growth After 2000

Export TEU	Base	9.0%	5.0% Annual Growth			
Far East	1992	2000	2010	2020	2030	2040
Over $5/lb	63,762	127,051	206,952	337,103	549,105	894,435
Over $10/lb	12,525	24,957	40,652	66,218	107,862	175,696
Over $15/lb	4,926	9,815	15,988	26,043	42,421	69,100
Over $20/lb	3,135	6,247	10,175	16,574	26,998	43,977
Over $25/lb	2,261	4,505	7,338	11,954	19,471	31,716
Over $30/lb	2,040	4,065	6,621	10,785	17,568	28,616
Over $0/lb	2,569,114	5,119,121	8,338,508	13,582,551	22,124,544	36,038,551

Import TEU	Base	9.0%	5.0% Annual Growth			
Far East	1992	2000	2010	2020	2030	2040
Over $5/lb	603,531	1,202,573	1,958,864	3,190,783	5,197,449	8,466,097
Over $10/lb	88,484	176,310	287,190	467,803	762,001	1,241,220
Over $15/lb	12,845	25,594	41,691	67,910	110,618	180,185
Over $20/lb	8,817	17,568	28,617	46,614	75,930	123,682
Over $25/lb	6,333	12,619	20,555	33,482	54,538	88,837
Over $30/lb	6,287	12,527	20,406	33,239	54,142	88,192
Over $0/lb	3,424,740	6,824,009	11,115,592	18,106,127	29,492,974	48,040,946

Export TEU	Base	9.0%	5.0% Annual Growth			
Europe	1992	2000	2010	2020	2030	2040
Over $5/lb	79,429	158,267	257,800	419,929	684,019	1,114,195
Over $10/lb	18,084	36,034	58,695	95,608	155,735	253,675
Over $15/lb	9,038	18,009	29,334	47,783	77,833	126,782
Over $20/lb	3,060	6,097	9,932	16,178	26,352	42,925
Over $25/lb	1,975	3,935	6,410	10,442	17,008	27,705
Over $30/lb	1,556	3,100	5,050	8,226	13,400	21,827
Over $0/lb	1,274,167	2,538,858	4,135,531	6,736,345	10,972,796	17,873,529

Import TEU	Base	9.0%	5.0% Annual Growth			
Europe	1992	2000	2010	2020	2030	2040
Over $5/lb	118,087	235,296	383,273	624,312	1,016,938	1,656,484
Over $10/lb	19,510	38,875	63,323	103,147	168,015	273,679
Over $15/lb	9,707	19,342	31,506	51,320	83,594	136,166
Over $20/lb	5,424	10,808	17,605	28,676	46,710	76,086
Over $25/lb	3,209	6,394	10,415	16,966	27,635	45,015
Over $30/lb	996	1,985	3,233	5,266	8,577	13,972
Over $0/lb	1,310,576	2,611,405	4,253,703	6,928,834	11,286,341	18,384,260

Appendix F-2

Aircraft Required	36 Teu per Aircraft 7 Days per Week Service

Far East Export	Base	9.0%	5.0% Annual Growth			
	1992	2000	2010	2020	2030	2040
Over $5/lb	5	10	16	26	42	68
Over $10/lb	1	2	3	5	8	13
Over $15/lb	0	1	1	2	3	5
Over $20/lb	0	0	1	1	2	3
Over $25/lb	0	0	1	1	1	2
Over $30/lb	0	0	1	1	1	2
Over $0/lb	196	390	635	1,034	1,684	2,743

Import TEU Far East	Base	9.0%	5.0% Annual Growth			
	1992	2000	2010	2020	2030	2040
Over $5/lb	46	92	149	243	396	644
Over $10/lb	7	13	22	36	58	94
Over $15/lb	1	2	3	5	8	14
Over $20/lb	1	1	2	4	6	9
Over $25/lb	0	1	2	3	4	7
Over $30/lb	0	1	2	3	4	7
Over $0/lb	261	519	846	1,378	2,245	3,656

Export TEU Europe	Base	9.0%	5.0% Annual Growth			
	1992	2000	2010	2020	2030	2040
Over $5/lb	6	12	20	32	52	85
Over $10/lb	1	3	4	7	12	19
Over $15/lb	1	1	2	4	6	10
Over $20/lb	0	0	1	1	2	3
Over $25/lb	0	0	0	1	1	2
Over $30/lb	0	0	0	1	1	2
Over $0/lb	97	193	315	513	835	1,360

Import TEU Europe	Base	9.0%	5.0% Annual Growth			
	1992	2000	2010	2020	2030	2040
Over $5/lb	9	18	29	48	77	126
Over $10/lb	1	3	5	8	13	21
Over $15/lb	1	1	2	4	6	10
Over $20/lb	0	1	1	2	4	6
Over $25/lb	0	0	1	1	2	3
Over $30/lb	0	0	0	0	1	1
Over $0/lb	100	199	324	527	859	1,399

Approximate Tons of Cargo + Tare per Aircraft: 324

Appendix F-3

TEU Projection	3.0% Annual Growth Rate to 2000 3.0% Annual Growth After 2000

Export TEU	Base	3.0%	3.0% Annual Growth			
Far East	1992	2000	2010	2020	2030	2040
Over $5/lb	63,762	80,772	108,551	145,884	196,056	263,482
Over $10/lb	12,525	15,866	21,323	28,656	38,512	51,756
Over $15/lb	4,926	6,240	8,386	11,270	15,146	20,355
Over $20/lb	3,135	3,971	5,337	7,173	9,639	12,955
Over $25/lb	2,261	2,864	3,849	5,173	6,952	9,343
Over $30/lb	2,040	2,584	3,473	4,667	6,273	8,430
Over $0/lb	2,569,114	3,254,477	4,373,745	5,877,947	7,899,469	10,616,226

Import TEU	Base	3.0%	3.0% Annual Growth			
Far East	1992	2000	2010	2020	2030	2040
Over $5/lb	603,531	764,535	1,027,470	1,380,834	1,855,726	2,493,941
Over $10/lb	88,484	112,089	150,638	202,445	272,069	365,638
Over $15/lb	12,845	16,272	21,868	29,388	39,496	53,079
Over $20/lb	8,817	11,169	15,010	20,173	27,110	36,434
Over $25/lb	6,333	8,022	10,782	14,489	19,473	26,170
Over $30/lb	6,287	7,964	10,703	14,384	19,331	25,979
Over $0/lb	3,424,740	4,338,358	5,830,391	7,835,557	10,530,334	14,151,888

Export TEU	Base	3.0%	3.0% Annual Growth			
Europe	1992	2000	2010	2020	2030	2040
Over $5/lb	79,429	100,618	135,222	181,727	244,226	328,219
Over $10/lb	18,084	22,908	30,787	41,375	55,604	74,728
Over $15/lb	9,038	11,449	15,387	20,678	27,790	37,347
Over $20/lb	3,060	3,876	5,209	7,001	9,409	12,645
Over $25/lb	1,975	2,502	3,362	4,519	6,073	8,161
Over $30/lb	1,556	1,971	2,649	3,560	4,784	6,430
Over $0/lb	1,274,167	1,614,077	2,169,184	2,915,202	3,917,788	5,265,179

Import TEU	Base	3.0%	3.0% Annual Growth			
Europe	1992	2000	2010	2020	2030	2040
Over $5/lb	118,087	149,590	201,036	270,175	363,093	487,967
Over $10/lb	19,510	24,715	33,214	44,637	59,989	80,620
Over $15/lb	9,707	12,297	16,526	22,209	29,847	40,112
Over $20/lb	5,424	6,871	9,234	12,410	16,678	22,413
Over $25/lb	3,209	4,065	5,463	7,342	9,867	13,260
Over $30/lb	996	1,262	1,696	2,279	3,062	4,116
Over $0/lb	1,310,576	1,660,198	2,231,168	2,998,503	4,029,737	5,415,630

Appendix F-4

Aircraft Required	36 Teu per Aircraft 7 Days per Week Service

Far East	Base	3.0%	3.0% Annual Growth			
Export	1992	2000	2010	2020	2030	2040
Over $5/lb	5	6	8	11	15	20
Over $10/lb	1	1	2	2	3	4
Over $15/lb	0	0	1	1	1	2
Over $20/lb	0	0	0	1	1	1
Over $25/lb	0	0	0	0	1	1
Over $30/lb	0	0	0	0	0	1
Over $0/lb	196	248	333	447	601	808

Import TEU	Base	3.0%	3.0% Annual Growth			
Far East	1992	2000	2010	2020	2030	2040
Over $5/lb	46	58	78	105	141	190
Over $10/lb	7	9	11	15	21	28
Over $15/lb	1	1	2	2	3	4
Over $20/lb	1	1	1	2	2	3
Over $25/lb	0	1	1	1	1	2
Over $30/lb	0	1	1	1	1	2
Over $0/lb	261	330	444	596	801	1,077

Export TEU	Base	3.0%	3.0% Annual Growth			
Europe	1992	2000	2010	2020	2030	2040
Over $5/lb	6	8	10	14	19	25
Over $10/lb	1	2	2	3	4	6
Over $15/lb	1	1	1	2	2	3
Over $20/lb	0	0	0	1	1	1
Over $25/lb	0	0	0	0	0	1
Over $30/lb	0	0	0	0	0	0
Over $0/lb	97	123	165	222	298	401

Import TEU	Base	3.0%	3.0% Annual Growth			
Europe	1992	2000	2010	2020	2030	2040
Over $5/lb	9	11	15	21	28	37
Over $10/lb	1	2	3	3	5	6
Over $15/lb	1	1	1	2	2	3
Over $20/lb	0	1	1	1	1	2
Over $25/lb	0	0	0	1	1	1
Over $30/lb	0	0	0	0	0	0
Over $0/lb	100	126	170	228	307	412

Approximate Tons of Cargo + Tare per Aircraft: 324

Appendix F-5

TEU Projection	6.0% Annual Growth Rate to 2000 6.0% Annual Growth After 2000

Export TEU	Base	6.0%	6.0% Annual Growth			
Far East	1992	2000	2010	2020	2030	2040
Over $5/lb	63,762	101,628	182,000	325,933	583,697	1,045,313
Over $10/lb	12,525	19,963	35,751	64,024	114,657	205,333
Over $15/lb	4,926	7,851	14,060	25,180	45,094	80,756
Over $20/lb	3,135	4,997	8,948	16,025	28,699	51,395
Over $25/lb	2,261	3,604	6,454	11,558	20,698	37,067
Over $30/lb	2,040	3,251	5,823	10,428	18,675	33,443
Over $0/lb	2,569,114	4,094,777	7,333,123	13,132,506	23,518,318	42,117,725

Import TEU	Base	6.0%	6.0% Annual Growth			
Far East	1992	2000	2010	2020	2030	2040
Over $5/lb	603,531	961,936	1,722,681	3,085,059	5,524,872	9,894,204
Over $10/lb	88,484	141,030	252,563	452,302	810,005	1,450,595
Over $15/lb	12,845	20,473	36,664	65,660	117,586	210,579
Over $20/lb	8,817	14,053	25,167	45,070	80,713	144,545
Over $25/lb	6,333	10,094	18,077	32,372	57,974	103,822
Over $30/lb	6,287	10,021	17,945	32,137	57,553	103,068
Over $0/lb	3,424,740	5,458,515	9,775,369	17,506,198	31,350,934	56,144,748

Export TEU	Base	6.0%	6.0% Annual Growth			
Europe	1992	2000	2010	2020	2030	2040
Over $5/lb	79,429	126,597	226,716	406,015	727,110	1,302,144
Over $10/lb	18,084	28,823	51,618	92,440	165,545	296,467
Over $15/lb	9,038	14,405	25,798	46,199	82,736	148,168
Over $20/lb	3,060	4,877	8,734	15,642	28,012	50,165
Over $25/lb	1,975	3,148	5,637	10,096	18,080	32,378
Over $30/lb	1,556	2,480	4,441	7,954	14,244	25,509
Over $0/lb	1,274,167	2,030,829	3,636,905	6,513,143	11,664,046	20,888,530

Import TEU	Base	6.0%	6.0% Annual Growth			
Europe	1992	2000	2010	2020	2030	2040
Over $5/lb	118,087	188,213	337,061	603,626	1,081,001	1,935,909
Over $10/lb	19,510	31,096	55,688	99,729	178,599	319,844
Over $15/lb	9,707	15,471	27,707	49,619	88,860	159,135
Over $20/lb	5,424	8,645	15,482	27,726	49,653	88,920
Over $25/lb	3,209	5,115	9,160	16,403	29,376	52,608
Over $30/lb	996	1,587	2,843	5,091	9,118	16,328
Over $0/lb	1,310,576	2,088,859	3,740,828	6,699,254	11,997,343	21,485,415

Appendix F-6

Aircraft Required	36 Teu per Aircraft 7 Days per Week Service

Far East	Base	6.0%	6.0% Annual Growth			
Export	1992	2000	2010	2020	2030	2040
Over $5/lb	5	8	14	25	44	80
Over $10/lb	1	2	3	5	9	16
Over $15/lb	0	1	1	2	3	6
Over $20/lb	0	0	1	1	2	4
Over $25/lb	0	0	0	1	2	3
Over $30/lb	0	0	0	1	1	3
Over $0/lb	196	312	558	999	1,790	3,205

Import TEU	Base	6.0%	6.0% Annual Growth			
Far East	1992	2000	2010	2020	2030	2040
Over $5/lb	46	73	131	235	420	753
Over $10/lb	7	11	19	34	62	110
Over $15/lb	1	2	3	5	9	16
Over $20/lb	1	1	2	3	6	11
Over $25/lb	0	1	1	2	4	8
Over $30/lb	0	1	1	2	4	8
Over $0/lb	261	415	744	1,332	2,386	4,273

Export TEU	Base	6.0%	6.0% Annual Growth			
Europe	1992	2000	2010	2020	2030	2040
Over $5/lb	6	10	17	31	55	99
Over $10/lb	1	2	4	7	13	23
Over $15/lb	1	1	2	4	6	11
Over $20/lb	0	0	1	1	2	4
Over $25/lb	0	0	0	1	1	2
Over $30/lb	0	0	0	1	1	2
Over $0/lb	97	155	277	496	888	1,590

Import TEU	Base	6.0%	6.0% Annual Growth			
Europe	1992	2000	2010	2020	2030	2040
Over $5/lb	9	14	26	46	82	147
Over $10/lb	1	2	4	8	14	24
Over $15/lb	1	1	2	4	7	12
Over $20/lb	0	1	1	2	4	7
Over $25/lb	0	0	1	1	2	4
Over $30/lb	0	0	0	0	1	1
Over $0/lb	100	159	285	510	913	1,635

Approximate Tons of Cargo + Tare per Aircraft: 324

Appendix F-7

TEU Projection	9.0% Annual Growth Rate to 2000 9.0% Annual Growth After 2000

Export TEU	Base	9.0%	9.0% Annual Growth			
Far East	1992	2000	2010	2020	2030	2040
Over $5/lb	63,762	127,051	300,775	712,044	1,685,666	3,990,586
Over $10/lb	12,525	24,957	59,082	139,868	331,119	783,880
Over $15/lb	4,926	9,815	23,237	55,009	130,227	308,295
Over $20/lb	3,135	6,247	14,788	35,009	82,879	196,205
Over $25/lb	2,261	4,505	10,665	25,249	59,773	141,505
Over $30/lb	2,040	4,065	9,623	22,781	53,931	127,674
Over $0/lb	2,569,114	5,119,121	12,118,820	28,689,654	67,918,846	160,788,609

Import TEU	Base	9.0%	9.0% Annual Growth			
Far East	1992	2000	2010	2020	2030	2040
Over $5/lb	603,531	1,202,573	2,846,927	6,739,711	15,955,346	37,772,107
Over $10/lb	88,484	176,310	417,390	988,113	2,339,223	5,537,792
Over $15/lb	12,845	25,594	60,591	143,442	339,579	803,907
Over $20/lb	8,817	17,568	41,591	98,461	233,092	551,814
Over $25/lb	6,333	12,619	29,874	70,721	167,423	396,352
Over $30/lb	6,287	12,527	29,657	70,208	166,207	393,473
Over $0/lb	3,424,740	6,824,009	16,154,911	38,244,549	90,538,757	214,338,165

Export TEU	Base	9.0%	9.0% Annual Growth			
Europe	1992	2000	2010	2020	2030	2040
Over $5/lb	79,429	158,267	374,675	886,991	2,099,831	4,971,063
Over $10/lb	18,084	36,034	85,304	201,947	478,081	1,131,791
Over $15/lb	9,038	18,009	42,633	100,929	238,935	565,645
Over $20/lb	3,060	6,097	14,434	34,171	80,896	191,511
Over $25/lb	1,975	3,935	9,316	22,055	52,212	123,606
Over $30/lb	1,556	3,100	7,340	17,376	41,135	97,383
Over $0/lb	1,274,167	2,538,858	6,010,399	14,228,801	33,684,746	79,744,044

Import TEU	Base	9.0%	9.0% Annual Growth			
Europe	1992	2000	2010	2020	2030	2040
Over $5/lb	118,087	235,296	557,032	1,318,698	3,121,838	7,390,525
Over $10/lb	19,510	38,875	92,031	217,871	515,780	1,221,038
Over $15/lb	9,707	19,342	45,789	108,399	256,621	607,515
Over $20/lb	5,424	10,808	25,586	60,571	143,393	339,462
Over $25/lb	3,209	6,394	15,137	35,835	84,835	200,836
Over $30/lb	996	1,985	4,698	11,122	26,331	62,335
Over $0/lb	1,310,576	2,611,405	6,182,145	14,635,385	34,647,279	82,022,710

Appendix F-8

Aircraft Required	**36 Teu per Aircraft** **7 Days per Week Service**

Far East	**Base**	**9.0%**	**9.0% Annual Growth**			
Export	**1992**	**2000**	**2010**	**2020**	**2030**	**2040**
Over $5/lb	5	10	23	54	128	304
Over $10/lb	1	2	4	11	25	60
Over $15/lb	0	1	2	4	10	23
Over $20/lb	0	0	1	3	6	15
Over $25/lb	0	0	1	2	5	11
Over $30/lb	0	0	1	2	4	10
Over $0/lb	196	390	922	2,183	5,169	12,237

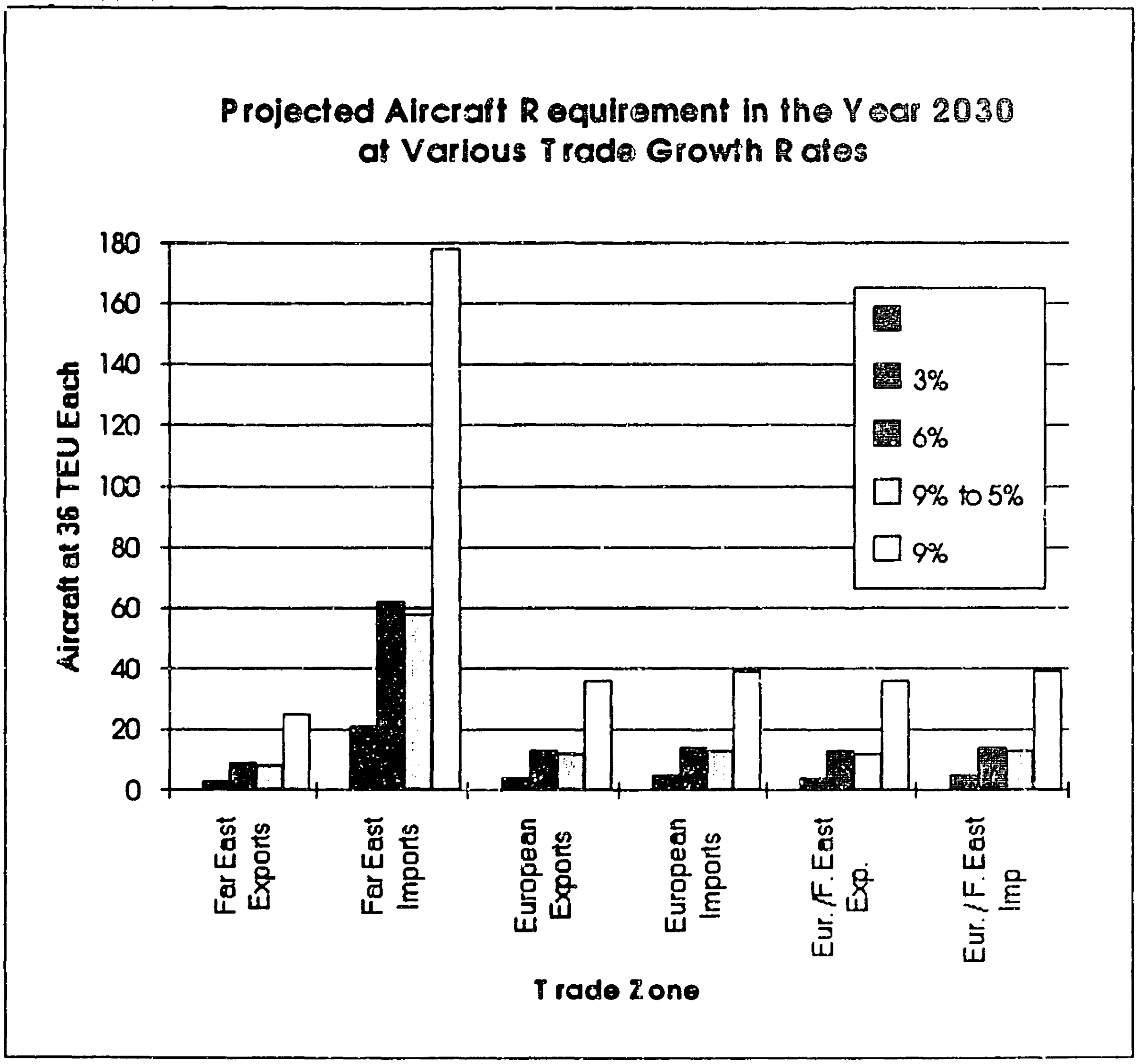
Import TEU	**Base**	**9.0%**	**9.0% Annual Growth**			
Far East	**1992**	**2000**	**2010**	**2020**	**2030**	**2040**
Over $5/lb	46	92	217	513	1,214	2,875
Over $10/lb	7	13	32	75	178	421
Over $15/lb	1	2	5	11	26	61
Over $20/lb	1	1	3	7	18	42
Over $25/lb	0	1	2	5	13	30
Over $30/lb	0	1	2	5	13	30
Over $0/lb	261	519	1,229	2,911	6,890	16,312

Export TEU	**Base**	**9.0%**	**9.0% Annual Growth**			
Europe	**1992**	**2000**	**2010**	**2020**	**2030**	**2040**
Over $5/lb	6	12	29	68	160	378
Over $10/lb	1	3	6	15	36	86
Over $15/lb	1	1	3	8	18	43
Over $20/lb	0	0	1	3	6	15
Over $25/lb	0	0	1	2	4	9
Over $30/lb	0	0	1	1	3	7
Over $0/lb	97	193	457	1,083	2,564	6,069

Import TEU	**Base**	**9.0%**	**9.0% Annual Growth**			
Europe	**1992**	**2000**	**2010**	**2020**	**2030**	**2040**
Over $5/lb	9	18	42	100	238	562
Over $10/lb	1	3	7	17	39	93
Over $15/lb	1	1	3	8	20	46
Over $20/lb	0	1	2	5	11	26
Over $25/lb	0	0	1	3	6	15
Over $30/lb	0	0	0	1	2	5
Over $0/lb	100	199	470	1,114	2,637	6,242

Approximate Tons of Cargo + Tare per Aircraft:	324

Appendix F, Figure 1



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