CURRENT AND FUTURE TRADING PROSPECTS FOR LARGE BULK CARRIERS IN THE IRON ORE AND COAL SEABORNE TRADES

by

George Constantinos Nicolaidis

B.Sc., Mechanical Engineering
Rensselaer Polytechnic Institute
(1982)

Submitted in partial fulfillment of the
requirements for the Degree of

MASTER OF SCIENCE

in

OCEAN SYSTEMS MANAGEMENT

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June, 1983

Signature of Author..
Department of Ocean Engineering, June 1983

Certified by..
Harilaos N. Psaraftis
Thesis Supervisor

Accepted by..
A. Douglas Carmichael
Chairman, Departmental Committee
on Graduate Students

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ABSTRACT

The present thesis is an analysis of the current and future trading prospects for large bulk carriers in the iron ore and coal seaborne trades in the context of current and future market trends.

The structure of the international iron ore and coal trades is reviewed and the past performance of large bulk carriers in these trades is quantified. The current and future market balance of the large bulk carrier sector is estimated based on available trade statistics and forecast trade growths. Economic investment and operating criteria are established and formulated into computer programs. Transport costs on major iron ore and coal trade routes are estimated and the differential economies of scale associated with different size bulk carriers are determined in order to comment on their respective trading potential.

Thesis Supervisor: Harilaos N. Psaraftis, Ph.D.

Title: Associate Professor of Marine Systems

ACKNOWLEDGEMENTS

This thesis is dedicated to my father and mother whose support throughout my life has been invaluable.

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INTRODUCTION

Traditionally iron ore movements have been occupying the largest share of the large - over 100,000 DWT - dry bulk sector.

Iron ore has to be shipped in large parcels in order to meet the needs of steel mills of the various industrialized nations, and importers and shippers have naturally sought to take advantage of the economies of scale offered by the utilization of large carriers.

However, the high shipbuilding costs associated with a large bulk carrier, and the limited trading potential - in bulk cargoes other than iron ore - that these carriers were facing during most of the 1970's, have forced shipowners to seek for an alternative kind of vessel with more diversified trading opportunities. This trend gave rise to the introduction of Ore-Bulk-Oil (OBO's) and Ore-Oil (O/O) combined carriers which have dominated the large - over 100,000 DWT - dry bulk sector during the past decade. Pure large bulk carriers - over 100,000 DWT - were considered by shipowners to be exhibiting a higher risk of unemployment and underemployment over combined carriers of comparative size, and a decision for the purchase of a large pure bulk carrier was most of the time undertaken only if it was backed by a long-term charter agreement that covered most of the vessel's economic life.

However, the oil crisis that hit most of the developed economies during the past decade has led to an ever increasing effort to substitute oil with alternative fuels which were plentiful in supply and of comparative cost. Naturally, thermal coal was the most prominent candidate since it exhibited all of the above qualities and, evenmore, its international trade was not controlled by any international cartels such as OPEC in the case of oil. The expansion of the thermal coal seaborne trade that took place after 1975 and the publication of a large number of optimistic reports on the prospects for thermal coal trades at the same time the dry bulk market was booming in 1979/80 - which was the result of the relative strength of the steel industry and of a combination of other factors - has led to a rejuvenation of the prospects for large bulk carriers and a vast amount of tonnage ordering was placed at the time. However, only a few dismal pessimists would have predicted three years ago that rates would have collapsed to present levels and that a record number of bulk carriers would be in lay-up. The currently depressed state of the dry bulk industry is the natural consequence of the resulted excessive surplus tonnage and the unexpected decrease in demand. Shipowners, faced with high capital costs for their new vessels, have found it extremely difficult to operate with the low freight rates that persist currently and many have chosen to lay-up their vessels awaiting for the expected world economic recovery to enter the market again.

In the chapters to follow, the present and future performance and trading prospects of the large bulk carrier fleet in the predominant iron ore and coal trades will be examined, and the present and future supply schedules of the large dry bulk sector will be estimated based on forecast trade growths, economic investment and operating criteria will be established, the transport costs on major iron ore and coal trade routes are to be estimated - in order to determine the differential economies of scale associated with different size bulk carriers and hence their trading potential - and finally conclusions are to be drawn based on the material presented.

This study differentiates itself by other similar ones [1],[2],[3],[4],[5],[8] in the following ways:

(1) It provides additional statistics on the performance of large carriers over the past years, especially in the case of the iron ore trades where the latest report known to the writer ("The Prospects for Seaborne Iron Ore Trade and Transportation" by H. P. Drewry)[3] was published in 1979.

(2) It uses present statistics and forecast trade growth prospects published elsewhere to estimate the current and future market balance of the large bulk carrier sector in order to give a feeling about the future state of the dry bulk freight rates.

(3) It presents the reader with the formulation of an investment decision and operating model which lends itself to computer programming. Using this model the required freight rate necessary to justify an investment in large bulk carriers (with 1983 shipbuilding prices) is estimated.

(4) It estimates transport costs resulting from the use of bulk carriers of different sizes for major iron ore and coal routes and also presents transport costs as a function of distance in order to approximate the economies of scale associated with

each size category and hence conclude on the maximum bulk carrier size which is economically attractive to shippers.

(5) It presents the reader with investment and operating decision computer programs written for a handheld calculator. The programs are designed to be 'user friendly' in the sense that they prompt the user for the necessary inputs utilizing English language statements. The reader interested in the use of these programs is not required to have any previous experience with computers. Thus, the program user is supplied with a fast and easy to use portable tool to aid him in his everyday operations - a necessity in the case of shipowners operating in the competitive shipping markets.

This analysis is not concerned with the historical evolution of the long-term chartering or single voyage chartering practices, or any draft and age profile comparisons of the large bulk carrier sector since these can be found in the available literature.[1],[2],[3],[4],[5] Also, it does not take into consideration any port constraints and developments for large bulk carriers since the subject has been thoroughly covered in a recently (1982) published H. P. Drewry report.[6]

CHAPTER 1

INTERNATIONAL IRON ORE AND COAL SEABORNE TRADE

The dry bulk trade is dominated by three commodities. Not only do shipments of iron ore, coal and grain account for over one third of all dry cargo entering seaborne trade, but they also represent close to half the total dry bulk transport ton-miles requirements, as Table 1 reveals. Pure dry bulk carriers presently meet about two-thirds of the transport requirement generated by dry bulk cargo shipments. The remainder is, in the main, accounted for by combined carriers, like OBOs, ore/oil carriers, etc. Table 2 shows the amount of volume of bulk cargo shipped in pure bulk carriers in the period 1971-81. As it can be seen from this table, iron ore and coal were responsible for almost 40 percent of all dry bulk cargo lifted by dry bulk carriers in 1981.

Significantly, the quantities of iron ore shipped in bulk carriers stabilized and then declined during the 1970's, as the number of combined carriers deployed in this trade increased. In 1981, as Table 2 reveals, iron ore accounted for 20 percent of the total volume of cargo lifted by bulk carriers, compared to 40 percent in 1971. In 1981, coal accounted for 20 percent of the total volume of cargo lifted by bulk carriers, compared to 15 percent in 1976 and 14 percent in 1971.

1.1 International Iron Ore Trade

Prior to the recession in the steel industry and the resulting slump in ore demand, the iron ore industry experienced a tremendous rate of growth. Presently, close to half the world's supply of iron ore is exported, mainly by sea.

TABLE-1

WORLD SEABORNE TRADE OF MAIN BULK COMMODITES 1971-81

In Million Metric Tons	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Iron Ore	250	247	298	329	292	294	276	278	327	314	303
Coal	94	96	104	119	127	127	132	127	159	188	210
Grain	91	108	139	130	137	146	147	169	182	198	206
Other Cargo	70	73	81	90	79	79	90	93	94	96	87
Total	505	524	622	668	635	646	645	667	762	796	806
In Billion Ton-Miles											
Iron Ore	1185	1156	1398	1578	1471	1469	1386	1384	1599	1613	1508
Coal	434	444	467	558	621	591	643	604	786	952	1120
Grain	487	548	760	695	734	779	801	945	1026	1087	1131
Other Cargo	229	252	292	326	295	283	327	330	246	359	311
Total	2335	2400	2917	3157	3121	3122	3157	3263	3757	4011	4070

Data derived from Ref. [10]

TABLE-2

SEABORNE BULK CARGO SHIPPED IN BULK CARRIERS: 1971-81

(million tons)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Iron Ore	202.2	204.1	242.2	222.1	188.6	183.4	162.0	159.0	162.2	138.0	142.5
Coal	61.4	69.0	73.2	80.5	86.4	88.9	94.2	94.0	104.6	133.0	143.0
Other Cargo	177.4	229.9	257.6	276.4	292.2	334.7	386.8	421.9	441.8	459.0	439.5
TOTAL	441.0	503.0	573.0	579.0	567.0	607.0	643.0	674.9	708.6	730.0	725.0

Data derived from Ref. [10]

The largest ore producers are Europe (including the USSR) and North America, although both are net importers of iron ore. The structure of international trade is relatively complex but within each continent one can identify a dominant supplier. These are: Sweden (Europe); Canada (North America); Brazil (South America); South Africa (Africa); India (Asia) and Australia (Oceania). Other countries like Venezuela, Liberia and Chile are also major exporters of iron ore.

The major consumers of iron ore are the European Economic Community (EEC), the USSR, the United States and Japan. The import requirements, in million tons, of the three major consuming areas, the EEC, the U.S. and Japan, are listed in Table 3 for the period 1971-81. From this table we see that Japan is the most important consumer importing 123.3 million tons in 1981, followed by the EEC which imported 97.0 million tons in 1981 and the U.S. with 19.5 million tons in 1981.

While the tonnage figures listed in Table 3 enable us to identify the development of the iron ore import requirments for the three major market areas, they are a poor indicator of the importance of individual routes in terms of the transport capacity utilized. The concept ton-miles (volume x distance) is employed in Table 4 to show the transport requirements generated by the shipment of iron ore to the EEC, Japanese and U.S. markets. From this table we see that Japan was responsible for 768 billion ton-miles in 1981 (about 59 percent of the total) followed by the EEC which was responsible for 494 billion ton-miles in 1981 (37.5 percent) and the U.S. with 49 billion ton-miles (3.7 percent). From the same table we see that the total ton-miles figures performed in the international iron ore trades have declined since 1979/80 when they

TABLE-3

SEABORNE IRON ORE IMPORTS OF THE PRINCIPAL MARKETS: 1971-81

(million tons)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
E.E.C	93.5	97.1	117.4	131.5	104.5	115.6	102.6	110.5	110.9	98.5	97.0
U.S.A	26.6	22.4	27.6	34.0	33.1	25.7	19.6	20.7	22.7	16.7	19.5
JAPAN	114.9	111.5	134.7	141.8	131.7	133.7	132.6	114.7	130.3	133.7	123.3
TOTAL	235.0	231.0	279.7	307.3	269.3	275.0	254.8	245.9	263.9	248.9	239.8

Data derived from Ref. [10]

TABLE-4

TON-MILES PERFORMED ON IRON ORE TRADE ROUTES TO THE PRINCIPAL MARKETS: 1971-81

(billion ton-miles)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
E.E.C	332	341	434	524	481	515	454	494	550	497	494
U.S.A	74	66	79	92	96	78	55	61	57	41	49
JAPAN	719	672	801	901	831	839	812	709	813	837	768
OTHERS	-	-	-	-	-	-	-	120	179	238	197
TOTAL	1125	1079	1314	1517	1408	1432	1321	1384	1599	1613	1508

Data derived from Ref:[10]

TABLE-5

AVERAGE TRANSPORT DISTANCES ON ROUTES TO THE PRINCIPAL IRON ORE MARKETS: 1971-81

(N.Miles)

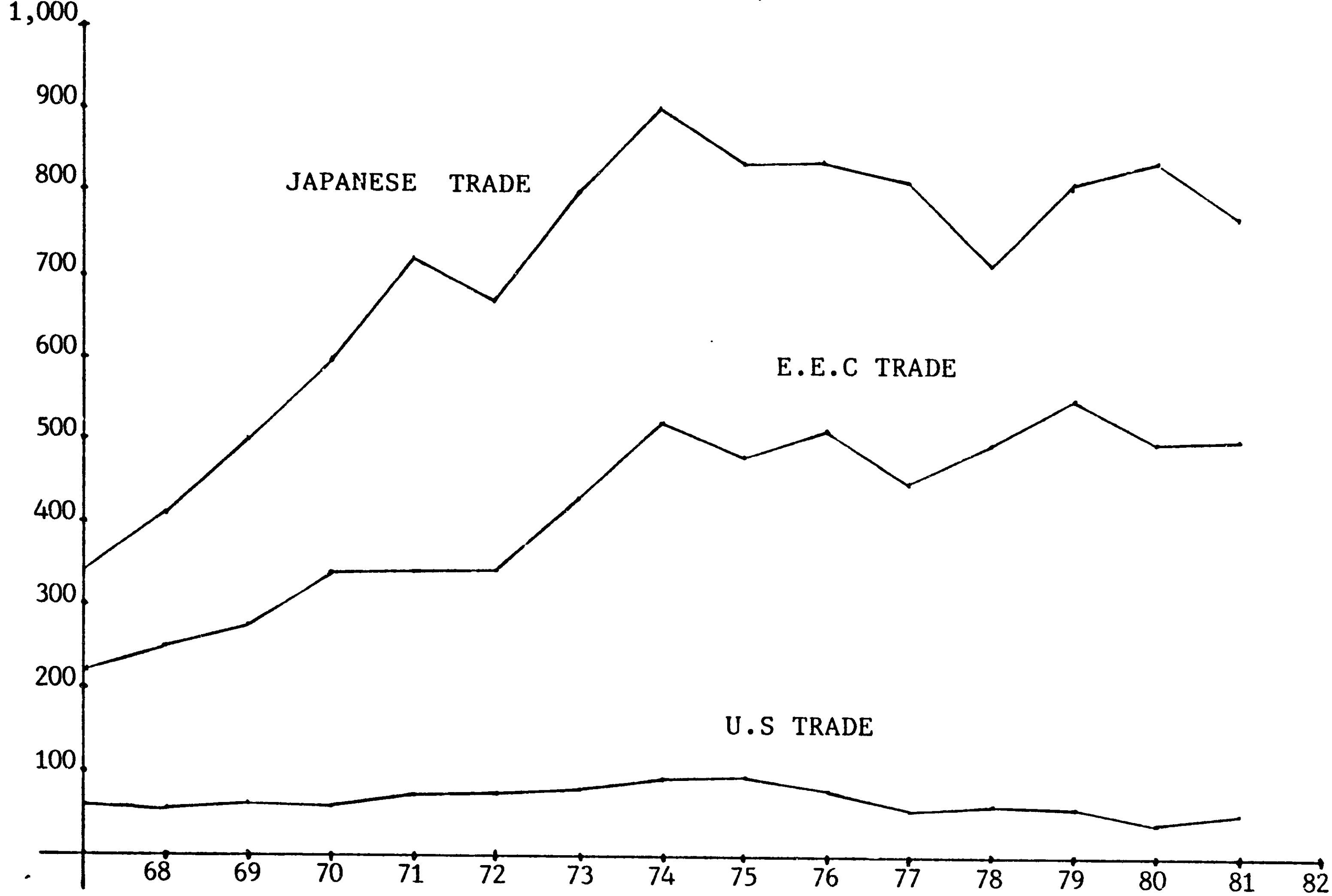
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
E.E.C	3551	3512	3697	3985	4603	4455	4425	4471	4959	5046	5093
U.S	2782	2946	2862	2706	2900	3035	2806	2947	2511	2455	2513
JAPAN	6258	6027	5947	6354	6310	6275	6124	6181	6239	6260	6229
AVERAGE	4787	4671	4698	4937	5228	5207	5184	5140	5381	5524	5467

Derived data from Tables 3 and 4.

FIGURE-1

THE GROWTH OF SEABORNE IRON ORE TRADE

(billion ton-miles)



reached a record number of about 1,600 billion ton-miles, compared to about 1,500 billion ton-miles in 1981.

From Table 5 we see that the average transport distance of the iron ore trade as a whole has been stabilized around 5,500 N miles in 1980 and 1981 compared to around 4,700 N miles in 1971, indicating an increasing dependence on more distant sources.

Figure 1 presents diagramatically the growth of the seaborne iron ore trade, in terms of ton-miles, for the three major ore importing areas. It is interesting to note that since 1974 the growth pattern has stopped and it seems that the figures of ton-miles performed annually have reached a plateau coinciding with the recession in the steel industry.

1.1.1 Future Prospects for Iron Ore Trade and Transport Requirements

The international seaborne iron ore trade obviously depends upon the state of the world steel industry - the trends in the world steel industry largely determining the state of the large bulk carrier sector. Currently over 50 percent of these vessels are in the iron ore trades and 25 percent in coal both metallurgical and steam.

The general reappraisal of the philosophy of size and cost which took place as a result of the oil price increases of the 1970's has been most influential in the area of steel consumption. As Table 6 suggests, world steel production has been declining since 1978, with 707.3 million tons produced in 1981 compared to 747.5 million tons in 1979. Europe and Japan, which are the two steel producing centers of vital importance for the shipping markets, both seem to be facing the prospect of extremely limited growth in crude steel production for many years to come, and any

TABLE-6

WORLD CRUDE STEEL PRODUCTION: 1972-81

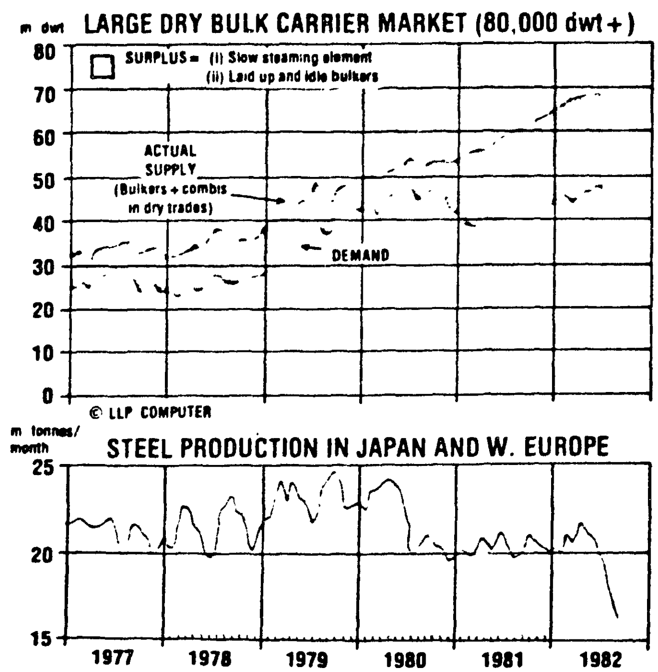
(million tons/year)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
JAPAN	96.9	119.3	117.1	102.3	107.4	102.4	102.1	111.8	111.4	101.7
W. EUROPE	166.2	179.6	186.7	154.7	163.7	155.3	163.8	174.0	161.7	158.5
KOREA	0.6	1.2	2.0	2.0	3.5	4.4	5.0	7.6	8.6	10.8
N. AMERICA	132.7	150.2	145.8	118.8	129.4	127.3	139.2	139.3	117.6	123.6
E. EUROPE	176.6	178.3	185.1	192.6	199.0	204.2	211.1	209.8	209.2	207.0
OTHERS	63.2	68.4	66.4	71.8	71.2	80.1	92.4	102.9	104.1	102.2
TOTAL	630.7	697.6	704.1	643.3	676.0	675.7	717.2	747.5	717.2	707.3

Ref. [8],[11]

FIGURE-2

THE LARGE DRY BULK CARRIER MARKET AND STEEL PRODUCTION IN JAPAN AND W.EUROPE



Source: Ref. [12]

increase in production will probably be located in developing countries, many of which will be much closer to their sources of raw material supply.

So far, evidence seems strongly to suggest that:

(1) Steel production will lag behind the general economic recovery in Europe and Japan, if the recovery materializes in the near future.

(2) Iron ore demand per ton of steel produced will decline.

(3) Iron ore ton-miles will fall relatively to the volume of iron ore being shipped.

Iron ore ton-miles, as Figure 1 suggests, have been on a plateau since the strong growth pattern in the late 1960's and early 1970's came to a halt in 1974, and evidently it is really improbable to see shipping demand in this sector to move ahead to any extent for several years to come. The figure of 1,600 billion ton-miles attained in the major areas iron ore trade in 1979 and almost repeated in 1980 according to Fearnleys,[7] may in fact mark the high point for the foreseeable future.

The graphs presented in Figure 2 illustrate how the state of the large bulk carrier sector is influenced by the state of the world steel output. The tonnage demand in the large bulk carrier sector, having moved upwards in 1979 and 1980 following the recovery in steel output that took place over the same period, has slumped over the past two years following the sharp decline in Japanese and W. European steel output.

As a conclusion, we may state that the iron ore trade is not promising any great surge in demand for bulk carrier tonnage, given the present sorry state of the world steel industry. In the near future, 1985 or so, and if the world economic recovery ever materializes, we can expect demand to return to 1979-80 levels when about 1,600 billion ton-miles were performed in the major trading areas. Predictions, as far as the end of the decade is concerned, are hard to establish given the economic uncertainty that prevails at the present time. However, a safe bet would be a moderate increase over 1979-80 figures, say of the order of 5 percent, or approximately 1,700 billion ton-miles.

1.2 International Coal Trade

In the early 1970's, seaborne coal trade was mostly composed of coal of coking quality for the needs of the world's steel making industry. However, the growing concern over the increasing cost of oil has resulted in an increase of steam coal demand for the needs of the energy generation plants.

However, despite the recent growth in steam coal exports, world coal trade is small in relation to the total output. Not more than 10 percent of the world's coal production moves in international trade, mainly because the largest producers, the U.S., the EEC, the USSR and China, are also the largest consumers. Nevertheless seaborne coal trade has increased rather fast since 1972 rising, as Table 7 suggests, from 99.7 million tons to 207.7 million tons in 1981.

The largest coal producers engaged in international seaborne trade are, in order of importance, the U.S. (86.2 million tons in 1981); Australia (48.9 million tons); South Africa (28.6 million tons); Canada (10.0 million tons) and Poland (8.6 million tons). A historical overview

TABLE-7

WORLD SEABORNE TRADE IN HARD COAL: 1972-81

(million tons)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
EXPORTERS										
U.S.A	38.4	35.4	45.8	48.0	44.1	38.0	26.1	42.3	66.8	86.2
CANADA	7.7	10.7	10.2	11.6	11.4	12.0	13.9	13.7	14.8	16.0
AUSTRALIA	22.9	27.1	27.9	29.1	32.4	34.7	35.8	38.9	43.1	48.9
S. AFRICA	1.2	1.2	1.6	1.8	5.6	11.3	14.2	22.1	27.3	28.6
POLAND	15.2	18.3	23.6	22.7	23.6	24.3	24.6	25.1	22.3	8.6
OTHERS	13.8	15.4	17.2	16.0	14.6	15.6	13.9	13.2	14.3	19.4
IMPORTERS										
W. EUROPE	46.5	46.4	55.8	60.0	62.5	65.1	65.3	78.3	97.8	103.7
N. AMERICA	0.3	0.4	1.7	1.0	1.2	1.6	2.9	2.2	1.9	2.2
JAPAN	49.2	56.9	64.1	62.1	60.8	60.8	52.2	58.8	69.1	78.9
OTHERS	3.7	4.4	4.7	6.1	7.2	8.4	8.1	16.0	14.7	21.2

Ref. [10]

of the growth of the international coal trade from 1972 to 1981 is presented in Table 7.

When it comes to importing countries, Western Europe, as a group, represents the largest market for imported coals, receiving in 1981 over 100 million tons by sea as Table 7 shows. The other primary market is Japan which imported 78.9 million tons of coal in 1981. Northern American and other areas were responsible for another 23.5 million tons as the same table suggests.

From Table 7 we also see that the international seaborne coal trade experienced its most abrupt growth over the period 1977-81, mostly as a result of the substitution of thermal coal as an alternative fuel to oil.

A break-down of the seaborne coal trade by source of destination and major importing areas is supplied in Table 8. It is interesting to observe the growing pattern in coal imports of other Far East markets, besides Japan, who have increased by a factor of five since 1977. Far East developing economies, like Korea and Taiwan, imported 13.5 million tons of seaborne coal in 1981, compared to 2.4 million tons in 1977, as Table 8 suggests.

The concept ton-miles (volume x distance) is again used in Table 9 to indicate the importance of each importing area in terms of ton-miles requirements. The EEC and Japan were the largest generators of ton-miles requirements with 431.4 billion ton-miles (38.7 percent) and 407.2 billion ton-miles (36.5 percent) in 1981 respectively, followed by other Far Eastern markets with 95.6 billion ton-miles (8.0 percent), as Table 9 suggests.

TABLE-8

SEABORNE COAL TRADE TO MAJOR IMPORTING AREAS: 1970-81

(million tons)

From \ To	1970	1975	1977	1978	1979	1980	1981
	JAPAN						
AUSTRALIA	16.5	23.0	26.4	25.1	26.9	29.1	34.3
S. AFRICA	0.3	-	2.5	2.5	2.4	3.1	4.3
U.S.A	25.1	23.1	15.2	9.3	14.0	20.5	23.6
CANADA	3.7	10.8	10.8	10.3	10.6	11.2	10.4
POLAND	0.9	1.1	0.8	0.7	0.5	0.4	-
U.S.S.R	2.6	3.3	-	-	-	-	-
U.K	-	-	-	-	-	-	-
OTHER	-	1.0	2.5	5.0	5.1	4.4	5.4
TOTAL	49.1	62.3	58.2	52.9	59.5	68.7	78.0
	E.E.C						
AUSTRALIA	0.9	5.7	6.8	8.2	7.4	6.4	8.1
S. AFRICA	0.8	1.6	7.6	10.6	13.6	20.9	20.4
U.S.A	15.5	13.4	10.3	7.4	16.4	29.3	34.3
CANADA	0.2	0.8	0.9	1.1	1.0	0.9	2.6
POLAND	10.3	14.6	14.4	15.2	17.3	12.4	6.2
U.S.S.R	4.4	3.7	-	-	-	-	-
U.K	2.8	1.9	-	-	-	-	-
OTHER	2.9	3.7	12.6	9.5	11.8	11.6	14.0
TOTAL	37.8	43.4	52.6	52.0	67.5	81.5	85.6
	OTHER FAR EAST						
AUSTRALIA	-	-	0.4	2.2	3.6	3.7	5.1
S. AFRICA	-	-	-	0.9	2.9	3.1	1.2
U.S.A	-	-	-	0.4	1.6	4.2	6.6
CANADA	-	-	-	0.2	-	-	-
POLAND	-	-	0.2	-	-	-	-
U.S.S.R	-	-	-	-	-	-	-
U.K	-	-	-	-	-	-	-
OTHER	-	-	1.8	-	-	0.2	0.1
TOTAL	-	-	2.4	4.4	8.7	12.6	13.5

Estimated data. Derived from Ref. [10]

TABLE-9

ESTIMATED SEABORNE COAL TRADE FROM MAJOR EXPORTING/IMPORTING AREAS

(billion ton-miles)

	1977	1978	1979	1980	1981
JAPAN	332.3	273.0	321.9	397.1	407.2
OTHER FAR EAST	7.6	24.1	55.4	82.2	95.6
E.E.C	233.5	256.9	308.5	383.9	431.4
OTHERS	80.2	71.8	99.3	124.2	182.1
TOTAL IMPORTS	653.6	625.8	785.1	987.4	1116.3
AUSTRALIA	223.6	247.8	246.8	250.6	298.9
S. AFRICA	72.0	94.2	117.5	180.2	188.0
U.S.A	217.4	146.1	254.2	406.6	489.0
CANADA	59.6	63.9	71.0	75.7	83.4
POLAND	55.6	51.3	60.9	46.7	26.2
OTHER	25.4	22.5	34.7	27.6	30.8
TOTAL EXPORTS	653.6	625.8	785.1	987.4	1116.3

Estimated data. Derived from Ref. [10]

TABLE-10

AVERAGE TRANSPORT DISTANCES ON ROUTES TO PRINCIPAL COAL MARKETS: 1977-81

(n.miles)

	1977	1978	1979	1980	1981
JAPAN	5710	5161	5410	5780	5221
E.E.C	4439	4940	4570	4710	5040
OTHER FAR EAST	3167	5477	6368	6524	7081
AVERAGE	4439	4830	4940	5060	5330

Data derived from Tables 9 and 7.

From the same table we see that the total ton-miles figures performed in the international coal trade have almost doubled since 1977, reaching 1,116.3 billion ton-miles in 1981 compared to 653.6 billion ton-miles in 1977.

From Table 10 we see that average transport distance of the sea-borne coal trade as a whole has increased to approximately 5,330 N miles in 1981 compared to approximately 4,400 in 1977, indicating an increasing dependence on more distant sources, like South Africa and Canada.

1.2.1 Future Prospects for Coal Trade and Transport Requirements

Clearly there are numerous factors that are directly relevant to the estimation of future coal trade volumes, these ranging from oil price developments (which govern both energy demand and energy source choice) to steel production in the developed economies.

With regard to the outlook for steel production and consequently coking coal demand, the foreseen limited demand development for steel will generate only limited coking coal trade growth, at least in the short-run, given the continued recession in the world's industrialized economies.

However, the Far Eastern developing economies with their growing steel industries could have a positive effect on the demand for coking coal.

With regard to the outlook for thermal coal trade development, falling oil prices could raise a pessimistic possibility for future demand. However, it is sometimes forgotten that coal has already been established as an alternative energy source and that coal trades have grown significantly between 1977 and 1981.

The dependence of the world's energy sector on coal of thermal quality has probably reached a plateau, given the cutback over the past years for energy demand, and therefore a marginal change in oil prices might not have any substantial effect on thermal coal consumption and trade. Although the official price of oil has recently fallen to $27-29 per barrel, it is not anticipated that the fall will be precipitous. The present inelastic demand for oil would mean that OPEC would have nothing to gain from allowing prices to fall too far.

The conclusion to be drawn for the thermal coal trade is that a fall in the price of oil is unlikely to reduce the level of trade and that there is a good possibility that the trade would be stimulated on the strength of increased energy demand given the expected economic recovery.

The data reproduced in Table 11 summarizes forecasts for seaborne coal demand by region and type - coking or thermal coal - for the period 1985-1995, produced by three different agencies, Cargo Systems Research Consultants,[8] H. P. Drewry[5] and Petroleum Economics Limited.[9] As can be seen from Table 11, forecasts produced by the three agencies tend to diverge. The data supplied by Cargo Research Consultants seems to be on the conservative side, and given that it is the most recently published one (1982), it is probably the safest to accept, the forecast coal trade volumes probably being closer to short-term expectations as they have been rejuvenated after the reduction in oil prices that occurred earlier this year.

TABLE-11

FORECAST SEABORNE COAL DEMAND BY REGION AND TYPE 1985/90/95

(million tons)

TYPE	1985			1990			1995		
	Ref [8]	Ref.[5]	Ref.[9]	Ref.[8]	Ref.[5]	Ref.[9]	Ref.[8]	Ref.[5]	Ref.[9]
THERMAL COAL									
JAPAN	25.8	22.0	24.0	44.0	53.5	35.0	66.0	-	55.0
OTHER FAR EAST	24.0	14.5	10.0	48.0	33.0	13.0	63.0	-	18.0
E.E.C	45.0	73.5	88.0	58.0	124.0	127.0	69.0	-	152.0
OTHER W. EUROPE	11.4	14.5		27.0	27.0		35.0	-	
OTHER AREAS	6.6	8.5	-	7.0	19.5	-	7.0	-	-
TOTAL	112.8	133.0	117.0	189.0	257.0	175.0	240.0	-	225.0
COKING COAL									
JAPAN	66.8	70.5	-	70.0	79.0	-	75.0	-	-
OTHER FAR EAST	12.2	10.0	-	17.0	16.0	-	22.0	-	-
E.E.C	46.8	28.3	-	50.0	34.0	-	54.0	-	-
OTHER W. EUROPE	15.1	10.7	-	16.0	14.0	-	18.0	-	-
OTHER AREAS	5.7	17.5	-	6.0	27.0	-	6.0	-	-
TOTAL	146.6	137.0	-	159.0	170.0	-	175.0	-	-
AREA TOTAL									
JAPAN	92.6	92.5	-	119.0	132.5	-	141.0	-	-
OTHER FAR EAST	36.2	24.5	-	65.0	49.0	-	85.0	-	-
E.E.C	91.8	101.8	-	108.0	158.0	-	123.0	-	-
OTHER W. EUROPE	26.5	25.2	-	43.0	41.0	-	53.0	-	-
OTHER AREAS	12.3	26.0	-	13.0	46.5	-	13.0	-	-
TOTAL	259.4	270.0	-	348.0	427.0	-	415.0	-	-

TABLE-12

FORECAST WORLD SEABORNE COAL TRADE IN TON-MILES: 1985/90

(billion ton-miles)

	1981	1985	1990
JAPAN	407.2	595.0	688.0
OTHER FAR EAST	95.6	250.0	365.0
E.E.C	431.4	464.0	604.0
OTHER W. EUROPE	75.6	179.0	290.0
SOUTH AMERICA	35.7	55.0	60.0
OTHERS	70.8	67.0	70.0
TOTAL	1,116.3	1,610.0	2,077.0
AUSTRALIA	298.9	415.0	512.0
S. AFRICA	188.0	340.0	463.0
U.S.A	489.0	533.0	666.0
CANADA	83.4	220.0	282.0
POLAND	26.2	74.0	91.0
OTHERS	30.8	28.0	63.0
TOTAL	1,116.3	1,610.0	2,077.0

Ref. [8]

TABLE-13

FORECAST COAL TRADE VOLUMES, TON-MILES AND AVERAGE SH.DISTANCE

1970 / 95

(million tons/billion ton-miles/n.miles)

	Trade Volume	Ton-miles	Average Sh. Dist
1970	101.1	488.8	4,830
1975	126.1	621.0	4,925
1980	187.9	987.4	5,255
1985	259.3	1610.3	6,210
1990	348.0	2077.0	5,970
1995	415.0	2325.0	5,603

Ref.[8]

Table 12 presents forecast seaborne coal trade in terms of ton-miles for 1985-90, in comparison with actual 1981 figures, by importing and exporting areas, as supplied by Cargo Research Consultants (CRC). The total outlook for shipping demand in terms of trade volumes, ton-miles and average shipping distances has been summarized in Table 13. As it can be seen, shipping demand in the 1980-85 period is likely to increase by an estimated 63 percent in line, not only with rapid trade volume increase, but also as average shipping distance will show a development from 5.255 N miles in 1980 to 6,210 N miles in 1985. This increase will be due largely to the greater market share of long haul suppliers - mainly South Africa - within the total market. The expected growth for the Far East economies, other than Japan, will further support this trend.

By 1990 total coal trade shipping demand should aggregate to some 207.7 billion ton-miles, this representing a future 29 percent increase over 1985, although average shipping distance, as Table 13 suggests, will actually begin to decline as short haul exporters increase their share.

CHAPTER 2

THE LARGE BULK CARRIER FLEET (100,000+ DWT) AND ITS CHANGING MARKET ROLE IN THE COAL AND IRON ORE TRADES

Presently, large carriers - that is, those with a capacity of more that 100,000 DWT - form a relatively large part of the world's dry bulk fleet constituting almost 30 percent of the total tonnage, if one includes combined carriers. At the moment pure bulk carriers are outnumbered by large OBOs and and Ore/Oil carriers, and it is only recently that ordering of this type of ship has been resumed, with an estimated 5.2 million DWT to be delivered until the end of 1985.[13]

Large carriers are mostly occupied in the iron ore trades since they are preferred in the large-volume, long haul routes. Large carriers over 100,000 DWT handle close to 65 percent and 30 percent of the iron ore and coal trades respectively,[10] and one would expect their share to increase. The fleet size of large pure bulk carriers has been increased close to 60 percent, allowing for future deliveries, since 1979 mainly because of the trading opportunities of these ships in coal and other commodities besides iron ore.

In 1981, large carriers (including combined carriers) handled approximately 30 percent of all cargo transported by bulk vessels, against 3 percent eleven years ago, as Table 14 shows. This table - derived from figures compiled annually by Fearnleys AS[10] - indicates that the bigger ships - those over 100,000 DWT - handled in excess of 280 million tons in 1981, compared to 15 million tons in 1971.

TABLE-14

THE MARKET SHARE OF LARGE BULK VESSELS* OVER 100,000 DWT: 1971-81

(shipments in million tons)

YEAR	71	72	73	74	75	76	77	78	79	80	81
By Bulk Vessels over 40,000 DWT	505	524	622	668	635	646	645	667	762	796	806
By Vessels over 100,000 DWT	29	54	85	116	132	156	173	187	253	272	281
% in Bulk Vessels over 100,000 DWT	6	10	14	17	21	24	27	28	33	34	35

* Including Combined Carriers.

Estimated data. Derived from Ref. [10]

2.1 The Role of Large Bulk Carriers in the Iron Ore and Coal Trades

In 1981, 70 percent of the dry bulk cargo shipped in large carriers was iron-ore, 23 percent coal and 7 percent grain and other commodities as Table 15 suggests. This table quantifies shipments of iron ore, coal and grain in ships over 100,000 DWT from 1970 through to 1981 when an estimated 276 million tons of these commodities were carried.

The figures presented in Table 16 suggest that the share of iron ore trade taken by large carriers increased from 11 percent in 1971 to 65 percent in 1981. International trade in coal has grown faster than iron ore during the 1970's, and large carriers handled as much as 30 percent of the total seaborne trade in 1981, compared to 1 percent in 1971.

One cannot say precisely what proportion of the coal and iron ore large carrier traffic was in pure bulk carriers or combined carriers, but an analysis of ship movements during 1980, carried out by HPD Shipping Consultants,[1],[6] to illustrate the pattern of employment of large carriers in the dry bulk markets, suggests that iron ore shipments accounted for 51 percent of all pure bulk carrier movements, 50 percent of all OBOs movements, 99 percent of all O/O carrier movements and 100 percent of all pure ore carrier movements. Furthermore, an analysis by size breakdown revealed that the iron ore trade employs over 90 percent of ships of more than 150,000 DWT, while most coal shipments were made in ships of 100-125,000 DWT.

TABLE-15

SHIPMENTS BY LARGE BULK VESSELS* (OVER 100,000 DWT) EMPLOYED IN THE PRINCIPAL DRY BULK TRADES: 1971-81

(million tons)

Commodity \ Year	71	72	73	74	75	76	77	78	79	80	81
IRON ORE	27.5	46.9	74.6	105.3	108.0	123.4	132.3	144.8	193.2	194.7	196.7
COAL	0.9	4.8	9.3	7.1	12.7	17.8	25.1	26.6	41.4	52.8	63.0
GRAIN	-	-	-	2.6	9.6	11.7	10.3	11.8	14.6	19.8	16.5
TOTAL	28.4	51.7	83.9	115.0	130.3	152.9	167.7	183.3	249.2	267.3	276.2
% Increase	-	+82	+62	+37	+13	+17	+10	+9	+36	+7	+3

* Including Combined Carriers.

Estimated data. Derived from Ref. [10]

TABLE-16

PERFORMANCE OF LARGE BULK VESSELS* OVER 100,000 DWT IN THE PRINCIPAL DRY BULK TRADES: 1971-81

(% of trade, in tons of each commodity)

Commodity / year	71	72	73	74	75	76	77	78	79	80	81
IRON ORE	11	19	25	32	37	42	48	52	59	62	65
COAL	1	5	9	6	10	14	19	21	26	28	30
GRAIN	-	-	-	2	7	8	7	7	8	10	8
% of Total Trade	7	12	16	20	23	27	30	32	37	38	39

* Including Combined Carriers.

Estimated data. Derived from Ref. [10]

2.1.1 Types and Sizes of Ship Employed in the Iron Ore Trades

Table 17 presents a historical analysis of the various types of carrier operating in the iron ore trades from 1971 to 1981 and it is obvious that the fastest growing influence within the market is the combined carrier fleet. In 1981, as the same table reveals, bulk carriers handled about 40 percent of all iron ore shipments compared to 81 percent in 1971 whereas combined carriers handled about 47 percent compared to 5 percent in 1971. The influx of combined carriers trading in the dry bulk market should be expected to rise given that the oil trades have been at particularly low levels over the past years.

Table 18 presents a historical analysis of the size of ships employed in the iron ore trade. As this table reveals, in 1981, 65 percent of the ore shipped was carried by vessels over 100,000 DWT, compared to 42 percent in 1976 and 11 percent in 1971. Obviously, the upgrading of ports shipping or receiving ore has a lot to do with the well established trend towards large carriers.

Presently, as the figures in Table 19 reveal, the larger ore carriers are especially dominant in the large-volume trades and on longer hauls, and their share of the total traffic would be even larger were it not for draft limitations in certain areas.

The large ore carriers are extensively employed in the large-volume Australian and Brazilian trades (83 percent and 69 percent share of the total trade respectively in 1981) and on the long hauls to Japan where an estimated 83 percent was carried on large ships compared to 50 percent in 1974 as Table 19 reveals.

TABLE-17

THE TYPES OF SHIP EMPLOYED IN THE IRON ORE TRADES

(% of Tonnage Shipped)

Ship Type	71	72	73	74	75	76	77	78	79	80	81
BULK CARRIERS (inc. Ore Carriers)	81	83	81	67	65	63	59	57	50	44	46
COMBINED CARRIERS	5	7	10	24	28	31	32	35	40	47	47
OTHER	14	10	9	9	7	6	9	8	10	9	7

Estimated data. Derived from Ref. [10]

TABLE-18

SIZES OF SHIP EMPLOYED IN THE IRON ORE TRADES

(% of Tonnage Shipped)

SHIP SIZE (DWT)	71	72	73	74	75	76	77	78	79	80	81
Under 40,000	36	30	27	22	20	17	15	14	12	9	7
40-60,000	29	25	23	19	17	14	12	9	7	9	7
60-80,000	20	21	20	20	18	18	17	17	17	12	12
80-100,000	4	5	5	7	8	9	8	8	8	8	9
100,000+	11	19	25	32	37	42	48	52	56	62	65

Ref. [10]

TABLE-19

IRON ORE SHIPMENTS-SIZE DISTRIBUTION OF VESSELS:1981

(% of Area Trade)

SHIP SIZE ('000 DWT)	-40	40-60	60-80	80-100	100+	TOTAL
EXPORTING AREAS						
SCANDINAVIA	10	1	19	24	46	100
OTHER EUROPE	21	16	26	33	4	100
WEST AFRICA	4	8	22	28	38	100
OTHER AFRICA	19	9	4	2	66	100
NORTH AMERICA	5	7	19	9	60	100
S. AMERICA ATL.	5	9	13	4	69	100
S. AMERICA PAC.	11	1	1	3	84	100
ASIA	26	19	9	7	39	100
AUSTRALIA	2	3	5	7	83	100
IMPORTING AREAS						
U.K/CONTINENT	5	3	13	15	64	100
MEDITERRANEAN	7	7	18	13	55	100
OTHER EUROPE	23	32	12	15	18	100
U.S.A	12	17	41	5	25	100
JAPAN	6	4	4	3	83	100
OTHERS	10	17	12	14	47	100
WORLD AVERAGE	7	7	12	9	65	100

Ref. [6],[10]

2.1.2 Types and Sizes of Ship Employed in the Coal Trades

Coal cargoes can be shipped on a variety of vessel types, however on deep sea hauls general purpose bulk carriers and combined carriers are favored (Ore/Oil carriers are mostly unsuitable for the carriage of coal).

Table 20 presents a historical analysis of the types of ship employed in the coal trades for the period 1971 to 1981. As this table reveals, in 1981, 65 percent of the coal entering seaborne trade was transported by bulk carriers. Combined carriers (OBOs) accounted for an additional 16 percent and the remainder was shipped by smaller vessels, mostly "twin deckers." It seems that coal trades are dominated by bulk carriers, and it is therefore reasonable to assume that any increase of the trade volume will be mostly handled by vessels of this type.

As Table 21 suggests, large carriers over 100,000 DWT handled about 30 percent of seaborne coal trade in 1981, compared to 10 percent in 1975 and almost nothing at the beginning of the 1970's. Table 21 presents a historical analysis of the various sizes of carriers employed in the coal trades. It is interesting to note that while the share of the large carrier sector has been increasing steadily, that of the 'Panamax' sector has been fluctuating in favor of the 'handy size' sector. The increased trade volume and the absence of coal distribution centers has favored the importer's dependence on the 'handy size' sector as a supplier to remote areas with draft limitations. However, given the current developments in port and terminal factilities for large thermal coal carriers it is

TABLE-20

THE TYPES OF SHIP EMPLOYED IN THE COAL TRADES

(% of Tonnage Shipped)

SHIP TYPE	71	72	73	74	75	76	77	78	79	80	81
BULK CARRIERS	65	72	70	68	68	70	71	75	68	67	67
COMBINED CARRIERS	3	5	7	9	9	10	10	9	12	14	16
OTHER	32	23	23	23	23	20	23	26	20	19	17

Estimated data. Derived from Ref. [10]

TABLE-21

SIZES OF SHIP EMPLOYED IN THE COAL TRADES

(% of tonnage shipped)

SHIP SIZE ('000 DWT)	71	72	73	74	75	76	77	78	79	80	81
Under 40,000	60	51	47	45	41	37	23	19	26	30	32
40-60,000	30	31	29	28	24	24	21	19	17	14	10
60-80,000	8	11	13	19	22	22	24	27	30	23	23
80-100,000	1	2	2	2	3	3	3	4	4	5	5
100,000+	1	5	9	6	10	14	19	21	23	28	30

Ref. [10]

TABLE-22

COAL SHIPMENTS-SIZE DISTRIBUTION OF VESSELS: 1981

(% of Area Trade)

SHIP SIZE ('000 DWT)	-40	40-60	60-80	80-100	100+	TOTAL
EXPORTING AREAS						
EAST EUROPE	70	11	12	-	5	100
OTHER EUROPE	79	2	10	9	-	100
NORTH AMERICA	29	11	24	6	30	100
AUSTRALIA	20	16	33	2	29	100
SOUTH AFRICA	20	5	13	6	56	100
OTHER	100	-	-	-	-	100
IMPORTING AREAS						
U.K/CONTINENT	23	4	18	6	49	100
MEDITERRANEAN	11	24	27	16	22	100
OTHER EUROPE	54	6	12	6	22	100
SOUTH AMERICA	33	25	31	-	11	100
JAPAN	29	11	30	2	28	100
OTHER	55	12	18	2	13	100
WORLD AVERAGE	32	10	23	5	30	100

Ref. [6],[10]

certain that the trend towards larger shiploads will reappear. Port developments, underway or planned, are generally aimed at accommodating ships of at least 150,000 DWT,[6] the present maximum for OBOs and pure bulk carriers employed in the coal trade. In 1981, as Table 22 suggests, the largest coal carriers were most in evidence in the large-volume trades and on the longer hauls. Prior to the late 1970's, the largest vessels were mainly constrained to Pacific trades, carrying Australian or Canadian coal to Japan. Recently, however, they have been brought into more widespread use, even trading part-laden from U.S. ports, topping off in Australia or South Africa.

2.2 The Capacity of the Large (100,000+ DWT) Iron Ore and Coal Carrying Fleet

Presently 30 percent of the shipping operating in the dry bulk market is comprised of ordinary bulk carriers, ore carriers, OBOs and O/O carriers over 100,000 DWT. Pure bulk carriers are responsible for approximately 9.7 percent of the total fleet, ore carriers for 2.5 percent, OBOs for approximately 10.3 percent and Ore/Oil (O/O) carriers for 7.5 percent of the total fleet.[14] Although the available tonnage for large combined carriers and ore carriers has remained relatively stable since 1977, that of the pure bulk carriers has increased approximately 85 percent over the same period. The growth in tonnage was more dramatic in 1981 and 1982, following the newbuildings order boom that took place in 1979/80. Presently,[14] the available tonnage for the pure large bulk carrier sector is 20.6 million DWT compared to 12.9 million DWT in 1980 and 8.4 million DWT in 1975. The respective figures for large (over

100,000 DWT) OBOs are 21.9 million DWT in 1982, 22.0 million DWT in 1980 and 19.8 million DWT in 1975. The orderbook[7] for large pure bulk carriers is approximately 5.2 million DWT with deliveries scheduled up to 1985, while that of the OBO sector is almost nonexistent. Therefore, it evidently seems that in the next few years, for the first time in shipping history, the size of the pure large bulk carrier fleet is going to exceed that of the large ore/bulk/oil (OBO) sector.

2.2.1 Capacity of the Large (100,000+ DWT) Iron Ore Carrying Fleet

The existing fleet - which by the end of 1982 had grown to 61.7 million DWT - is divisible into vessels of the bulk carrier and combined carrier design. Bulk carriers are further divisible into pure bulk carriers and pure ore carriers, while combined carriers are further divisible into large OBOs and large O/O carriers. Pure bulk carriers - with a total fleet capacity of 20.6 million DWT, constitute 33 percent of the available iron ore fleet tonnage, ore carriers - with a total fleet capacity of 4.7 million DWT - are responsible for another 7.7 percent, OBOs - with a total fleet capacity of 21.9 million DWT - are responsible for 35.5 percent, and large O/O carriers - with a total fleet capacity of 14.5 million DWT - are responsible for the last 23.8 percent.[9]

Table 23 supplies a historical review of the growth of the large iron ore carrying fleet since 1970. The growth of the pure bulk carrier sector has been responsible for almost all the tonnage increase since 1978.

TABLE-23

GROWTH OF THE LARGE (100,000+ DWT) IRON ORE CARRYING FLEET

(million DWT)

YEAR END	71	72	73	74	75	76	77	78	80	82	85
BULK CARRIERS[1]	4.3	6.7	9.2	10.3	11.9	14.2	15.7	16.6	17.6	25.3	30.5
COMBINED CARRIERS[2]	10.1	16.5	24.3	28.6	31.6	34.2	35.9	36.7	36.3	36.4	36.0
TOTAL FLEET	14.4	23.2	33.5	38.9	43.5	48.4	51.6	53.3	53.9	61.7	66.5

1. Including Ore Carriers.
2. OBO's and Ore-Oil Carriers.

Estimated data. Derived from Ref. [2],[3],[10]

2.2.2 Capacity of the Large (100,000+ DWT) Coal Carrying Fleet

The world large bulk carrier fleet comprises specialized ships and those - in the majority - which are not, but in both categories there are ships which are not suitable for shipping coal. One must exclude all pure ore carriers from the coal carrying fleet, as well as those designed to carry only oil or ore (O/O carriers) which reduces the total available tonnage significantly. Even so, one is still left with a sizeable fleet, the ships in it having an aggregate capacity of over 42.0 million DWT, as the figures in Table 24 suggest.

In its size and structure, the present large coal-carrying fleet is very different to that which existed at the beginning of the 1970s. Excluding ore carriers of all types, the capacity of the large bulk carrier fleet increased from 1.2 to 20.6 million DWT, which at present represents 48.5 percent of the total large coal carrying fleet, while the OBO fleet - which at present represents 51.5 percent of the total fleet - incrased from 6.5 to 21.0 million DWT. In the early 1970's, large OBOs constituted one of the fastest growing sectors of the large carrier fleet, with annual increases of 30 percent or more in capacity, while this is the case presently for the large pure bulk carrier sector. However, in the latter part of the decade, the net increase in OBO capacity was comparatively small, due, in part, to scrapping, losses and conversions of OBO carriers and the extremely high cost of newbuildings. By the end of 1985, as Table 24 suggests, the pure large bulk carrier sector will experience a net increase of 5.2 million DWT, whereas the OBO sector will actually experience a slight decline.[15]

TABLE-24

GROWTH OF THE LARGE (100,000+ DWT) COAL CARRYING FLEET

(million DWT)

YEAR END	71	72	73	74	75	76	77	78	80	82	85
BULK CARRIERS[1]	2.3	3.7	5.5	6.4	8.4	9.7	11.1	11.8	12.9	20.6	25.8
OBO's[2]	9.6	13.0	15.9	18.3	19.8	26.0	21.4	22.2	22.0	21.9	21.0
TOTAL FLEET	11.9	16.7	21.4	24.7	28.2	30.7	32.5	34.0	34.9	42.5	46.8

1. Excluding Ore Carriers.
2. Excluding Ore-Oil Carriers.

Estimated data. Derived from Ref. [5],[16]

CHAPTER 3

TRANSPORT REQUIREMENT PROSPECTS FOR LARGE COAL AND IRON ORE CARRIERS

The future prospects for the iron ore and coal international trades were discussed in the previous chapter (see Chapter 2). As far as the iron ore international trade is concerned, the prevailing theme in the previous discussion was that the figure of ton-miles performed yearly by the iron ore carrying fleet as a whole is unlikely to exceed its 1979/80 high point of 1,600 billion ton-miles (as reported by Fearnley's[10]), at least in the near future. The world steel industry is in really bad shape and its recovery will most probably lag a few years behind the expected world economic recovery. Another factor that will influence the demand for large iron ore carriers is the fact that large volume shipping practices in this bulk trade sector have been strongly established over the past years, and one should not expect dramatic increases in the current share of the large carrier sector. In 1981, the estimated share of the large carrier fleet in the iron ore trades was 65 percent and given the existing and scheduled port developments, one can safely assume that this figure could at most rise to 70 percent by 1985 and 73 percent by the end of the decade. However, there is no way of determining precisely how demand - in DWT - for the large carrier fleet may evolve between now and 1990, as much depends on the development of trade. For the purposes of this analysis, we are going to assume that by 1985, following the expected world economic recovery by the end of

1983, ton-miles performed in the iron ore trade will reach the high point of 1,600 billion ton-miles attained in 1979/80 according to Fearnley's,[10] while no further increase is forecast for the end of the decade. There are a number of arguments that support the latter proposition, namely:

(1) The general reappraisal of the philosophy of size and cost which took place as a result of the oil price increases of the 1970's, which has been nowhere marked than in the area of steel consumption.

(2) The use of steel scrap itself as a raw material for steel production has been on the increase as a more energy efficient practice than the use of iron ore.

(3) The switch of steel production activity from major developed economies, like the EEC and Japan, to Far East developing economies, like South Korea and Taiwan, which are located closer to their sources of raw material supply.

(4) The debt crisis of the Third World developing economies, like Brazil and Mexico. which has postponed industrial growth and consequentially decreased steel consumption, for many years to come.

(5) The tendency of raw material supplying nations to switch from low value - high volume unprocessed products to high value - low volume processed products.

When it comes to the coal sector of the dry bulk market, forecasting the future growth prospects for ton-miles performed in this trade

TABLE-25

FORECAST SEABORNE COAL TRADE VOLUMES, TON-MILES AND AVERAGE SHIPPING DISTANCE 1985/90

YEAR	TRADE VOLUME (m. tons)	TON-MILES (bill. ton-miles)	AV. SHIPP.DIS. (n.miles)
1985	259.3	1,610.3	6,210
1990	348.0	2,077.0	5,970

Ref. [8]

TABLE-26

TRADE SHARE OF LARGE BULK CARRIERS ON MAJOR COAL TRADES:1985/90

(% of trade movements)

R O U T E	100,000 DWT plus	
	1985	1990
AUSTRALIA TO THE FAR EAST	42	52
AUSTRALIA TO WEST EUROPE	51	62
S. AFRICA TO WEST EUROPE	70	72
U.S.A TO THE FAR EAST	21	32
U.S.A TO WEST EUROPE	42	37
CANADA TO THE FAR EAST	68	71
POLAND TO WEST EUROPE	4	4
WORLD AVERAGE	40	43

Ref. [8]

becomes very difficult, mainly because the available forecasting sources tend to diverge depending on the year of publication. For the purposes of our analysis, we will consider the most recent published one, that of Cargo Systems Consultants[8] published in 1982 and being on the conservative side of the forecasting spectrum.

Table 25 reproduces CSC's forecast for the development of seaborne coal trade for the period 1985-90 in terms of ton-miles requirements. Table 26 reproduces CSC's forecast for the trade share of large bulk carriers over 100,000 DWT on major coal trades. The analysis is based on present and future loading/discharging port developments as well as on future trends in coal shipping practices. CRS estimates, as Table 26 suggests, that by 1985 large carriers over 100,000 DWT will have a 40 percent share of all coal trade movements, compared to 30 percent in 1981 - as reported in Fearnley's 'World Bulk Trades'[10]. The figure forecast for 1990 is 43 percent of all coal trade movements.

3.1 Future Demand (DWT) for Large Iron Ore and Coal Carriers

To attain the market share foreseen for it by the late 1980's, in terms of ton-miles requirements, the capacity of the large iron ore and coal fleet will have to be enlarged. However, in the latter part of the 1970's the productivity (or operating efficiency) of the large carrier fleet actually declined, the poor trading conditions which persisted until 1979 affecting the fleet's performance. Contributory factors included:

(1) The steep rise in the cost of buker fuel, which led to the widespread practice of 'slow steaming;' bulk carriers operating at lower speeds to conserve fuel.

(2) The increasing frequency of delays at ports, due to worsening congestion, strikes, etc.

(3) The higher incidence of ballasting; bulk carriers often steaming long distances empty.

(4) The lower DWT utilization; bulk carriers frequently loading less than a full cargo and trading part laden.

The effect of these factors on the overall productivity of the large carrier sector cannot be easily measured, but HPD Consultants has come out with an estimate - based on the large carrier fleet performance in 1980[1] - of a low 30,000 ton-miles per DWT per year. In its report HPD suggests that if one wants to calculate future demand for large carriers, in terms of DWT, a higher productivity - 33,000 ton-miles per DWT per year - has to be assumed. No supporting arguments are given but the following may suffice:

(1) The new generation bulk carriers are designed to be fuel efficient at operating speeds exceeding 12 knots per hour, and older ones have been mostly modified with gearing mechanisms to allow them to perform so, thus reducing the incidence of slow steaming in order to conserve fuel.

(2) Loading and discharging port developments and more efficient handling facilities have resulted in the reduction of port congestions, a common scene in the 1979/80 period.

(3) The scrapping of obsolete and inefficient carriers that has taken place over the past two years, mainly because of the bulk market crisis.

By applying this measure of efficiency - 33,000 ton-miles per DWT per year - to the predicted market shares in ton-miles, one could arrive at an estimate of the large carrier tonnage required in 1985 and 1990. However, in order to arrive at an estimate of the larger carrier sector demand in the years to come, one has to consider other opportunities open to large carriers (besides iron ore and coal trades) such as the future share of this sector in the grain and other minor cargo trades. The potential market share of large carriers in trades other than iron ore and coal have been estimated from sources [1], [2] and [17].

On the basis of the above sources and previous assumptions, Table 27 has been constructed. Table 27 presents a trade breakdown of actual ton-miles performed in 1981, together with estimated share of the large carrier sector as reported by Fearnley's 'World Bulk Trades.'[10] The corresponding estimated tonnage demand for the large carrier sector has been calculated by assuming an operating efficiency for the large carrier fleet as a whole of 30,000 ton-miles per DWT per year. Table 27 also presents the forecasted bulk trades growth figures for the period 1985-90 and the corresponding share of the large carrier sector - in terms of ton-miles requirements. The corresponding estimated tonnage

TABLE-27

ESTIMATED TON-MILES REQUIREMENTS AND TONNAGE DEMAND FOR LARGE BULK CARRIERS* (100,000+ DWT)

(Billion Ton-Miles/Million DWT)

YEAR	(Actuall) 1981			1985			1990		
TRADE	Ton-Miles Total Trade	Ton-Miles 100,000+DWT	DWT Utiliz. 100,000+DWT	Ton-Miles Total Trade	Ton-Miles 100,000+DWT	DWT Utiliz. 100,000+DWT	Ton-Miles Total Trade	Ton-Miles 100,000+DWT	DWT Utiliz. 100,000+DWT
IRON ORE	1,508	980	32.7	1,600	1,120	34.0	1,600	1,168	35.4
COAL	1,120	336	11.2	1,610	644	19.5	2,077	893	27.1
GRAIN	1,131	85	1.1	1,120	160	1.8	1,130	225	4.6
OTHER CARGO	2,470	50	0.8	2,790	85	1.8	3,170	190	3.7
TOTAL	6,229	1,515	45.8[1]	7,120	2,009	57.1[2]	7,977	2,476	70.8[2]

* Including Combined Carriers.

1. Assumes an average fleet productivity of 30,000 Ton-Miles per DWT per Year.

2. Assumes an average fleet productivity of 33,000 Ton-Miles per DWT per Year.

Ref. [1],[2],[10],[17] plus calculations of the writter.

demand for the large carrier sector has been arrived at assuming an operating efficiency for the large carrier fleet as a whole of 33,000 ton-miles per DWT per year. The source used to arrive at future estimates are those mentioned previously.

From Table 27 we see that the estimated demand for large bulk carriers in 1981 was 45.8 million DWT, of which 32.7 million DWT were accounted for iron ore transport requirements, 11.2 million DWT for coal, and 1.9 million DWT for grain and other cargoes. To check the validity of our assumptions we can compare this total demand figure - 45.8 million DWT - to the figures for the large carrier sector reported monthly by 'Lloyd's Shipping Economist.'[18] The average yearly demand in 1981 for the large bulk carrier sector was 45.7 million DWT, about equalling our estimated figure of 45.8 million DWT. Hence, our estimates for the large carrier sector of 57.1 and 70.8 million DWT in the years 1985 and 1990 respectively - as listed in Table 27 - are not very off the mark, provided the forecasted growth patterns for ton-miles requirements are not extremely over or understated.

The present capacity of the large carrier sector is 61.7 million DWT and the estimated 1985 capacity is close to 67.0 million DWT. However, these figures assume that 100 percent of the combined carrier fleet trades into the dry bulk market sector which is an unrealistic situation. During the last two years, the percentage of combined carriers trading in the dry bulk market - as reported monthly by 'Shipping Statistics and Economics'[16] - ranges anywhere from 50 percent to 75 percent depending on the respective strength of the oil markets.

If one markes the necessary adjustments to accommodate for the combined carriers trading in the oil markets, then the above figures are reduced to about 55.0 million DWT and 60.0 million DWT respectively.

3.2 Future Demand and Supply Balance in the Dry Bulk Markets

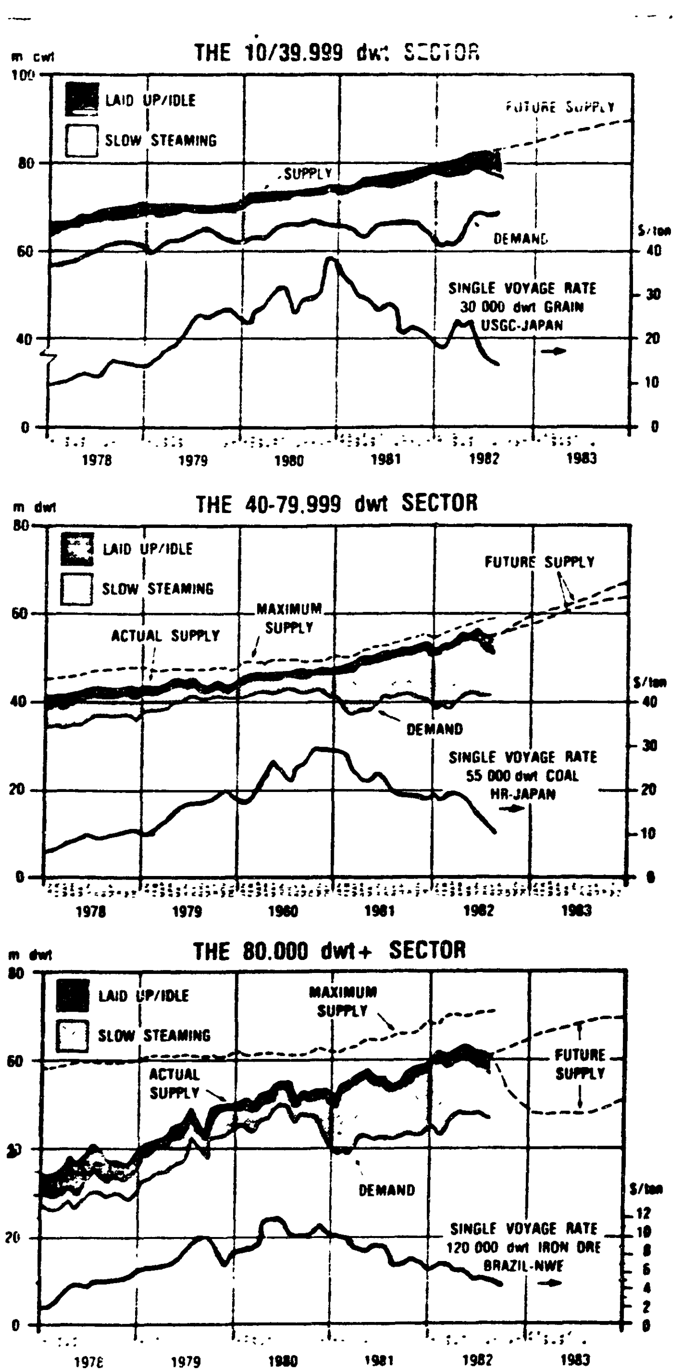
The three graphs presented in Figure 3, and produced by 'Lloyd's Shipping Economist,'[19] give a feeling for the state of the main sectors of the dry bulk market. In all cases demand has been calculated by subtracting the identifiable surplus (vessels that are laid up or idle and vessels practicing slow steaming) from the actual supply of bulk carriers and combined carriers trading in dry bulk. The reference point that has the most relevance for shipowners might be October 1980, when single voyage rates reached their peak and the surplus was reduced to a minimum. Even then there was an apparent surplus - as can be seen from Figure 3, of about 19 million DWT, reflecting probably a certain permanent slow steaming element in the fleet caused by high bunker prices relative to charter rates fixed in the pre-boom period.

Since that time, as Figure 3 suggests, peak rates for all three sectors have fallen abruptly, but by slightly different degrees. In the handy size sector (10-40,000 DWT) one year charter rates fell by 60 percent between October 1980 and November 1982. Over the same period charter rates for medium size bulk carriers (40-80,000 DWT) and large size (80,000 DWT plus) declined 73 percent in both cases.

The growth in the surplus tonnage for each sector shows the same pattern. In the handy size sector the surplus has increased by 64 percent between October 1980 and August 1982, whereas the medium size

FIGURE-3

THE STATE OF THE DRY BULK CARRIER MARKET



Source: Ref. [19]

and large sectors have grown by much larger proportions, by 202 percent and 163 percent respectively. Even worse, the growth in supply in these sectors has overflooded the market. In the handy size sector actual supply increased by 11 percent. Medium size supply, already saturated by new ships ordered in 1980-81, has shown an increase of 17 percent. Partly as a result of the influx of combined carriers trading in the dry bulk market, supply in the large sector rose by 11 percent. Shipowners ordered 34 million DWT of dry bulk carriers during 1980-81 and 15 percent of these orders (5.1 million DWT) was for the large, over 100,000 DWT, sector.[19],[20]

Before attempting to carry on an analysis concerning the future balance of the dry bulk market it is worth looking at how much the tonnage balance has been distorted by the 1980-81 trend.

Table 28 presents estimated figures for the end 1985 supply tonnage - taken from Tables 23 and 24 and sources [13] and [20] - the current demand level for each sector,[13] and the calculated demand needed by the end of 1985 to restore the market to favorable 1980 conditions (see Table 28 for details). The handy size sector appears to have the best future tonnage balance but in the medium size sector demand will have to increase by about half of its present level to restore the high market of late 1980.

Comparatively, the large sector, even assuming a continuation of the present combined carrier presence, is less out of balance. In section 3.1, our analysis concerning the future demand for large carriers (over 100,000 DWT) concluded that an estimated 57.1 million DWT will be required

TABLE-28

ESTIMATED END 1985 TONNAGE BALANCE

(million DWT)

SHIP SIZE (DWT)	10-40,000	40-80,000	80,000+	TOTAL
Supply end 1985[1]	89.0	70.3	62.0	221.3
Current Demand[2]	64.9	42.2	40.7	147.8
Demand needed for market balance[3]	78.3	63.3	55.8	197.0
%increase from current demand to restore market balance	21%	50%	37%	33%

1. Assuming scrapping at current level and adjusted for future deliveries. (65% of combined carriers trading in the dry bulk markets)
2. Figures as of Dec. 1982. Ref. [13]
3. Assuming same balance between supply and demand as of Oct. 1980. Ref. [18]

e.g.	10-40,000	40-80,000	80,000+
SUPPLY/DEMAND:	88%	90%	90%

to satisfy the end of 1985 demand for this size sector in the major dry bulk trades (see Table 27 for reference). Table 28 suggests that an estimated demand of 55.8 million DWT will be needed to restore the large dry bulk sector to the high market of late 1980.

Therefore, the year 1985 does seem to be very promising for the large carrier sector since the balance between supply and demand, (96 percent as of the end of 1985), is much better than that of the high market of late 1980 (90 percent as of late 1980). However, one cannot say with certainty whether freight rates will climb to late 1980 levels, since other factors involved in the shaping of the market may counter-balance the effect of a rise in market demand.

It is not possible to predict what the market balance will be, for the large carrier sector, since it depends on a combination of hard to predict factors - such as new orders, scrapping levels, etc. - nor is it possible to say what trade share of the large size sector will be carried by pure bulk or combined carriers. However, towards the end of the decade, an estimated demand of 70.8 million DWT (see Table 27 for reference) will more than exceed the capacity of the large carrier fleet, assuming it remains close to 1985 levels, with the subsequent effects of an unbalanced market which would strongly favor the shipowner.

CHAPTER 4

ECONOMICS OF BULK CARRIERS

The costs borne by the shipowners serving the dry bulk market are generally composed of:

(1) Capital charges associated with the purchase of the ship.

(2) Costs of operating the ship, such as manning costs, insurance costs, repair and maintenance costs, etc.

(3) Expenses incurred on the voyage, such as fuel costs, port charges, canal tolls, and other costs associated with transits of international waterways.

All these costs are highly variable, reflecting differences in the age of the employed ships and their acquisition costs, crew wages, repair costs, insurance costs, bunker prices and many other factors.

It is the purpose of this chapter to interrelate all these cost elements and consequently arrive at a decision model which would be of help to a shipowner who operates in the dry bulk market. The proposed decision model should be composed of two independent from each other models, a strategic one, i.e., should one invest into a new vessel or not, and a tactical one, i.e., should the shipowner keep operating his vessel under depressed market conditions or lay it up. The alternatives of scrapping or selling a vessel will not be considered here because their modeling requires the estimation of prospective revenues that will be realized over the vessel's remaining operating life - a rather hard task to undertake given the cyclicality and unpredictability of the shipping market.

Further on, a computer model based on the methodology of the investment and operating decision models will be developed in order to aid in the simplification of the laborious calculations involved in the decision process.

4.1 Investment Decision Model

Usually a shipowner does not invest on a new vessel unless he is offered a time charter contract, often expressed in U.S.$ per DWT per month or in U.S.$ per day, which would generate a sufficient stream of cash to cover his initial investment costs and the annual costs associated with the operating of a vessel plus an adequate return on his investment.

For newbuildings, in order to justify a proposed investment, it is necessary to spread all the prospective cash flows over the ship's service life, and estimate what charter rate, let us call it the Required Freight Rate (RFR), would produce a Net Present Value (NPV) for the investment equal to zero, after all cash flows are discounted to the present time at the shipowner's opportunity cost of capital, R.

Zannetos, Papageorgiou and Cambouris[21] propose a model that, after some modifications, can be useful for our purposes. The desired RFR is given by the following relation:

$$Kd = \sum_{t=1}^{n} [(1-\hat{u})Cm(t)RFR-OC(t)](1+R)^{-t}(1-TR)$$
$$- \sum_{t=1}^{n} MP(1+R)^{-t} + \sum_{t=1}^{n} MP(t)(1+R)^{-t}TR$$
$$+ \sum_{t=1}^{n} D(t)(1+R)^{-t}TR$$

$$+ Sn(1+R)^{-n}$$

$$+ [I - \sum_{t=1}^{n} D(t) - Sn](1+R)^{-n} TR$$

where,

Kd = The downpayment

$(1-\hat{u})$ = The probability of employment

Cm(t) = The annual carrying capacity

RFR = The unknown required freight rate

OC(t) = The annual out-of-pocket operating costs which may be a function of time

n = A time index which ranges from one year to 20 years, the life of the vessel

R = The owner's opportunity cost of capital

TR = The income tax rate

MP = The yearly payments for liquidation of the loan used to finance the purchase of the vessel

MP(t) = The interest part of the yearly payments which is a decreasing function of time

D(t) = The yearly depreciation for income tax purposes

Sn - The scrap value of the vessel at retirement n years from building it

I = The total cost of building the vessel

This model follows the practice commonly used in the financing world of reducing all prospective cash flows - which are spread out over the service life of the vessel - to a NPV using the shipowner's opportunity cost of capital as the common discount rate. The limitation of this model is that it is confined to a single route since the annual carrying capacity, Cm(t), depends on the length of the route under examination. Another factor that further complicates our analysis is the vast diversification of financial borrowing schemes that are available to the shipowner, and the differences that exist between different countries of registry as far as the income tax rate is concerned.

For a general purpose analysis, as the one we are proposing to carry on , it seems that it is necessary to adopt a simplified approach to what is, in reality, a complex subject. Our proposed model will not deviate from the 'spirit' of the previously suggested one, in the sense that it would also use the NPV formulation to deduce the value of the investment to a zero value at a point in time.

The NPV of the investment in a new vessel is given by the following relation:

NPV Investment = PV Prospective Revenues
+ PV Residual Value of the Vessel
- PV Shipbuilding costs (capital costs)
- PV Operating Costs

when all cash flows are discounted at a common rate equal to the shipowner's opportunity cost of capital.

The principal assumptions made here are:

(1) That 80 percent of the purchase price of the vessel would be loaned for 8 years at an interest rate of 8 percent per annum.

(2) That a 20 percent cash payment will be made by the owner upon signing the contract, the balance (80 percent) being paid in two equal installments during the time the vessel is being built.

(3) That there is a two year lead time from the time of the signing of the contract to the actual delivery of the vessel.

(4) That the vessel will have a zero residual value at the end of its service life.

(5) That the vessel would sail under a flag of convenience, hence no income taxes and no depreciation charges should be considered.

(6) That the probability of employment is 100 percent, i.e., $(1-u)=1$

(7) That annual operating costs will keep increasing at a rate of 10 percent per annum over the service life of the vessel.

(8) That the service life of the vessel is fifteen years.

(9) That the owner's opportunity cost of capital is 15 percent per annum.

4.1.1 Capital Costs. NPV Calculation

The capital costs associated with a vessel are a function of: (1) the age of the ship, (2) the initial price, and (3) the method of financing the purchase. In this analysis, we will consider ships that were purchased new by the owner. It is important to realize that new-building and second-hand prices are dependent on the market conditions at the time the owner places his order to a shipyard. When the market is booming, and everyone rushes to the shipyards to secure orders for new vessels, then newbuilding prices rise in proportion to the required demand for newbuildings. Similarly, when the market is depressed, as it happens to be today, the newbuilding prices tend to fall and reflect more the actual shipbuilding cost for a vessel. For example, a vessel that was ordered in early 1978, a short time before the dry bulk market started to boom, cost an average 25 percent less than a vessel that was ordered at the peak, late 1980, of the boom.

The newbuilding prices listed in Table 29 are those quoted by Japanese shipyards and assume a 'lead' time - the period which elapses between the signing of the contract and the delivery of the ship - of two years.

Capital costs are governed not only by the initial price but also by financing terms and conditions, as an owner is not normally in a position to raise the full price on his own account, and will be obliged to seek a loan to cover a large part of the contract price. An owner's capital outflow will, therefore, include - in addition to any downpayment at the time he placed the order - periodic loan repayments plus interest. These outflows may not be of equal amounts, nor spread over the whole trading 'life' of the vessel in question. For the purposes of our analysis we will assume that the principal will be paid out in equal installments starting one year after the ship's delivery, and that loan interest at 8 percent will be paid on the remaining of the principal every consecutive year.

TABLE-29

NEWBUILDING COSTS OF BULK CARRIERS

(million U.S $)

SIZE DWT / YEAR	40,000	65,000	120,000	175,000
End 1978	16.0	18.0	25.4	31.6
End 1980	20.0	25.0	34.0	40.0
End 1982	17.0	22.0	32.0	38.0

Ref. [15]

PV Calculations for Capital Costs

Assume that the total shipbuilding price is I. Of this amount 20 percent or 0.2I will be paid in cash by the owner at the time the contract is signed, 80 percent or 0.8I is going to be loaned for 8 years at an interest rate of 8 percent per annum, the principal paid out in equal installments starting one year after the ship's delivery. The loan interest at 8 percent will be paid on the remainder of the principal every consecutive year.

The following notes should be considered in conjunction with the calculations presented in Table 30:

Column

1	Year 0 is contract signing, end year 2 delivery
2	Building installments: 20 percent down, 40 percent after one year plus 40 percent at the time of delivery
3	Owner pays his 20 percent first
4	Remaining 80 percent advanced to pay installments
5	Equal repayments of loan over eight years
6	Loan outstanding = cumulative sum of column 4 minus column 5
7	Loan interest at 8 percent on column 6, paid at end of each time interval
8	Owner's cash outflow, i.e., owner's 20 percent plus loan repayments plus loan interest = column 3 plus column 5 plus column 7
9	PV factor at R percent discounted rate
10	Discounted cash flows (DCF)

TABLE-30

NPV CALCULATION OF SHIPBUILDING COSTS

1	2	3	4	5	6	7	8	9	10
YEAR	Building Instalments	Owner's 20%	Loan 80%	Loan Repayments	Loan Outstanding	Loan Interest	Cash Outflow	PV Factor	Discounted Cash Flow
0	0.2I	0.2I					0.2I	1	0.2I
1	0.4I		0.4I		0.4I	0	0.0	$1/(1+R)^1$	0.0
2	0.4I		0.4I		0.8I	0.032I	0.032I	$1/(1+R)^2$	$(1+R)^{-2}(0.032)I$
Delivery									
3				0.1I	0.7I	0.064I	0.164I	$1/(1+R)^3$	$(1+R)^{-3}(0.164)I$
4				0.1I	0.6I	0.056I	0.156I	$1/(1+R)^4$	$(1+R)^{-4}(0.156)I$
5				0.1I	0.5I	0.048I	0.148I	$1/(1+R)^5$	$(1+R)^{-5}(0.148)I$
6				0.1I	0.4I	0.040I	0.140I	$1/(1+R)^6$	$(1+R)^{-6}(0.140)I$
7				0.1I	0.3I	0.032I	0.132I	$1/(1+R)^7$	$(1+R)^{-7}(0.132)I$
8				0.1I	0.2I	0.024I	0.124I	$1/(1+R)^8$	$(1+R)^{-8}(0.124)I$
9				0.1I	0.1I	0.016I	0.116I	$1/(1+R)^9$	$(1+R)^{-9}(0.116)I$
10				0.1I	0.0	0.008I	0.108I	$1/(1+R)^{10}$	$(1+R)^{-10}(0.108)I$
									N P V

R= Shipowners Opportunity Cost of Capital.

I= Total Shipbuilding Cost.

The sum of all the Discounted Cash Flows in column 10 represents the Net Present Value of all the costs associated with financing a new ship under the previous assumptions. However, this is a rather cumbersome method for calculating the NPV and a more convenient method, suitable to computer programming follows next.

If one constructs a cash flow diagram of all the cash outflows listed in column 8 of Table 30, then the diagram presented in Figure 4-a results. The cash flow diagram is composed of two discrete cash flows 0.2I and 0.032I, occurring at t=0 (signing of the contract) and t=2 (ship's delivery) respectively, plus a constant annuity of 0.1I starting at t=3 plus a linearly decreasing annuity, also starting at t=3, the first payment equalling 0.064I at t=3 and the last payment equalling 0.008I at t=10. The last form of annuity can be separated into a constant annuity of value 0.064I minus an increasing gradient series, as it is commonly referred in the financing literature,[22] of gradient G=0.008I. The cash flow diagram presented in Figure 4-b is equivalent to that of Figure 4-a after the above transformations are taken into account.

The present value of an annuity A for N years discounted at a rate R per annum is given by:[23]

$$PV_A = A \left\{ \frac{1}{R} \left[1 - \frac{1}{(1+R)^N}\right] \right\}$$

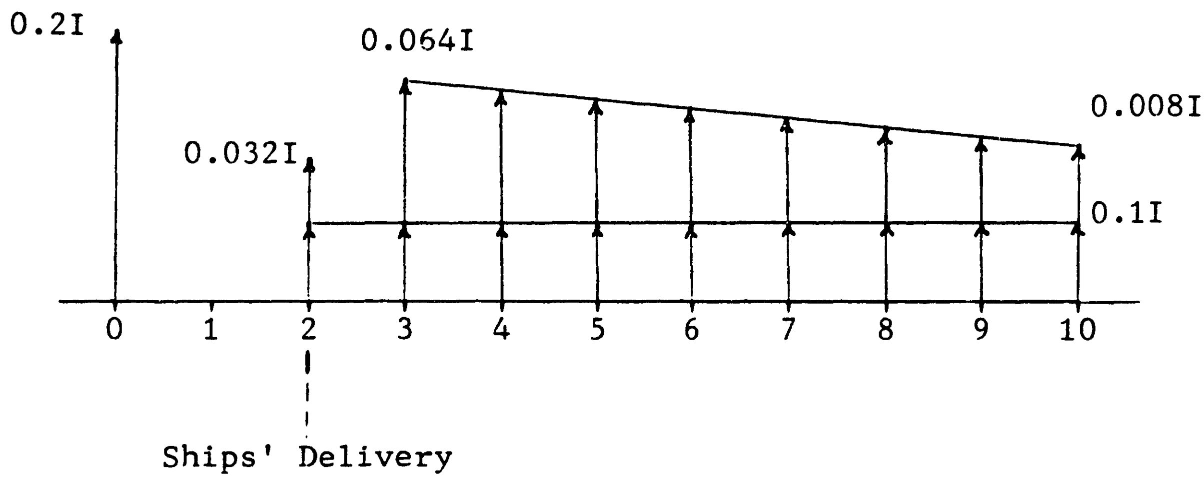
The present value of a discrete cash flow of value P discounted for N years at a rate R per annum is given by:[23]

$$PV_P = P \left\{ \frac{1}{(1+R)^N} \right\}$$

FIGURE-4

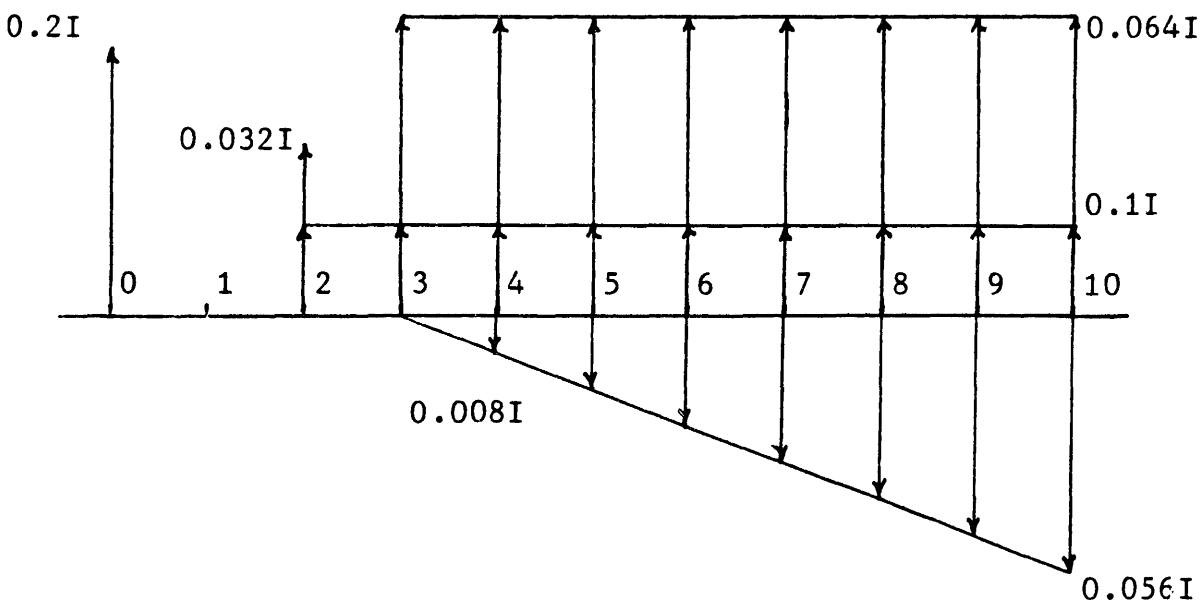
CASH FLOW DIAGRAM OF SHIPBUILDING COSTS

(a)



Equivalent to:

(b)



NOTE: CASH FLOWS ARE NOT DRAWN TO SCALE.

The present value of an increasing gradient series of gradient G for N years discounted at a rate R per annum is given by: [22]

$$PV_G = G\left\{\frac{1}{R}\left[\frac{(1+R)^N-1}{R(1+R)^N} - \frac{N}{(1+R)^N}\right]\right\}$$

The future value of a discrete cash flow of value P_o to be received after N years discounted at a rate R per annum is given by: [23]

$$FV_{P_o} = P_o\,(1+R)^N$$

For future reference, and as long as we are consistent, it is convenient to discount all the cash flows in Figure 1b to t=2, the time the ship is delivered. Doing so:

$$PV_{\text{capital costs}} = (0.2I)(1+R)^2 + 0.032I + \frac{1}{R}\left[1 - \frac{1}{(1+R)^8}\right](0.1+0.064)I$$

$$- \frac{1}{R}\left[\frac{(1+R)^8-1}{R(1+R)^8} - \frac{8}{(1+R)^8}\right](0.008)I$$

where R, the owner's opportunity cost of capital, is left as a variable input.

4.1.2 Annual Operating Costs. PV Calculation

As generally understood, operating costs exclude capital charges, nor do they include such items as fuel. Manning, maintenance and insurance costs usually are listed under the headline 'operating costs.' There are, however, wide differences in the operating costs of bulk carriers even among ships of the same size. Broadly, differences in the costs borne by owners of the bulk carriers of the same size and type can be attributed to one or more of the following variables:

(1) The country of registry (or 'flag') of the vessel, which affects - among other things - wage scales, tax liability, etc.

(2) The size and nationality of the crew.

(3) The age and general condition of the vessel, which influences not only expenditures on repairs, but also the cost of insurance.

(4) The incidence of repairs, which include drydocking but also unforseen repairs caused by engine breakdown, accidental damage, etc.

Typically, manning costs represent between 40 percent and 50 percent of an owner's annual outgoings, and consist of wages and salaries, overtime payments, benefits, traveling expenses, etc. Table 31 lists representative crew costs for different size bulk carriers sailing under a flag of convenience. These figures represent an average crew of 32 seamen, most of the crew members being of Asian nationality except for the officers.

The expenditure per annum on maintenance and repairs to bulk carriers varies considerably, the actual outlay depending on the incidence of drydocking, etc. Generally, repair and maintenance costs represent between 20 percent and 25 percent of an owner's annual outgoing as Table 31 reveals. Insurance rates are largely determined by the owner's previous record and prevailing repair charges. Other factors to be taken into account include hull value and the age and general condition of the individual vessel. As seen from Table 31 insurance costs represent between 10 and 20 percent of the total operating costs.

TABLE-31

ANNUAL OPERATING COSTS* OF BULK CARRIERS

('000 U.S $)

Ship Size (DWT)	40,000		65,000		120,000		175,000	
Manning	740.0	(44%)	814.0	(42%)	896.0	(43%)	910.0	(34%)
Victualling	70.5	(4%)	78.0	(4%)	78.0	(4%)	80.0	(3%)
Stores	160.0	(9%)	170.0	(9%)	185.0	(9%)	300.0	(11%)
Insurance	195.5	(12%)	215.0	(11%)	265.0	(13%)	485.0	(18%)
Repairs	340.0	(20%)	450.0	(23%)	470.0	(22%)	650.0	(24%)
H.O Administration	145.0	(9%)	150.0	(8%)	153.0	(7%)	180.0	(7%)
Taxes	43.0	(3%)	46.0	(2%)	60.0	(3%)	65.0	(2%)
Total Annual Costs	1,696.0		1,923.0		2,107.0		2,670.0	
Per Day [1] ($/Day)	4,846.0		5,494.0		6,020.0		7,629.0	

1. Assumes 350-day trading year, 15 days off-hire.

* Vessels sailing under a flag of convenience.

Source: ORION AND GLOBAL CHARTERING CO, INC.

Administration costs vary considerably for each vessel depending on the method of accounting, the size and composition of the owner's fleet and the domicile of the owner or management company. For a company managing 30 to 35 vessels, administration costs represent between 7 and 9 percent of the total operating costs.

Table 31 shows the importance of each of the main cost headings expressing outlay as a precentage of the total annual operating costs of typical bulk carriers of different size categories. The data has been supplied by ORION & GLOBAL CHARTERING CO., INC., a flag of convenience operator managing 30 to 35 ships at the present time. Comparing these costs, one finds that those of the typical bulk carrier in the 120,000 DWT class are no more than 10 percent above those of one of 65,000 DWT as Table 31 reveals. On a daily basis, outgoings range from about U.S.$4,846 for a 40,000 tonner, to U.S.$7,629 for the largest bulk carrier.

PV Calculations for Operating Costs

Assume that the annual operating costs (OC(t)) are a function of time and that they keep increasing at a rate of 10 percent per annum over the ship's service life.

The present value of a cash flow P which keeps increasing at an annual rate g every consecutive year, discounted for N years at a rate R per annum is given by:

$$PV_P = P\left\{\frac{1}{R-g}\left[1-\left(\frac{1+g}{1+R}\right)^N\right]\right\},\ R\neq g$$

(see Appendix I for a proof of this relation)

Operating costs do not come into play until the time after the ship's delivery. For convenience, we will assume that payment occurs at the end of each operating year, starting one year after the ship's delivery, and we will discount them at year t=2 coinciding with the delivery time. Hence:

$$PV_{\text{operating costs}} = OC \left\{ \frac{1}{R-g} \left[1 - \left(\frac{1+g}{1+R}\right)^{15}\right] \right\}$$

where the annual value of the operating costs (OC) can be taken as these listed in Table 31, g is the annual growth rate of the operating costs and R is the shipowner's opportunity cost of capital. Note that R and g are treated as variable inputs and no value has been assigned to them yet.

4.1.3 Annual Revenues. PV Calculation

Annual Revenues represent the unknown whose value we want to determine so that the Net Present Value of our investment equals zero. Annual Revenues are usually expressed in \$ per year or \$ per payload (PDWT) per month or in terms of \$ per operating day. In our formulation of the annual revenues we will assume the following:

(1) The trading time of the vessel is 350 days per year, the remaining is being devoted to repair and maintenance purposes.

(2) Annual revenues are constant with time.

(3) Annual revenues are spread over the operating life of the vessel which has been assumed to be 15 years.

Annual Revenues expressed in terms of \$ per PDWT per month are given by

$$AR = \text{Payload} \times \frac{\text{days in service}}{30.4 \text{ (days/month)}} \times \text{(RFR)} \qquad 4.1$$

where, days in service have been assumed to be 350 per year and the Required Freight Rate (RFR) is expressed in \$ per PDWT per month.

Annual Revenues expressed in terms of \$ per day are given by

$$AR = \text{Days in service} \times \text{(RFR)} \qquad 4.2$$

where again, days in service have been assumed to be 350 per year and this time the Required Freight Rate is expressed in \$ per operating day.

PV Calculation of Annual Revenues

The cash flows generated by the annual revenues represent a constant annuity spread over the vessel's service life, starting one year after the ship's delivery. Hence, if we discount the constant annuity at time t=2 (the ship's deliver time) we get

$$PV_{revenues} = AR \left\{ \frac{1}{R} \left[1 - \frac{1}{(1+R)^{15}}\right] \right\}$$

where R is the owner's opportunity cost of capital, an input variable, and the expression for AR is one of the previously presented expressions, 4.1 or 4.2, depending on wheather the Required Freight Rate is expressed in \$ per PDWT per month or in \$ per operating day.

4.1.4 Calculation of RFR, the Required Freight Rate

In the previous sections we formulated the present values of the three major cash flows associated with our investment decision, namely: Capital Costs, Operating Costs and Prospective Revenues.

So far we have been consistent in discounting all cash flows at the same point in time, taken as t=2 coinciding with the vessel's delivery time. Once again the Net Present Value of our investment at the ship's delivery time is given by:

$$NPV_{t=2} = PV_{revenues_{t=2}} - PV_{capital\ costs_{t=2}} - PV_{operating\ costs_{t=2}}$$

We stated earlier that the calculation of the required freight rate RFR assumes that we set the NPV of our investment equal to zero and solve for the unknown RFR. If the Required Freight Rate is expressed in terms of $ per PDWT per month then, after we substitute for the corresponding expressions derived previously, we get:

$$NPV = 0 = \left\{ PDWT \times \frac{350}{30.4} \times (RFR) \times \frac{1}{R} \left[1 - \frac{1}{(1+R)^{15}}\right] \right\} \quad \text{Revenues}$$

$$- \left\{ 0.2(1+R)^2 + (0.032) + \frac{1}{R} \left[1 = \frac{1}{(1+R)^8}\right](0.164) - \frac{1}{R} \left[\frac{(1+R)^8 - 1}{R(1+R)^8} - \frac{8}{(1+R)^8}\right](0.008) \quad I \right\} \quad \text{Capital Costs}$$

$$- \left\{ OC \left[\frac{1}{R-g} \left[1 - \left(\frac{1+g}{1+R}\right)^{15}\right]\right] \right\} \quad \text{Operating Costs}$$

where as before

PDWT = The payload of the vessel (DWT)

RFR = The required freight rate we are looking for, expressed in $ per PDWT per month

OC = The annual operating costs

R = the owner's opportunity cost of capital

g = The annual growth rate of the operating costs

The above formulation assumes that the method of financing the vessel is the one described earlier and that the service life of the vessel is 15 years. The other parameters are left as variable inputs and they depend on the particular vessel under consideration and the shipowner's preferences as to what he considers to be opportunity cost of capital and his expectations on the growth rate of his vessel's annual operating costs.

A computer program based on the above formulation is presented in Appendix II.

4.1.5 An Example Using the Investment Decision Model

A shipowner can benefit from our model in the following way:

Assume that the shipowner is offered a time charter contract for 15 years for utilizing his vessel on the Turbarao (Brazil) to Rotterdam (Netherlands) route carrying iron ore. Also, assume that the contract requires a bulk carrier whose payload is around 110,000 DWT. From Table 1 we see that a 120,000 DWT (which has a payload of approximately 114,000 DWT) bulk carrier is quoted by Japanese shipyards, as of January 1983, for US$32 million. Assume that the annual operating costs for this size of vessel are those listed in Table 31, i.e., $2,107,000 per year. Also assume that the shipowner's opportunity cost of capital, R, is 15 percent and that the expected annual growth rate of the opearing costs, g, is 10 percent and that the vessel trades 350 days per year. Summarizing:

I = \$32 million

OC = \$2,107,000 per year

g = 10 percent per year

R = 15 percent per year

RFR = ? \$ per PDWT per month

Substituting in the derived formula for RFR:

$$0 = \left\{ (114,000)\left(\frac{350}{30.4}\right) \times \text{RFR} \times \frac{1}{0.15}\left[1 = \frac{1}{(1+0.15)^{15}}\right] \right\}$$

$$- \left\{ 0.2(1+0.15)^{2} + (0.032) + \frac{1}{0.15}\left[1 = \frac{1}{(1+0.15)^{8}}\right](0.164) \right.$$

$$\left. - \frac{1}{0.15}\left[\frac{(1+0.15)^{8} - 1}{(0.15)(1+0.15)^{8}} - \frac{8}{(1+0.15)^{8}}\right] (0.008) \quad (32\text{x}10^{6}) \right\}$$

$$- \left\{ (2.107,000) \left[\frac{1}{0.15-0.10}\left[1 - \left(\frac{1+0.10}{1+0.15}\right)^{15}\right]\right] \right\}$$

RFR = 6.56 \$/PDWT-month

Now, if the time charter rate (T/C) offered to the shipowner is greater or equal to the Required Freight Rate (RFR) then the shipowner should consider this offer, otherwise the proposed investment is unprofitable.

Table 32 lists the Required Freight Rate expressed in \$ per PDWT per month - for representative sizes of bulk carriers. The newbuilding

TABLE-32

REQUIRED FREIGHT RATES FOR NEWBUILDINGS

(U.S $ per PDWT per Month)

SIZE (DWT)	40,000	65,000	120,000	175,000
Newbuilding Cost (million U.S $)	17.0	22.0	32.0	38.0
Annual Operating Costs (m. U.S $)	1.7	1.9	2.1	2.7
R F R	12.65	9.44	6.56	5.49

prices are those listed in Table 29, operating costs are assumed to be those lsited in Table 31, the owners opportunity cost of capital is assumed to be 15 percent and the expected annual growth of operating costs is taken as 10 percent.

4.2 Operating Decision Model

Once the new vessel is delivered to the shipowner then the capital costs associated with its purchase should be treated as a sunk cost. In other words, if at any point in time the owner wants to evaluate the Net Present Value of the remaining life of his vessel, he should do so without considering the shipbuilding costs.

Normally, a shipowner operates his vessel for the first five to ten years under a long term charter agreement which generates a stream of cash equalling or exceeding the owner's capital and operating costs, provided that all cash flows are reduced to a NPV. After the expiration of the long-term charter agreement then the owner has a number of options available to him depending on the particular market conditions.

If the market is strong then he can either look for another long-term charter agreement or he can operate his vessel in the spot market realizing higher revenues and taking a higher risk.

If the market is depressed, as it is today, the owner can either look for a charter that covers his out of pocket expenses, or, if he is not able to do so, he can decide to lay up his vessel, sell it or scrap it.

The latter two alternatives, selling or scrapping the vessel, will not be considered here for a number of reasons:

(1) The estimation of the annual prospective revenues over the ship's reamaining service life cannot be carried on with sufficient accuracy given the cyclicality and unpredictability of the shipping market.

(2) The selling or scrapping of a vessel is an irreversible process. Most shipowner's are incurable optimists and they are reluctant to scrap or sell their vessel, always hoping for an upturning future market.

(3) Most owners usually end up selling or scrapping their vessels when they are in financial difficulty and they have to raise cash to meet bank payments, etc., in which case the cash at hand at that moment is more important than their prospective earnings.

However, it still holds that any decision taken by the shipowner - as far as the future of his vessel is concerned - should be based mostly on strong financial reasoning and less on future market expectations, which unfortunately do not always materialize.

4.2.1 Voyage Costs

Voyage costs which are affected by the distance of the haul, the number of ports of call, canal transits, etc., as well as the operating performance of the vessel are essentially composed of:

(1) The purchase of fuel (or bunkers)

(2) Commissions to agents expressed in a percentage of the cargo on board.

(3) The expenses incurred when the vessel is in port loading and discharging.

(4) The payment of canal tolls.

The largest component of voyage costs of typical bulk carriers is the expenditure on fuel oil. At present bunker prices, fuel costs for an average 6,000 N mile haul can represent between 25 to 30 percent of the total voyage costs for a bulk carrier. The average quantities of fuel consumed by typical bulk carriers of different sizes while at sea laden, in port or passing through the Panama or Suez canals are estimated in Table 33, but no single set of figures can embrace this aspect of bulk carrier operation.

Port charges constitute another element of the voyage costs. The actual charges borne by the owner of the ship vary quite considerably depending on:

(1) The size of the ship.

(2) The port turn-around time.

(3) The harbor of berth.

If one wishes to have a quick estimate of the approximate port charges then the following formula is satisfactory for general purposes.[24]

Port Charges = $U.S. {1,650 + 0.078 (DWT)} for the first day in port

plus: $U.S. {133 + 0.0267 (DWT)} for every day in port thereafter.

Table 34 lists representative average port turn-around times and estimated port charges for different size bulk carriers.

TABLE-33

ESTIMATED BUNKER CONSUMPTION AND COSTS FOR BULK CARRIERS:1983

SHIP SIZE (DWT)		40,000	65,000	120,000	175,000
(a) FUEL CONSUMPTION PER DAY (Tons/Day)					
At Sea Laden	IFO	43	58	64	73
	MDO	2	2.5	3	3.5
In Port	IFO	9	12	13	14
	MDO	2	2.5	3	3.5
In Canal	IFO	22	29	32	36
	MDO	2	2.5	3	3.5
(b) ESTIMATED DAILY BUNKER COSTS* ($/Day)					
At Sea Laden	IFO	7,310	9,860	10,880	12,410
	MDO	600	750	900	1,050
In Port	IFO	1,530	2,040	2,210	2,380
	MDO	600	750	900	1,050
In Canal	IFO	3,740	4,930	5,440	6,120
	MDO	600	750	900	1,050

IFO=Fuel Oil (HVF) MDO=Marine Diesel Oil

*Assumes average prices of $170 for IFO and $300 for MDO as of Jan. 1983. [15]

Ref. [25]

TABLE-34

(a) ESTIMATED AVERAGE TURNROUND TIMES FOR BULK CARRIERS

Size (DWT)	LOADING	DISCHARGING	TOTAL PORT TIME
40,000	1.5	2.5	4
65,000	2.5	4.5	7
120,000	4.0	6.0	10
170,000	4.0	8.0	12

Ref. [26]

(b) ESTIMATED AVERAGE PORT CHARGES (Loading and Discharging)

Size (DWT)	Days in Port	Total Port Charges $
40,000	4	11,950
65,000	7	22,783
120,000	10	48,716
175,000	12	78,655

Port Charges=$1,650 + 0.078(DWT) For the first day in port

$ 133 + 0.0267(DWT) For every day in port thereafter.

Ref. [24]

Canal transit tolls also represent a considerable fraction of the total voyage costs. On certain routes- for example, between Australia and Southern France - the transport distance will be reduced appreciably if the ship proceeds through major international waterways, such as the Suez or Panama canals. Offsetting the savings in distance are the substantial tolls and other charges associated with the transit of these waterways as Table 35 demonstrates. They may, in fact, outweigh other savings particularly in the case of the Suez canal.

4.2.2 Single Voyage Estimate

A shipowner who operates in the dry bulk spot market cannot control the freight rates, for these are set by prevailing market conditions. The shipowner is presented with a freight rate for a given route and for a certain amount of cargo - which does not necessarily equal the actual capacity of his vessel. The decision on whether to accept the proposed freight rate - expressed in U.S.$ per DWT of cargo - depends on whether the net outcome of the single voyage represents the least costly alternative for the shipowner. For example, a proposed freight rate may be sufficient to cover the out-of-pocket voyage costs borne by the shipowner, in which case the alternative for the vessel remaining idle in the harbor should be discarded. It may also happen that laying up the vessel is a less costly alternative than accepting the proposed single voyage rate (this case will be examined in the next section).

It is common practice for shipowners to express the net profits out of a single voyage in a time charter equivalent rate (T/C rate) - expressed in $ per payload (PDWT) per month - in order to provide a

TABLE-35

ESTIMATED COSTS ASSOCIATED WITH TRANSITS OF THE SUEZ AND PANAMA CANALS BY BULK CARRIERS

(U.S $)

SUEZ CANAL

SHIP SIZE (DWT)	40,000	65,000	120,000	175,000
Suez NRT	21,000	32,000	58,000	90,000
Laden Transit Tolls (SDR's)	50,300	64,000	98,400	140,000
Equivalent U.S $*	57,845	74,290	113,160	161,000
Agency,Light Dues etc	6,232	7,000	7,620	8,670
Total Transit Costs	64,077	81,290	120,780	169,670

PANAMA CANAL

SHIP SIZE (DWT)	40,000	65,000
Panama NRT	17,900	29,300
Laden Transit Tolls**	32,757	53,620
Agency,Light Dues etc	5,445	8,833
Total Transit Costs	38,202	62,453

* 1 Special Drawing Right (SDR)=$1.15 [27]

** Rate=$1.83 per Panama NRT, effective March 12th,1983 [15] benchmark for judging the actual worth of the single trip. A proposed single voyage rate can be expressed to its equivalent time charter rate expression by the following relationship:

$$\text{T/C rate (\$/PDWT-month)} = \frac{[Rs \times (1-\frac{C}{100}) \times \text{Cargo}] - (\text{Voyage Costs})}{(\text{PDWT}) \times \frac{\text{Trip time}}{30.4\,(\text{days/month})}}$$

where Rs is the spot rate ($/DWT), C represents the agent's commission as a percentage of the cargo on board and Trip time is the total voyage time including port and other delays.

A T/C rate less or equal to zero suggests that the proposed single voyage rate is not sufficient to cover the out-of-pocket voyage costs borne by the shipowner, but it does not necessarily suggest that this is a more costly process than laying up the vessel. As it will be demonstrated in the next section, a shipowner should have a benchmark T/C rate below which it would be less costly for him to lay up his vessel than continue to operate it.

Where a voyage involves the loading of two bulk parcels at different ports (for example, a bulk carrier loading coal at Hampton Roads and 'topping off' in Australia on its way to Japan), it is often desirable to establish the relationship between the individual freight rates and the overall time charter equivalent return (T/C return) from the voyage. The basic relationship is given by:

$$\text{T/C return (\$/PDWT-month)} = \frac{[\text{CargoA} \times \text{RsA}) + (\text{CargoB} \times \text{RsB})]\,(1-\frac{C}{100}) - (\text{Voyage Costs})}{(\text{PDWT}) \times \frac{\text{Total trip time}}{30.4\ (\text{days/month})}}$$

where again Rs is the single voyage rate and C is the agent's commission as a percentage of the cargo aboard. The voyage costs in the above expression represent overall costs from port of origin to port of destination and so does the time factor.

A computer program based on the above formulations is supplied in Appendix III. It can be used to quickly estimate the T/C rate given the corresponding single voyage rate and cargo capacity and vice-versa. It also calculates the equivalent average T/C return for a top-off voyage if the corresponding freight rates and cargo quantities are given.

4.2.3 Lay-Up Decision Model

Under depressed market conditions, as it happens today, a shipowner operating in the dry bulk markets is sometimes faced with low rates not sufficiently high enough to cover his out-of-pocket voyage costs, let alone his operating costs. An alternative to the shipowner is to lay-up his vessel since lay-up costs are much lower than the operating costs for a vessel. It is evident that the shipowner should establish a benchmark criterion in order to be able to determine which is the lowest possible rate he can afford to accept to keep operating in the market. A satisfactory condition, for most purposes, is that his annual net profits should equal or exceed the net difference of his annual operating and estimated lay-up costs. Or:

$$[\text{Net Profits}] \geq [\text{Operating Costs}] - [\text{Lay-up Costs}]$$

where the operating costs in the above expression are those described in section 4.1.3 and lay-up costs include:

(1) Anchorage costs.

(2) Manning costs (usually a crew of 6 to 10 seamen).

(3) Maintenance costs. These include the purchase of specialized dehumidification equipment to be installed in the engine and navigation compartments to prevent corrosion and protect sensitive electronic equipment.

(4) Fuel costs. A diesel generator is used to supply electric power to the vessel. Fuel consumption usually ranges between 1 and 1.5 tons of MDO fuel per day.

(5) Costs of recommissioning the vessel.

However, although the annual operating and lay-up costs can be approximated with sufficient accuracy, the prospective profits over a year's span are hard to estimate, given the uncertainty of employment or underemployment that exist under depressed market conditions. Therefore, it seems that we should devise a decision model that can be of use to the owner in his everyday operations. A satisfactory approach would be to try to evaluate what is the minimum T/C rate that would satisfy the relationship above. If we express the annual operating costs, annual lay-up costs and the annual net profits in terms of $ per payload (PDWT) per month, then the above relationship is equivalent to:

$$\text{Min T/C rate} = \frac{[\text{Annual Operating Costs} - \text{Annual Lay-Up Costs}]}{\text{PDWT} \times 12}$$

The convenience of this formulation is that it supplies the shipowner with a benchmark decision criterion. An owner can estimate his annual operating and lay-up costs and using the above expression can establish the minimum T/C rate he can afford to accept to let his vessel continue operating in the market. For any given route and a correspon- ding single voyage rate, the owner can quickly estimate what is the equivalent T/C rate using the computer program supplied in Appendix III. If the resulting T/C rate is higher or equal to the required minimum T/C rate then it makes sense for the shipowner to continue operating his vessel, otherwise he should consider laying-up.

It should be understood that the decision to lay-up a vessel is not solely a function of economic variables. A particular shipowner may be optimistic about the short-run future of the market and might decide to operate his vessel under any cost in order to be ready to enter the up- turning market at the right time.

However, if market conditions are extremely depressed, without any signs of improvement - at least in the short-run - then it makes sense for the owner to commit his vessel into lay-up, since he would have sufficient time to react in case of any signs of future recovery.

4.2.4 An Example Using the Operating Decision Model

To demonstrate the use of our formulation of the investment deci- sion model let us work out the following example:

Suppose a shipowner operates a 120,000 DWT bulk carrier - which has a payload of about 114,000 DWT - and he is offered a single voyage freight rate of 4.4$ per ton of cargo to carry 100,000 tons of iron ore from Tubarao (Brazil) to Rotterdam (Netherlands). Assume that bunker costs, port charges and port delays are those listed in Tables 33 and 34. Also assume that the annual lay-up costs for this particular vessel are estimated to be about $350,000 per year.

From Table 36 we see that the haul from Tubarao to Rotterdam is approximately 5,035 N miles. We can also assume an operating speed of 14.0 knots and an agent's commission of 2.5 percent.

Summarizing our data:

Route: Tubarao to Rotterdam

Freight rate: 4.4$/ton

Distance: 5,035 N miles

Speed: 14 0 knots

Steaming time: $\frac{5,035}{14x24}$ = 15 days

Port time: 10 days

Total voyage time: 25 days

Fuel costs in sea: $11,780/day x 15 days = $176,700

Fuel costs in port: $3,110/day x 10 days = $31,100

Total Fuel Costs: $207,800

Port Charges: $48,716

Total Voyage Costs: $256,516

Cargo: 100,000 tons

C = 2.5 percent

Annual Lay-up Costs: $350,000 per year

Annual Operating Costs: $2,107,000 per year

TABLE-36

DISTANCES BETWEEN PRINCIPAL WORLD IRON ORE LOADING AND DISCHARGING PORTS
(Nautical Miles)

LOADING PORT \ DISCHARGE PORT	W. GERMANY -WESERPORT	BENELUX-ROTTERDAM	FRANCE-DUNKIRK	ITALY-TARANTO	UK-PT. TALBOT	OTH. EUROPE -BAKAR	US-BALTIMORE	US-MOBILE	JAPAN-FUKUYAMA	OTH. WORLD -TSINGTAO
SCANDINAVIA-NARVIK	1,045	1,716	1,188	3,641	1,590	4,020	4,053	5,138	15,602	15,415
MEDITERRANEAN-ANNABA	2,205	2,000	1,906	607	1,763	980	4,124	5,136	8,990 Suez	8,757 Suez
MAURITANIA-POINT CENTRAL	2,491	2,216	2,175	2,332	2,031	2,860	3,345	4,300	12,372	11,550
LIBERIA-LOWER BUCHANAN	3,470	3,265	3,170	3,415	3,033	3,790	4,145	4,784	11,357	10,848
SOUTH AFRICA-SALDANHA BAY	6,320	6,115	6,020	6,270	5,882	6,650	6,870	6,205	8,200	7,980
INDIA-VIZAKHAPATNAM	11,450 Cape 7,780 Suez	11,245 Cape 7,575 Suez	11,150 Cape 7,480 Suez	11,405 Cape 5,241 Suez	11,010 Cape 7,345 Suez	11,780 Cape 5,555 Suez	11,990 Cape 9,670 Suez	12,305 Cape 10,711 Suez	4,234	4,036
CANADA-SEVEN ISLANDS	3,148	3,101	2,832	4,081	2,688	4,350	1,451	2,560	15,195	14,605
VENEZUELA-PUERTO ORDAZ	4,525	4,302	4,209	4,879	4,065	5,255	2,132	2,295	9,660	10,270
BRAZIL-TUBARAO	5,240	5,035	4,940	5,154	4,737	5,530	4,543	4,784	11,870 Mag. 11,300 Cape	12,456 Mag. 11,086 Cape
CHILE-HUASCO BAY	7,415 Pan. 9,360 Mag.	7,210 Pan. 9,150 Mag	7,120 Pan. 9,060 Mag.	7,970 Pan. 8,960 Mag	6,913 Pan. 8,855 Mag.	8,342 Pan. 9,340 Mag.	4,315 Pan. 8,350 Mag.	3,770 Pan. 8,590 Mag.	9,610	10,370
PERU-SAN NICOLAS	6,640	6,435	6,340	7,190	6,140	7,570	3,540	3,000	9,103	9,420
AUSTRALIA-PORT HEDLAND	11,620	11,415	11,320	11,576	11,185	11,950	12,160	12,475	3,578	3,527
USSR-ILYCHEVSK	3,710	3,500	3,410	1,150	3,272	1,450	5,630	6,640	15,734	15,140

SOURCE : H.P. DREWRY (SHIPPING CONSULTANTS) LTD. [3]

TABLE-37

TRANSPORT DISTANCES BETWEEN MAJOR COAL LOADING AND DISCHARGING PORTS

(Nautical Miles)

LOADING PORT \ DISCHARGE PORT		DENMARK	W.GERMANY	NETHERLANDS	FRANCE	ITALY	BRAZIL	JAPAN	HONG KONG	TAIWAN
		Aabenraa	Hamburg	Rotterdam	Marseilles	Taranto	Vitoria	Fukuyama	Hong Kong	Kaohsiung
POLAND	Gdansk	377	433	874	2,934	3,276	5,851	12,377 S 15,155 C	11,166 S 13,944 C	10,585 S
USSR	Odessa	4,214	3,780	3,538	1,740	1,144	6,094	15,734 C	7,630 S	7,781 S
US	Hampton Roads	4,158	3,733	3,544	4,049	4,540	4,417	9,910 P	11,018 P	10,820 P
	New Orleans	5,468	5,146	4,797	5,241	5,781	4,856	9,533 P	10,645 P	10,399 P
CANADA	Vancouver	9,480 P 15,223 M	9,134 P 14,862 P	8,866 P 14,609 M	9,080 P 14,187 M	9,420 P 14,727 M	8,042 P 9,605 M	4,635	5,756	5,515
S.AFRICA	Richards Bay	7,624 C	7,240 C	7,010 C	6,563 C 5,855 S	6,940 C 5,490 S	3,958 C	7,444	6,233	6,518
AUSTRALIA	Hay Point (a)	14,537 C 12,235 S	14,109 C 11,798 S	13,868 C 11,555 S	13,479 C 9,793 S	14,019 C 9,221 S	10,871 C	4,064	3,594	3,195
	Newcastle (NSW) (b)	13,442 C 12,305 S	13,014 C 11,870 S	12,828 C 11,625 S	12,381 C 9,863 S	12,924 C 9,285 S	9,776 C	4,437	4,452	4,220
CHINA	Tsingtao	15,077 C	14,650 C	14,410 C	9,109 S	8,530 S	11,410 C	1,226	1,116	899

(a) via Thursday Island (b) via Cape Leeuwin

S = Suez Canal C = Cape of Good Hope P = Panama Canal M = Cape Horn

Source : HPD Shipping Consultants Ltd. [5]

Hence,

$$\text{Min T/C rate} = \frac{[\text{Annual OC} = \text{Annual Lay-up Costs}]}{\text{PDWT} \times 12}$$

$$= \frac{[2,107,000 - 350,000]}{(114,000) \times 12}$$

$$= 1.28\$/\text{PDWT-month}$$

and

$$\text{T/C rate} = \frac{[Rs(1 - \frac{C}{100}) \times \text{Cargo}] - (\text{Voyage Costs})}{(\text{PDWT}) \ \frac{\text{Voyage time}}{30.4}}$$

$$= \frac{[4.4(1 - \frac{2.5}{100})(100,000)] - 256,516}{(114,000)\ (\frac{25}{30.4})}$$

$$= 1.84\$/\text{PDWT per month}$$

Since a single voyage rate of 4.4$/ton for this specific route produces an equivalent T/C rate of 1.84$/PDWT-month which is higher than the minimum T/C rate of 1.28$/PDWT-month, the shipowner can accept this offer.

CHAPTER 5

OCEAN TRANSPORT COST OF IRON ORE AND COAL UTILIZING BULK CARRIERS

Ocean freight and other shipping and cargo handling costs are an important component of the international coal and iron ore trades, generally representing between 15 and 30 percent of these costs. These costs, which tend to increase with shipping distance and decrease with increasing ship size, can add as much as 50 percent to the FOB price of the lower-value coal and iron ore cargoes, and are of crucial importance to both producers and consumers. Transport costs are also largely responsible for shaping shipping practices, shippers trying to realize the economies of scale that result from the substitution - whenever possible - of a smaller carrier for a larger one.

Unlike the oil markets, where economies of scale have been extensively utilized, large bulk carriers have only recently been introduced into the dry bulk markets. From our analysis point of view it is important to evaluate the savings differentials that will result from the substition of a - say - 65,000 DWT carrier for a 120,000 DWT carrier, or the latter for an even larger one, say 175,000 DWT .If the saving differentials over one size carrier to another are significant, then we can expect to observe - port limitations and storage handling facilities permitting - a switch in the long-run from smaller carriers to larger ones.

In the iron ore trades, economies of scale have been utilized for a good time, large carriers over 100,000 DWT being responsible for 65 percent of all cargo movements in 1981.[10] However, most carriers over

100,000 DWT trading in the iron ore market are pure ore carriers, OBOs or ore-oil carriers, the largest ones having a carrying capacity of over 200,000 DWT. Pure bulk carriers of over 120,000 DWT represent only a small percentage of the large ore carrying capacity, the opposite being true for OBOs and ore-oil carriers.

In the coal markets large carriers over 100,000 DWT were responsible for 30 percent of all ocean movements in 1981.[10] However, shiploads rarely exceed 120,000 DWT due to port infrastructure limitations and storage constraints.

In the following section we will try to evalute transport costs for iron ore and coal trades for a number of trading routes, under the assumption that pure bulk carriers are utilized for this purpose. In the process we will be able to evaluate the savings differentials that result from economies of scale, and therefore we will be able to comment on the prospects for each bulk carrier size category to penetrate the iron ore and coal trade market.

5.1 Transport Cost Estimation

To develop, for a variety of trade routes, estimates of transport cost for different size classes of bulk carriers, it is necessary to adopt a simplified approach to what is, in reality, a complex subject. To simplify our approach transport costs will be evaluated only for the loaded leg of a specific route.

For a particular size bulk carrier with a given payload (PDWT), the transport cost per PDWT can be expressed as:

$$\text{Transport Cost} = \frac{\text{(Fixed Costs) + (Voyage Costs)}}{\text{Payload (PDWT)}} \qquad 5.1$$

where the fixed costs include capital charges and operating costs and voyage costs include all the variable items discussed in section 5.2.1 of Chapter 5.

Operating costs, expressed in $/operating day, have been presented back in Chapter 5 for a number of bulk carrier sizes and are listed in Table 32.

Voyage costs can be broken down into:

(1) Fuel costs = (Fuel per day in sea) x (days in sea)

+ (Fuel per day in port) x (days in port)

(2) Port Charges

(3) Canal Transit Tolls (wherever applicable)

Hence, our formula for the transport cost is equivalent to:

$$TC = \frac{[FCx(DS+DP) + (DSxFS+DPxFP) + PCH + CTL]}{PDWT} \qquad 5.2$$

where

TC = Transport Cost ($/PDWT)

FC = Fixed costs per operating day ($/day)

DS = Days in sea

DP = Days in port

FS = Cost of fuel per day while in sea laden ($/day)

FP = Cost of fuel per day while in port ($/day)

PCH = Port Charges ($)

CTL = Canal Tolls ($)

PDWT = Payload of the vessel

All of the above variables can be estimated from Tables 32, 33, 34 and 35. The days that a vessel spends at sea steaming can be found by assuming an operating speed, in this case 14.5 knots, and dividing the corresponding distances from port of origin to port of destination (can be taken from Tables 36 and 37) with the daily steaming distance (operating speed x 24 hours per day).

Based on the above formulation and assumptions, transport costs for coal and iron ore trades have been evaluated for a number of major routes and they are presented in Tables 38 and 39. The estimated values presented in these tables represent 1983 conditions.

Referring to the above tables it is abvious that transport costs decrease with ship size and increase with distance. If a 120,000 DWT bulk carrier were to be used to transport coal from, say, Richards Bay to Aaberna instead of one in the 40,000 DWT class, the effective saving in cost on the loaded leg would be over 40 percent, or nearly 6$ per ton. Between certain ports, the substitution of a larger bulk carrier for one of smaller size may require a much longer haul, as for example between Western Canada and Europe, resulting in little or no potential savings in transport cost. For example, if a 120,000 DWT ship were to be used to transport coal from Roberts Bank to Aaberna instead of one in the 65,000 DWT class, the effective savings in cost - as it is seen from Table 39 - would be only 1.2 percent.

TABLE-38

ESTIMATED UNIT COST OF TRANSPORTING IRON ORE BY SHIP SIZE AND TRADE ROUTE: 1983

(U.S $ per ton)

LOAD PORT	DISCHARGE PORT	65,000 DWT	120,000 DWT	175,000 DWT
NARVIK	WESERPORT	3.7	3.6	-
	ROTTERDAM	4.5	4.2	4.0
	DUNKIRK	3.9	3.7	3.6
	TARANTO	7.1	3.9	5.4
	BALTIMORE	7.6	-	-
	FUKUYAMA	22.7	16.3	14.1
LOWER BUCHANAN	WESERPORT	6.8	5.7	-
	ROTTERDAM	6.6	5.5	-
	DUNKIRK	6.4	5.5	-
	TARANTO	6.8	5.7	-
	BALTIMORE	7.7	-	-
	FUKUYAMA	17.1	12.6	-
SALDANHA BAY	WESERPORT	10.6	8.2	-
	ROTTERDAM	10.3	8.0	7.2
	DUNKIRK	10.2	7.9	7.2
	TARANTO	10.5	8.2	7.3
	BALTIMORE	11.3	-	-
	FUKUYAMA	13.0	9.8	8.7
SEVEN ISLANDS	WESERPORT	6.4	5.4	-
	ROTTERDAM	6.4	5.4	5.0
	DUNKIRK	6.0	5.2	4.8
	TARANTO	7.6	6.3	5.8
	BALTIMORE	4.2	-	-
	FUKUYAMA	22.2	15.9	13.8
TUBARAO	WESERPORT	9.2	7.3	-
	ROTTERDAM	8.9	7.1	6.4
	DUNKIRK	8.8	7.0	6.4
	TARANTO	9.0	7.2	6.5
	BALTIMORE	8.2	-	-
	FUKUYAMA	17.1	12.5	11.0
PORT HEDLAND	WESERPORT	17.5	12.8	-
	ROTTERDAM	17.2	12.8	11.1
	DUNKIRK	17.1	12.6	11.0
	TARANTO	17.4	12.8	11.2
	BALTIMORE	18.2	-	-
	FUKUYAMA	7.0	5.8	5.4

TABLE-39

ESTIMATED UNIT COST OF TRANSPORTING COAL BY SHIP SIZE AND TRADE ROUTE: 1983

(U.S $ per Ton)

LOAD PORT	DISCHARGE PORT	40,000 DWT	65,000 DWT	120,000 DWT	175,000 DWT
HAMPTON ROADS	AABERNA	9.5	7.7	6.3	-
	ROTTERDAM	8.4	6.9	5.8	-
	MARSEILLES	9.3	7.6	6.2	-
	VITORIA	9.9	8.1	-	-
	FUKUYAMA	P 21.1	P 16.6	S 15.9	-
	HONK KONG	P 23.0	P 18.1	-	-
ROBERTS BANK	AABERNA	P 20.4	P 16.1	15.9	-
	ROTTERDAM	P 19.2	P 15.3	15.4	13.4
	MARSEILLES	P 19.6	P 15.5	15.0	13.0
	VITORIA	P 17.8	P 14.2	-	-
	FUKUYAMA	10.3	8.4	6.7	6.1
	HONK KONG	12.3	9.8	-	-
RICHARDS BAY	AABERNA	15.5	12.3	9.3	-
	ROTTERDAM	14.5	11.5	8.8	7.9
	MARSEILLES	13.1	10.9	8.4	7.6
	VITORIA	9.1	7.5	-	-
	FUKUYAMA	15.2	12.0	9.2	8.2
	HONK KONG	13.1	10.4	-	-
GDANSK	AABERNA	2.8	2.8	3.0	-
	ROTTERDAM	3.7	3.4	3.5	-
	MARSEILLES	7.3	6.1	5.3	-
	VITORIA	12.4	9.9	-	-
	FUKUYAMA	S 28.2	S 21.7	15.8	-
	HONK KONG	S 26.0	S 20.1	-	-
HAY POINT	AABERNA	S 27.9	S 21.5	S 15.7	-
	ROTTERDAM	S 26.7	S 20.6	S 15.1	12.9
	MARSEILLES	S 23.6	S 18.3	S 13.6	12.6
	VITORIA	21.3	16.5	-	-
	FUKUYAMA	9.3	7.6	6.2	5.7
	HONK KONG	8.5	7.0	-	-
NEWCASTLE	AABERNA	S 28.0	S 21.6	S 15.8	-
	ROTTERDAM	S 26.9	S 20.7	S 15.2	-
	MARSEILLES	S 23.8	S 18.4	S 13.6	-
	VITORIA	19.3	15.1	-	-
	FUKUYAMA	9.9	8.1	6.6	-
	HONK KONG	10.0	8.1	-	-

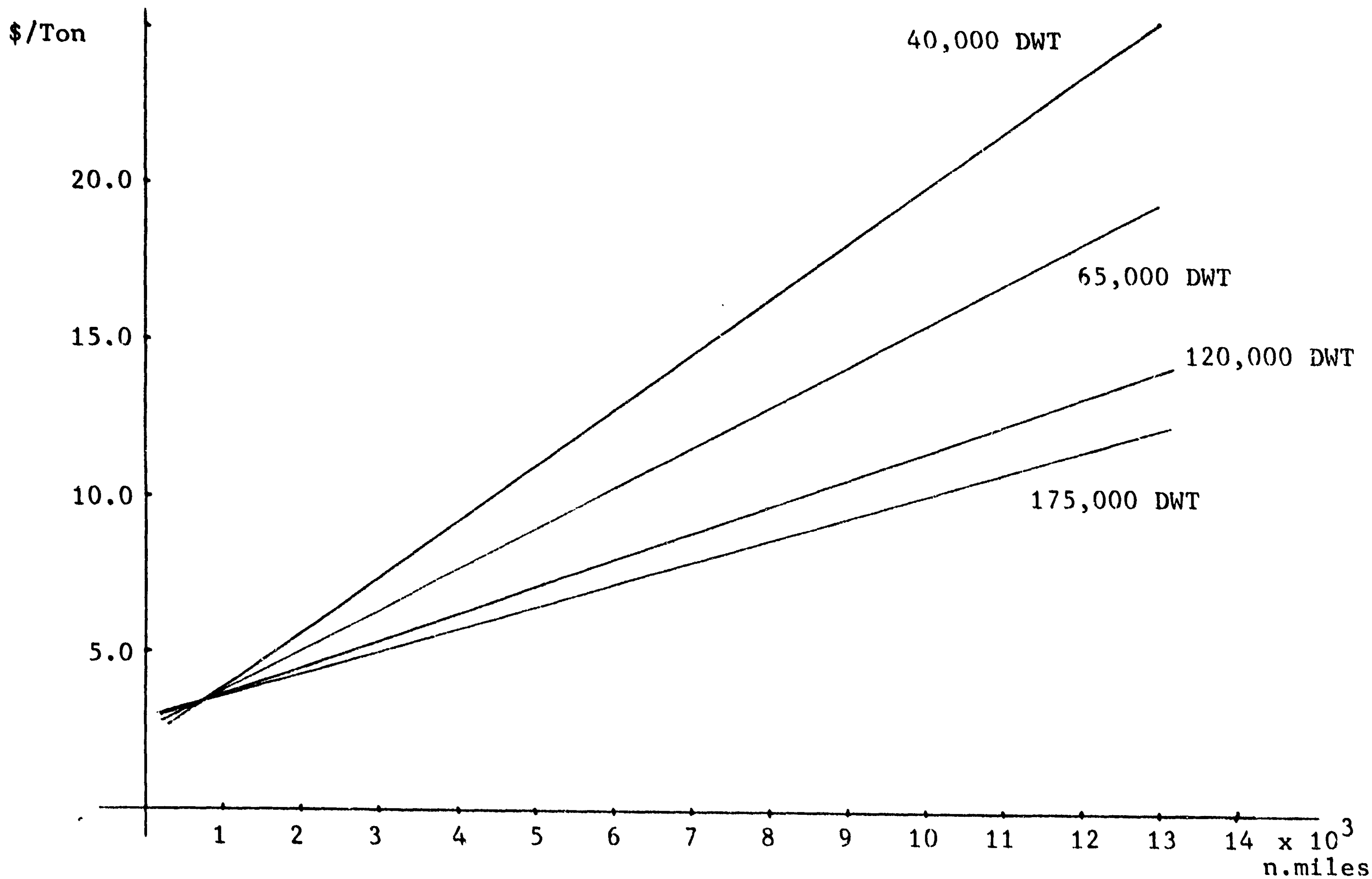
S=Suez Canal P=Panama Canal

Figure 5 presents a plot of transport cost versus haul distance for different size bulk carriers. Transport costs have been evaluated by assuming different haul lengths (and hence different voyage times and resulting voyage costs) in the relationship presented earlier to estimate transport cost.

It is interesting to note from Figure 5 that the substitution of a 175,000 DWT carrier for a 120,000 DWT carrier produces substantial transportation cost savings - say - in the order of 10 percent - only for very long hauls exceeding 7,000 N miles. Importers of coal may be reluctant to such large cargoes mainly because the economies of scale in transport cost realized by the substitution of a 120,000 DWT bulk carrier with a 175,000 DWT DWT one are offset by the sharply rising costs for stockpiling the larger cargo. In the iron ore trades, where stockpiling of large parcels of cargo (sometimes over 250,000 tons) has been common practice for a long time, the use of a - say - 225,000 DWT ore carrier or O/O carrier will produce much better savings - compared to a 120,000 DWT carrier - than a 175,000 DWT bulk carrier. Therefore, it is reasonable to assume that the future prospects for Very Large Bulk Carriers (VLBC) in the coal and iron ore trades is not very promising in the short-term, unless future port and handling facilities developments justify economically their use. Furthermore, since the building costs of a bulk carrier of about 130-135,000 DWT are not much larger than that of a 120,000 DWT one, it seems that a vessel of this size is probably the most attractive vessel in the large pure bulk carrier size category.

FIGURE-5

DRY BULK CARGO TRANSPORTATION COST AS A FUNCTION OF DISTANCE FOR DIFFERENT SIZE CARRIERS



CHAPTER 6

CONCLUSIONS

Presently the dry bulk market is in a rather depressed state. The slump in freight rates that took place over the last two years was the natural result of an unbalanced market facing overcapacity in tonnage supply and a reduction in demand. The state of the dry bulk industry is tied to the respective health of the world's industrially developed economies. This is especially true in the case of the large bulk carrier sector whose prosperity depends solely - unlike the medium and handy size sectors where a great percentage of the available capacity is occupied on the grain trades - on the relative strength of the demand for iron ore and coal from the developed industrial economies.

The economic crisis that hit most of the developed economies after 1979 and the overcapacity that saturated the large bulk carrier sector - as a result of ordering placed when the dry bulk market was booming in 1970-80 - has distorted the balance of the shipping market with all of the above mentioned consequences. Shipowners that ordered new vessels during 1979-80 have found themselves unable to operate in the presently depressed market and many have been forced to lay-up their vessels as the least costly alternative to them.

A healthy market can be described as the one where the prevailing freight rates are sufficiently high to cover the shipowner's capital, operating and voyage costs plus an adequate return on their investment or, to put it in other words, freight rates must equal or exceed transport costs as they were defined and estimated in Chapter 5. For example, a 120,000 DWT bulk carrier operating in the Tubarao (Brazil) to Rotterdam (Netherlands) iron ore haul requires a single voyage freight rate, as Table 38 suggests, of 7.1$ per ton of cargo (when it is loaded to full cargo capacity) in order to satisfy the above conditions. Presently, the prevailing single voyage freight rates for the same haul are about 4.4$ per ton of cargo.[20] In comparison, the 1980 average for the same haul was 10.0$ per ton of cargo[18] - reflecting a particularly strong market at that period.

The market balance in 1980 (demand over supply) was an average of 90 percent[18] compared to 73.1 percent as of December 1982.[13] In Chapter 3 we concluded that by 1985 the demand - calculated on the basis of forecast trade growths - would have risen sufficiently to restore the large carrier dry bulk sector to profitable 1980 conditions. The estimated 1985 market balance, 96 percent (see section 3.2), was derived on the basis of future deliveries and future scrappings of obsolete vessels and, evidently, is sufficiently high to guarantee a rise in rates.

In Chapter 3 we also concluded that the estimated 1990 demand, 70.8 million DWT for the large carrier sector, will exceed the 1985 large sector maximum supply of 60.5 million DWT. What would the market balance be in 1990 - it is impossible to say because it depends on the tonnage that will be ordered between 1985 and 1990.

In Chapter 4 we presented the formulation of an investment and operating decision model. Based on 1983 shipbuilding prices and current operating cost levels (which were allowed to increase at a rate of 10 percent per annum) we estimated the required freight rate necessary to justify the investment for a new vessel. The results are presented in Table 32. From this table we see that for a 120,000 DWT bulk carrier a 6.56$ per PDWT per month is necessary to justify the investment in this vessel. Using the formulations presented in Chapter 4 we can convert this T/C rate to its equivalent single voyage freight rate for any route we choose to. For example, in the iron ore haul from Tubarao to Rotterdam a 7.1$ per ton of cargo - equivalent to the transport cost for the same route presented in Table 38 of Chapter 5 - is required to justify the proposed investment. Presently, as we mentioned before, single voyage rates on the same route range around 4.4$ per ton, compared to 10.0$ per ton in 1980. Since by 1985, the market balance in the large carrier sector would have been restored to profitable levels it seems an investment on this kind of vessel - even in the absence of a time charter agreement - is a promising one to undertake. Allowing for a two year lead time between the signing of the contract, in 1983, and the ship's delivery, in 1985, the prospective owner would enter the market at its peak with a brand new vessel with the highest possibilities to find a very attractive time charter or operate profitably in the spot market.

In Chapter 5 we estimated transport costs as a function of distance. Since transport costs are extremely sensitive to initial capital costs and since capital costs keep increasing with the size of the vessel there must be a point where the economies of scale offered by a larger vessel will be offset by its much higher shipbuilding and operating costs. From

Figure 5 presented in this chapter we concluded that the substitution of a 120,000 DWT bulk carrier for a 175,000 tonner does not offer substantial economies of scale but on the longest routes exceeding 10,000 N miles.

Therefore, it seems reasonable to assume that a bulk carrier of approximately 120-135,000 DWT will be the optimum vessel in the large bulk carrier sector, as the 65,000 DWT 'Panamax' size has been established as the optimum vessel in the medium bulk carrier sector.

However, the major aspect of concern to the shipowner is the level of risk involved in owning a large size vessel, say a 120-135,000 DWT, against another smaller one and the profitability of each. A proposal for a future study would be for someone to assess the risk involved in operating the larger vessel considering the degree of variation in freight rates between the two sizes and the fluctuations in second-hand values. Large fluctuations would indicate a considerable risk so that, for example, if large carrier rates and values showed greater relative fluctuation than Panamax sized, then the risk of owning such a vessel could be considered greater.

A study like this would probably show a greater risk involved in owning a large bulk carrier against, say, a Panamax sized for the most part of the 1970's and insignificant differences in risk for the late 1970's and up to the present period.

The large bulk carrier, after its employment opportunities have been rejuvenated starting with the expansion of the thermal coal trade, has overcome the reluctance of shipowners and shippers and it could probably prove to be the 'workhorse' of the 1980's. It is unfortunate that the expansion of the large bulk carrier fleet has coincided with the worst depression in the dry bulk shipping industry, and this fact should not be considered as an evidence against its employment potential and profitability. The moral for shipowners should be that the critical factor in bulk shipping is not so much the type of ship the owner invests in, but the timing - when he enters the market and when he leaves it.

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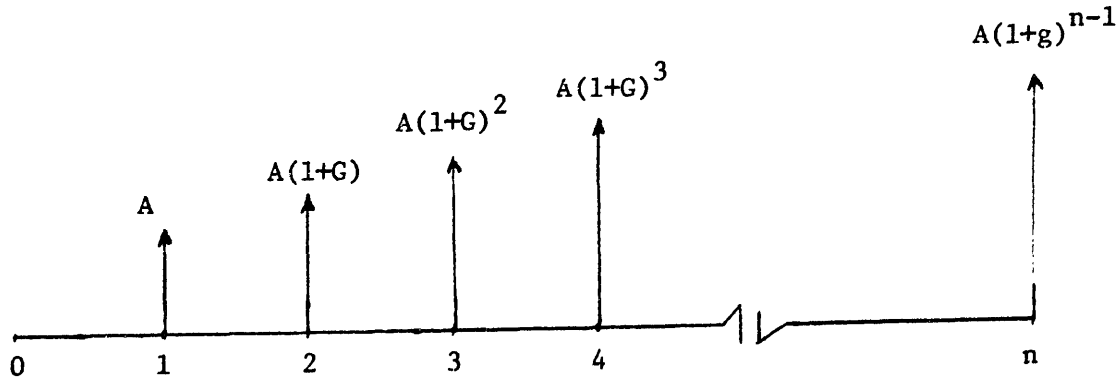
APPENDIX I

CALCULATION OF THE PRESENT VALUE OF A CASH FLOW INCREASING AT A RATE G PER YEAR

Suppose we have a cash flow A which keeps increasing at a rate G each consecutive year for n years. The cash flow diagram looks like:



The present value of this stream of cash flows discounted at t=0 at a rate R per year is given by:

$$PV_{t=0} = \frac{A}{(1+R)} + A\,\frac{(1+G)}{(1+R)^2} + A\,\frac{(1+G)^2}{(1+R)^3} + \ldots . A\,\frac{(1+G)^{n-1}}{(1+R)^n}$$

Multiplying both sides of this relation by $\frac{(1+G)}{(1+R)}$

$$(PV_{t=0})\,\frac{(1+G)}{(1+R)} = A\,\frac{(1+G)}{(1+R)^2} + A\,\frac{(1+G)^2}{(1+R)^3} + A\,\frac{(1+G)^3}{(1+R)^4} + \ldots . A\,\frac{(1+G)^n}{(1+R)^{n+1}}$$

If one subtracts one from the other then:

$$\left(1 - \frac{1+G}{1+R}\right) PV_{t=0} = A\,\frac{1}{(1+R)} + A\,\frac{(1+G)^n}{(1+R)^{n+1}}$$

$$PV_{t=0} = A\left\{\frac{1}{1-\frac{1+G}{1+R}}\left[\frac{1}{1+R} - \frac{(1+G)^n}{(1+R)^{n+1}}\right]\right\}$$

$$PV_{t=0} = A\left\{\frac{(1+R)}{(1+R-1-G)} \times \frac{1}{(1+R)}\left[1 - \frac{(1+G)^n}{(1+R)^n}\right]\right\}$$

$$PV_{t=0} = A\left\{\frac{1}{R-G}\left[1 - \left(\frac{1+G}{1+R}\right)^n\right]\right\}, \quad r \neq g$$

APPENDIX II

INVESTMENT DECISION PROGRAM

This program calculates the Required Freight Rate for a newbuilding under the assumptions made in Chapter 5. The program is written for the HP-41C programmable calculator, and it is designed to be 'user friendly,' in the sense that all required inputs are prompted in the calculator's display in English. The HP-41C printer is required for a printed display of the output.

The required inputs to the program are the following:

(1) The shipbuilding price of the vessel, expressed in U.S.$.

(2) The payload of the vessel, expressed in DWT.

(3) The annual operating costs for the vessel, expressed in U.S.$.

(4) The expected annual growth rate G for the operating costs, expressed in percent.

(5) The shipowner's opportunity cost of capital (R), expressed in percent.

The program calculates the required freight rate and displays it in three equivalent forms, namely:

Rs = U.S.$ per payload DWT per year

T/C = U.S.$ per payload DWT per month

T/C = U.S.$ per operating day

350 operating days per year are assumed.

Investment Decision Program

Step	Instruction	Input	Key	Display
1	Load Program			
2	Start Program		R/S	Ship Cost?
3	Enter Shipbuilding Cost	I	R/S	Payload?
4	Enter DWT Payload	DWT	R/S	Operating Costs?
5	Enter Annual Operating Costs	OC	R/S	G% = ?
6	Enter Operating Costs Growth Rate	G%	R/S	R% = ?
7	Enter Shipowner's Opportunity Cost of Capital	R%	R/S	Rs = ( ) $/year T/C = ( ) $/ton-month T/C = ( ) $/day

INVESTMENT DECISION PROGRAM

```
01•LBL "INVEST"
02 "SHIP COST?"
03 PROMPT
04 STO 00
05 "PAYLOAD=?"
06 PROMPT
07 STO 01
08 "OPER COSTS?"
09 PROMPT
10 STO 03
11 "G%=?"
12 PROMPT
13 100
14 /
15 STO 04
16 1
17 +
18 STO 06
19 "R%=?"
20 PROMPT
21 100
22 /
23 STO 05
24 1
25 +
26 STO 07
27 X↑2
28 .2
29 *
30 .032
31 +
32 1
33 RCL 07
34 8
35 Y↑X
36 STO 08
37 1/X
38 -
39 RCL 05
40 /
41 .164
42 *
43 +
44 RCL 08
45 1
46 -
47 RCL 05
48 /
49 RCL 06
50 /
51 6
52 RCL 08
53 /
54 -
55 RCL 05
56 /
57 .003
58 *
59 -
60 RCL 00
61 *
62 1
63 RCL 06
64 RCL 07
65 /
66 15
67 Y↑X
68 -
69 RCL 05
70 RCL 04
71 -
72 /
73 RCL 03
74 *
75 +
76 1
77 RCL 07
78 15
79 Y↑X
80 1/X
81 -
82 RCL 05
83 /
84 /
85 STO 20
86 RCL 01
87 /
88 STO 09
89 FIX 2
90 "P"
91 ACA
92 1.5
93 ACCHR
94 "="
95 ACA
96 RCL 09
97 ACX
98 " $/TON-YEAR"
99 ACA
100 PRBUF
101 ADV
102 RCL 20
103 RCL 01
104 /
105 11.51
106 /
107 "T/C="
108 ACA
109 ACX
110 " $/TON-MNTH"
111 ACA
112 PRBUF
113 ADV
114 "OR"
115 PRA
116 ADV
117 "T/C="
118 ACA
119 RCL 20
120 350
121 /
122 FIX 0
123 ACX
124 " $/DAY"
125 ACA
126 PRBUF
127 ADV
128 STOP
129 END
```

APPENDIX III

VOYAGE ESTIMATE PROGRAM

This program is intended to estimate the equivalent time charter rate (T/C rate) - expressed in \$ per DWT per month - when the corresponding spot freight rate is supplied - expressed in \$/DWT of cargo - and vice versa.

The relationships utilized are the following:

$$\text{Freight Rate} = \frac{(\text{T/C rate} \times \text{PDWT} \times \frac{\text{Time}}{30.4}) + (\text{Voyage Costs})}{\text{Cargo} \times (1 - \frac{C}{100})}$$

and

$$\text{T/C Rate} = \frac{[\text{Freight rate} \times (1 - \frac{C}{100}) \times \text{Cargo}] - (\text{Voyage Costs})}{\text{PDWT} \times \frac{\text{Time}}{30.4}}$$

where C = agent's commission, expressed as a percentage of the cargo on board

Where a voyage involves the loading of two bulk cargoes at different ports, the relaionship expressing the equivalent T/C return is given by:

$$\text{T/C return} = \frac{[(\text{CargoAxFreightA})+(\text{CargoBxFreightB})] \times (1 - \frac{C}{100}) - \text{Total Voyage Costs}}{(\text{Total time}) \times \frac{\text{PDWT}}{30.4}}$$

The program is written for the HP-41C programmable calculator and it is designed to be 'user friendly,' in the sense that all required inputs are prompt in the calculator's display in English. The HP-41C printer is required for a printer display of the output.

The required inputs to the program are the following:

(1) The payload of the vessel (PDWT)

(2) The cargo (DWT)

(3) The agent's commission C, expressed as a percentage of the cargo on board

(4) The distance between harbor of origin and harbor of destination (N miles)

(5) The operating speed of the vessel (knots)

(5) The bunker consumption of the vessel while in sea laden (tons of IFO/day)

(4) The vessel's auxiliary engine consumption while in sea laden (tons of MDO/day)

(5) The vessel's auxiliary engine consumption while in port (tons of MDO/day)

(6) The price of IFO fuel ($/ton)

(7) The price of MDO Fuel ($/ton)

(8) Port charges ($)

(9) Port time and other delays (days)

(10) Canal Tolls, if any ($)

(11) Any miscellaneous costs ($)

(12) The Freight Rate ($/DWT)

or

(13) The T/C Rate ($/DWT-month)

Voyage Estimate Program

Step	Instruction	Input	Key	Display
1	Load Program			
2	Start Program		R/S	Ready
3	To find T/C rate given Freight rate		A	
	To find Freight rate given T/C rate		B	
	Top-off voyage estimate		C	DWT = ?
4	Insert vessel's payload	PDWT	R/S	Cargo = ?
5	Insert amount of cargo	DWT/C	R/S	C% = ?
6	Insert agent's commission	C%	R/S	Distance = ?
7	Insert Voyage Distance	N miles	R/S	Speed = ?
8	Insert Ship's Operating Speed	Knots	R/S	IFO/day = ?
9	Insert Bunker Consumption	Tons/day	R/S	MDOS/day = ?
10	Insert MDO Consumption While at Sea	Tons/day	R/S	MDOP/day = ?
11	Insert MDO Consumption While in Port	Tons/day	R/S	$/IFO = ?
12	Insert IFO Price	$/ton	R/S	$/MDO = ?
13	Insert MDO PRice	$/ton	R/S	Port Chrg = ?

Voyage Estimate Program (continuation)

Step	Instruction	Input	Key	Display
14	Insert Estimated Port Charges	$	R/S	Delays = ?
15	Insert port time and other delays	# days	R/S	Canal tolls = ?
16	Insert Estimated Canal Tolls	$	R/S	Misc.Costs?
17	Insert any other fixed costs	$	R/S	Frgh rate = ? or T/C rate
18	Insert FR or T/C Rate *	$	R/S	T/C rate = $/PDWT-month or Freight rate = $/DWT

*If routine C is used (top-off voyage estimate) then the program prompts back to step 5 to input the set of data for the second leg of the voyage.

VOYAGE ESTIMATE PROGRAM

```
01♦LBL "VOYEST"
02 SF 27
03 "READY"
04 AVIEW
05 STOP
06♦LBL 01
07 "DWT=?"
08 PROMPT
09 STO 00
10♦LBL 03
11 FS? 00
12 "VOYAGE A"
13 FS? 01
14 "VOYAGE B"
15 FS? 02
16 AVIEW
17 FS? 02
18 PSE
19 CF 01
20 "CARGO=?"
21 PROMPT
22 STO 01
23 "C%=?"
24 PROMPT
25 STO 02
26 "DISTANCE=?"
27 PROMPT
28 STO 03
29 "SPEED=?"
30 PROMPT
31 STO 04
32 "IFO/DAY=?"
33 PROMPT
34 STO 05
35 "MDOS/DAY=?"
36 PROMPT
37 STO 06
38 "MDOP/DAY=?"
39 PROMPT
40 STO 07
41 "$/IFO=?"
42 PROMPT
43 STO 08
44 "$/MDO=?"
45 PROMPT
46 STO 09
47 "PORT CHRG=?"
48 PROMPT
49 STO 10
50 "DELAYS=?"
51 PROMPT
52 STO 11
53 "CANAL TOLS?"
54 PROMPT
55 ST+ 10
56 "MISC COSTS?"
57 PROMPT
58 STO 12
59 RCL 02
60 100
61 /
62 CHS
63 1
64 +
65 RCL 01
66 *
67 STO 13
68 RCL 03
69 RCL 04
70 24
71 *
72 /
73 STO 14
74 RCL 05
75 RCL 08
76 *
77 RCL 06
78 RCL 09
79 *
80 +
81 *
82 RCL 07
83 RCL 09
84 *
85 RCL 11
86 *
87 +
88 STO 15
89 RCL 14
90 RCL 11
91 +
92 STO 17
93 RCL 12
94 ST+ 15
95 RCL 10
96 ST+ 15
97 RTN
98♦LBL A
99 XEQ 01
100 "FRGHT RATE=?"
101 PROMPT
102 RCL 13
103 *
104 RCL 15
105 -
106 RCL 00
107 /
108 RCL 17
109 30.4
110 /
111 /
112 ADV
113 "T/C RATE="
114 ACA
115 FIX 2
116 ACX
117 "$/DWT-MNT"
118 ACA
119 PRBUF
120 XEQ 02
121♦LBL B
122 XEQ 01
123 "T/C RATE=?"
124 PROMPT
125 RCL 00
126 *
127 RCL 17
128 *
129 30.4
130 /
131 RCL 15
132 +
133 RCL 13
134 /
135 ADV
136 "FREIGHT RATE="
137 ACA
138 FIX 2
139 ACX
140 "/TON"
141 ACA
142 PRBUF
143♦LBL 02
144 ADV
145 "TIME="
146 ACA
147 FIX 1
148 RCL 17
149 ACX
150 " DAYS"
151 ACA
152 PRBUF
153 STOP
154♦LBL C
155 SF 00
156 SF 02
157 XEQ 01
158 "FR. RATE A?"
159 PROMPT
160 RCL 13
161 *
162 RCL 15
163 -
164 STO 19
165 RCL 17
166 STO 20
167 CF 00
168 SF 01
169 XEQ 03
170 "FR. RATE B?"
171 PROMPT
172 RCL 13
173 *
174 RCL 15
175 -
176 ST+ 19
177 RCL 17
178 ST+ 20
179 RCL 19
180 RCL 20
181 /
182 RCL 00
183 30.4
184 /
185 /
186 FIX 2
187 ADV
188 "AVP T/C="
189 ACA
190 ACX
191 "$/DWT-MNT"
192 ACA
193 ADV
194 "TIME="
195 ACA
196 RCL 20
197 FIX 1
198 ACX
199 " DAYS"
200 ACA
201 PRBUF
202 CF 02
203 STOP
204 END
```