SHIPPING

NIKO WIJNOLST • TOR WERGELAND

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Niko Wijnolst Tor Wergeland

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Niko Wijnolst (1946) became in 1988 professor in shipping, ship innovation and maritime business studies at the Delft University of Technology, besides his work as a maritime consultant. Before that he was vice president corporate development of the Transport and Trading Division of the Thyssen-Bornemisza Group in London and head of development of Furness NV in Rotterdam. He started his career as assistant professor at the Faculty of Civil Engineering and became later on planner with the Rural Access Roads Programme of the Ministry of Works, Nairobi, Kenya.
He is on the supervisory board of many maritime companies and has recently become president of the medium- and small business association MKB-Nederland.

Tor Wergeland (1952) spent his entire academic career at the Norwegian School of Economics and Business Administration (NHH). Ever since he started with shipping economics in 1975, his main interest has been to demonstrate that economic theory can be useful in practise. In 1985 he created the SIS-Programme - a special recruitment programme for shipping, where economists or engineers follow the doctoral programme in business and economics at NHH and at the same time work in a shipping company. He has also created a MBA Programme in Shipping Management, so teaching and research dissemination has been his main activities. From the position of Ass. Prof. at the Institute for Shipping Research he spent 3 years as Managing Director for the foundation Centre for International Business and 1 year as Research Director at the foundation Centre for Research in Economics and Business Administration, both at NHH, before returning to his current position at the Centre for International Economics and Shipping at NHH.

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Niko Wijnolst Tor Wergeland

with assistance from Frans Waals

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PREFACE

Shipping is a multi-faceted industry which is rather complex to define from an academic point of view. This book attempts to grasp these complexities and provide the reader with an overview of the main topics and terminology in shipping.

The book is based on material from our courses in shipping at the universities in Delft and Bergen. As with our lectures, we draw upon quite a varied material, from research studies at a high academic level to lower level student work and purely descriptive material from a multitude of sources. No particular attempts have been made to make all figures very updated. The reference years for descriptive data varies a lot, therefore. The book aims at being a useful textbook for students in engineering, economics and logistics and could be used both at an elementary introductory level as well as on higher levels up to MBA.

There are two distinct contributions in this book, which represent our respective backgrounds in engineering/operations and economics. We are of course indebted to many people, and many are particularly mentioned in the Chapter Notes.

The book has been made with record speed, simply because we wanted it out to an audience which is invited to give us feedback. If this book fills a role in the teaching of shipping, we will certainly consider making a larger, more researched and more updated future version, with fewer language errors and maybe even a keyword index.

Ir. F.A.J. Waals provided us with valuable assistance in putting the book together. Without his enthusiasm and support, the book would have been quite different, or not at all.

September 1996

Prof. dr ir Niko Wijnolst
Delft

ass. Prof. Tor Wergeland
Bergen

CHAPTER 1: WORLD SEABORNE TRADE FLOWS

World trade, expressed in US$ value, more than doubled over the last decade from 1.77 trillion US$ in 1983 to 4.09 trillion US$ in 1994. In a long historical perspective **Table I** compares the growth rates of merchandise trade with world GDP. With the exception of the highly protectionistic inter-war period, world trade has in general been growing 1.5 times as fast as the general value added in the world.

Annual average growth in	1870-1900	1900-1913	1913-1950	1950-1973	1973-1993
Gross domestic product	2.9	2.5	2.0	5.1	2.6
Merchandise trade	3.8	4.3	0.6	8.2	3.8

Source: GATT, (1994)

Table I: Growth in volume of trade and output 1870-93

World shipping is an economic activity directly dependent on global international trade. Global trade statistics are, therefore, of high potential interest to the world shipping community. The problem is that international trade statistics are normally based on the *value of trade*, but shipping is primarily interested in *volumes of cargo*, as shipping is being paid per unit of volumes carried on the numerous trade routes.

1.1 The commodities in world seaborne trades

The international shipping community does not have one, good source of truly *global* statistics for *all parts* of seaborne trade. For a number of years, the United Nations published data on world total seaborne trade by commodity and region, which is the only such source to date. The latest publication in this series was published in 1989, covering the years 1983-86, which is sadly the latest year for which complete data exist for a detailed commodity breakdown of world seaborne trade with a broad geographical coverage.

A number of *specialised data sources* do exist, however, and particularly major broking companies, as Fearnleys, Simpson, Spence & Young and Clarkson's are monitoring world trade flows. Perhaps the sources most frequently referred to are the publications of Fearnley Research in Oslo, notably their *"World Bulk Trades"* and *"Fearnleys Review"*. If we compare the data from Fearnleys with the UN statistics (using the latest available year, 1986) a picture as given in **Table II** emerges.

Commodity group	Data from Fearnleys			Data from United Nations		
	Million tonnes	Billion TM*	ALH**	Million tonnes	Billion TM	ALH
Crude oil	958	4640	4843	1043	4147	3977
Oil products	305	1265	4148	317	914	2887
Iron ore	311	1699	5463	303	1653	5461
Coal	276	1558	5645	283	1404	4957
Grain	165	914	5539	159	805	5056
Five main bulk	2015	10076	5000	2105	8923	4239
Other commodities	1370	3780	2759	1066	4293	4027
Total seaborne trade	**3385**	**13856**	**4093**	**3171**	**13216**	**4168**

* TM stands for tonne-mile, defined as tonne*mile, where tonne = tonnes of cargo, mile = nautical miles the cargo has been carried
** ALH stands for Average Length of Haul, i.e. the number of nautical miles cargo has been carried

Source: Fearnley Review, 1995 and United Nations, Statistical Series D, 1989

Table II: Comparative data for world seaborne trade 1986

Table II illustrates a main point when dealing with international seaborne trade statistics: There are many sources and often big differences from source to source, which makes it difficult to be a data user. Fearnleys bases its statistics mainly on cargo movements by tracking vessels, normally vessels over 10,000 dwt. The United Nations database was based on a conversion of official trade statistics into seaborne trade data, using detailed transport statistics for 14 countries and conversion factors for all other countries without such detailed transport statistics. Generally one would believe that the UN statistics had a greater coverage, with generally more short hauls as trade flows and the basic units are not ships. Some of the comparative data from **Figure 1** come, therefore, as a surprise. Only the estimates for iron ore that almost equal. For a data user it is impossible to judge which source to rely on, and the comparison is made just to remind all data users of the uncertainty involved in published statistics. Fearnleys have, however, been compiling the same statistics since the beginning of the 1960s, and there is no reason to doubt that every effort has been made to make the statistics consistent over time. Sometimes this is more important than anything else, as data are often used to analyse changes from one year to another.

Even though the United Nation's seaborne trade statistics are discontinued and outdated, the latest data still can give a useful and detailed picture of what cargoes are dominating world seaborne trade. **Table III** to **Table V** give a total breakdown of world seaborne trade in 1986 for all the 128 commodity groups of the UN nomenclature. **Table III** comprises main bulk commodities, both dry bulk and liquid bulk, while **Table IV** and **Table V** comprise the general cargoes as classified by the UN. It is difficult to find a classification that can serve all analytical pur-

Commodity groups	Million ton	Billion TM	ALH	Nature of cargo
Grains	159	805	5056	
Wheat , unmilled	78	371	4740	Bulk
Rice	10	54	5396	Bulk, bags
Cereals n.e.s., unmilled	71	380	5357	Bulk, bags
Sugar	23	117	5161	
Raw sugar, beet and cane	17	91	5482	Bags, baskets
Refined sugar	6	26	4266	Bags
Oil seeds, nuts and kernels	33	186	5580	
Groundnuts, green	1	4	4749	Bulk, bags
Soya beans	26	160	6135	Bulk, bags
Oil seeds n.e.s.	6	22	3400	Bulk, bags
Timber	77	279	3604	
Pulpwood	15	51	3483	Pressed bales
Logs, conifer	19	85	4586	Logs, 'packaged'
Logs, non-conifer	19	60	3102	Logs, 'packaged'
Lumber, shaped	24	81	3332	'Packaged'
Other wood n.e.s.	0	2	3145	Logs, 'packaged'
Ores	366	1960	5360	
Iron ores	303	1653	5461	Bulk
Copper ores	3	16	4945	Bulk
Bauxite	40	183	4615	Bulk
Manganese ores	6	36	5849	Bulk
Non-ferrous ores n.e.s.	14	72	5169	Bulk, bags, drums
Metal scrap	21	118	5691	
Iron and steel scrap	17	97	5673	Loose, bales
Non-ferrous metal scrap	4	21	5777	Loose, bales
Coal and coke	292	1437	4917	
Coal	283	1404	4957	Bulk
Coke	7	28	4210	Bulk
Other solid fuels n.e.s.	2	4	1923	Bulk, bags
Fertilisers	63	224	3543	
Natural phosphates	27	86	3220	Bulk
Natural fertilisers	5	26	5307	Bulk, bags
Fertiliser, manufactured	32	113	3546	Bulk, bags
Ferrous base metals	110	427	3870	
Pig iron	4	19	4707	Bulk,
Other ferro-alloys	5	24	5049	Ingots, coils, pipes etc.
Products of ferrous base metals	101	384	3782	Ingots, coils, pipes etc.
Animal Feeding stuff	45	231	5081	Bulk, bags
Other dry bulk	99	292	2954	
Gypsum, plaster	16	35	2111	Bulk, bags
Mineral sands	6	10	1591	Bulk, bags
Sulphur	11	63	6015	Bulk, drums
Iron pyrites	0	0	1279	Bulk,
Salt	22	71	3248	Bulk, bags, drums
Crude asbestos	1	6	6741	Bags, drums
Other crude minerals n.e.s.	43	107	2502	Bulk, bags, drums
Crude petroleum	1043	4147	3977	Liquid
Petroleum products	317	914	2886	
Gasolenes	78	274	3514	Liquid, barrels, drums
Kerosene and jet fuels	21	59	2783	Liquid, barrels, drums
Distillate fuels	70	156	2251	Liquid, barrels, drums
Residual fuel oils	148	425	2869	Liquid, barrels, drums
Liquefied fuel gases	64	230	3622	Refrigerated liquid
Other liquid bulk	12	48	4079	
Molasses	6	30	4717	Liquid, drums
Oils etc. from coal	5	18	3349	Liquid, barrels, drums

Table III: Main bulk commodity groups in world seaborne trade, 1986 poses, and for particular trade, more detailed statistics from specialised sources are necessary. Typical examples are chemicals, steel products and cement, where highly specialised industry institutes can provide a wealth of detailed information.

Commodity groups	Million tonnenes	Billion TM	ALH	Nature of cargo
Refrigerated foods	33	119	3656	
Meat	5	25	4895	Cases, cartons, etc.
Milk and cream	0	1	2695	Kegs
Butter and cheese	2	8	3978	Cases, cartons, etc.
Fresh eggs	0	1	3341	Cases, cartons, etc.
Fish	5	18	3632	Boxes, cases, cartons, etc.
Oranges etc.	2	8	3507	Cases, cartons, etc.
Bananas	7	23	3045	Cases, cartons, etc.
Potatoes	2	4	2210	Cases, cartons, etc.
Other fresh fruit	9	33	3753	Cases, cartons, etc.
Coffee	4	21	5119	Bags, chests, containers
Tea and mate	1	5	5263	Bags, chests, containers
Other foods	38	171	4491	
Meat, dried, salted, smoked	1	3	2821	Bags, cases, cartons, etc.
Milk and cream, non-fresh	2	10	4638	Bags, cases, cartons, etc.
Fish, dried, salted, smoked	0	1	2898	Bags, cases, cartons, etc.
Fish, tinned or prepared	1	6	5148	Bags, cases, cartons, etc.
Meal and flour	6	20	3619	Bags, cases, cartons, etc.
Cereal grains, prepared	4	17	4723	Bags, cases, cartons, etc.
Edible nuts	1	4	4906	Bags, cases, cartons, etc.
Dried fruits	5	23	4830	Bags, cases, cartons, etc.
Dry leguminous vegetables	3	10	3449	Bags, cases, cartons, etc.
Vegetables n.e.s., preserved	3	12	3946	Bags, cases, cartons, etc.
Sugars n.e.s., confectionery	2	7	4386	Bags, cases, cartons, etc.
Cocoa and chocolate	2	8	4447	Bags, cases, cartons, etc.
Spices	1	2	4444	Bags, cases, cartons, etc.
Margarine cooking fats	0	1	1934	Bags, cases, cartons, etc.
Food preparations n.e.s.	1	5	3592	Bags, cases, cartons, etc.
Vegetable products	7	58	8459	Bags, cases, cartons, etc.
Beverages	7	23	3175	
Non-alcoholic beverages	1	3	2867	Tanks, cartons, cases
Alcoholic beverages	6	19	3235	Liquid, tanks, cartons, cases
Tobacco	1	7	4896	
Tobacco, unmanufactured	1	6	5233	Bales, bags
Tobacco, manufactured	0	1	3660	Carton, cases, etc.

Table IV: Main food-related commodity groups in world seaborne trade, 1986

To show the relationship between the commodities listed and the shipping industry, the nature of the cargo in terms of packaging has been added. This gives an indication as to the kind of tonnage required to handle the various commodities.

Table VI clearly indicates that international seaborne trade is dominated by three main cargoes (crude oil, iron ore and coal), a few larger bulk commodities (grain, oil products, fuel gases) and a large number of much smaller product groups.

To more clearly see the difference between using transportation work as a criterion instead of values, the UN Seaborne Trade Statistics could be compared to

Commodity groups	Million tonnes	Billion TM	ALH	Nature of cargo
Crude rubber	6	30	4899	Bales, cases, drums
Textile fibres	8	41	4841	
Wool and animal hair	1	9	7300	Pressed bales
Cotton	4	19	4648	Pressed bales
Jute	0	2	4503	Pressed bales
Hard fibres	0	1	5000	Pressed bales
Other fibres n.e.s.	2	10	3916	Pressed bales
Other crude materials	3	10	3424	
Fur skins, undressed	0	1	5542	Bales
Cork, raw and waste	0	0	4218	Bulk, bags
Crude organic materials n.e.s.	3	9	3317	Bulk, bales, bags
Non-energy petroleum products	31	128	4147	Bulk, bags
Oil and fats	16	81	5026	
Olive oil	0	1	2940	Cases, barrels, drums
Palm oil	5	25	5050	Cases, barrels, drums
Other oils and fats	11	56	5048	Cases, barrels, drums
Chemicals	85	326	3855	
Organic chemicals	33	139	4200	Liquid, bulk, bags, drums
Inorganic chemicals	25	91	3715	Liquid, bulk, bags, drums
Chemicals n.e.s.	8	30	3771	Liquid, bulk, bags, drums
Radio-active & assoc. materials	0	0	5200	Drums
Dyeing, tanning, colour materials	2	8	3832	Cases, drums
Pharmaceutical products	1	2	3655	Cases, boxes, drums
Essential oils & cosmetics	2	6	3171	Cases, boxes, drums
Plastic materials	14	50	3453	
Paper etc.	26	80	3115	
Paper and paperboard	24	76	3159	Rolls, bales
Articles of paper	2	4	2524	Rolls, cases
Textiles	9	34	3724	Bales, cartons
Machinery	17	78	4536	
Electrical machinery	8	35	4389	Cases, boxes etc.
Other machinery n.e.s.	9	43	4660	Cases, boxes etc.
Other manufactures	94	312	3314	
Leather, rubber manufactures	4	18	4779	Cases, boxes etc.
Veneer sheets and plywood	6	30	4995	'packaging'
Wood and cork manufactures	5	17	3254	'packaging', cases etc.
Cement	44	97	2197	Bulk, bags, drums
Non-metal, mineral manufactures	13	44	3371	Crates, boxes
Misc. metallic products	5	25	4708	Crates, boxes
Misc. manufactures n.e.s.	17	81	4896	
Woodpulp and paper waste	19	92	4868	Pressed bales
Crude minerals n.e.s.	1	4	3966	Bulk, bags, drums
Non-ferrous base metals	13	55	4332	
Copper	4	20	4896	Ingots, coils
Aluminium	5	21	3950	ingots, coils
Tin	0	1	3828	ingots, coils
Non-ferrous based metals n.e.s.	3	14	4267	ingots, coils
Manufactures of metal	3	13	3884	
Finished structures and parts	2	7	3914	Crates, boxes
Metal containers, wire products	2	6	3848	Crates, boxes, loose
Machinery and equipment	25	127	5132	
Agricultural machinery	1	5	3847	Crates, boxes, loose
Metal working and machinery	4	20	4502	Crates, boxes, loose
Passenger motor cars	8	50	6129	Crates, boxes, loose
Motorcycles and parts	0	1	6137	Crates, boxes, loose
Other road motor vehicles n.e.s.	8	34	4505	Crates, boxes, loose
Railway and non-motor vehicles	1	5	4563	Crates, boxes, loose
Aircraft, boats and their parts	2	12	5924	Crates, boxes, loose
Miscellaneous	8	22	2969	
Live animals	1	2	3790	Loose
Hides and skins, undressed	1	7	4873	Bales
Explosives and pyrotechnic products	0	1	4136	Boxes, chests
Commodities n.e.s.	5	13	2351	Cases, boxes, loose etc.

Table V: Other general cargoes in world seaborne trade, 1986

Rank	Commodity group	Million tonnes	ALH	Billion TM	% of TM
1	Crude petroleum	1042.6	3977	4147	31.4
2	Iron ores	302.7	5461	1653	12.5
3	Coal	283.3	4957	1404	10.6
4	Residual fuel oils	148.1	2869	425	3.2
5	Products of ferrous base metals	101.5	3782	384	2.9
6	Cereals n.e.s., unmilled	71.0	5357	380	2.9
7	Wheet, unmilled	78.2	4740	371	2.8
8	Gasolenes	77.9	3514	274	2.1
9	Animal feeding stuff	45.4	5081	231	1.7
10	Liquefied fuel gases	63.6	3622	230	1.7
11	Bauxite	39.7	4615	183	1.4
12	Soya beans	26.1	6135	160	1.2
13	Distillate fuels	69.5	2251	156	1.2
14	Organic chemicals	33.2	4200	139	1.1
15	Non-energy petroleum products	30.8	4147	128	1.0
16	Fertiliser, manufactured	31.7	3546	113	0.9
17	Other crude minerals n.e.s.	42.8	2502	017	0.8
18	Cement	44.2	2197	97	0.7
19	Iron and steel scrap	17.1	5673	97	0.7
20	Woodpulp and paper waste	18.8	4868	92	0.7
21	Raw sugar, beet and cane	16.7	5482	91	0.7
22	Inorganic chemicals	24.6	3715	91	0.7
23	Natural phosphates	18.6	3220	86	0.7
24	Logs, conifer	24.4	5486	85	0.6
25	Lumber, shaped	16.5	3332	81	0.6
26	Misc. manufactures n.e.s	23.9	4896	81	0.6
27	Paper and paperboard	13.9	3159	76	0.6
28	Non-ferrous ores n.e.s.	21.8	5169	72	0.6
29	Salt	10.5	3248	71	0.5
30	Sulphur	19.2	6015	63	0.5
31	Logs, non-conifer	21.2	3102	60	0.5
32	Kerosene and jet fuels	6.8	2783	59	0.5
33	Vegetable products	11.1	8459	58	0.4
34	Other oils and fats	9.9	5048	56	0.4
35	Rice	14.5	5396	54	0.4
36	Pulpwood	14.4	3483	51	0.4
37	Plastic materials	18.1	3453	50	0.4
38	Passenger motor cars	13.2	6129	50	0.4
39	Non-metal, mineral manufactures	9.3	3371	44	0.3
40	Other machinery n.o.s.	6.1	4660	43	0.3
41	Manganese ores	16.4	5849	36	0.3
42	Gypsum, plaster	7.9	2111	35	0.3
43	Electrical machinery	7.5	4389	35	0.3
44	Other road motor vehicles n.e.s.	9.1	4505	34	0.3
45	Textiles	8.8	3724	34	0.3
46	Other fresh fruit	6.0	3753	33	0.2
47	Veneer sheets and plywood	7.9	4995	30	0.2
48	Chemicals n.e.s.	6.3	3771	30	0.2
49	Molasses	6.0	4717	30	0.2
50	Crude rubber	6.7	4899	30	0.2

Table VI: Main cargoes in seaborne trade 1986 ranked according to share of TM the traditional trade statistics classified according to the SITC[1]. **Table VII** has been compiled by a regrouping of the UN Seaborne Trade data as given in **Table III** to **Table V** to match the broad classification used by the WTO (World Trade Organisation) in their yearly publication International Trade.

Commodity groups	Seaborne trade 86		Share of US$ value of trade		
	Billion TM	% of TM	1980	1990	1994
Agricultural products	2690	20.4%	15.3%	12.7%	12.3%
Food	1651	12.5%	11.4%	9.6%	9.6%
Raw materials	1039	7.9%	3.9%	3.0%	2.7%
Mining products	9107	69.0%	28.8%	14.6%	11.0%
Ores and minerals	2212	16.8%	2.2%	1.6%	1.2%
Fuels	6746	51.1%	23.9%	10.8%	7.8%
Non-ferrous metals	148	1.1%	2.6%	2.3%	2.0%
Manufactures	1410	10.7%	56.1%	72.7%	76.6%
Iron and steel	440	3.3%	4.0%	3.2%	3.0%
Chemicals	326	2.5%	7.3%	9.0%	9.6%
Other semi-manufactures	392	3.0%	7.0%	8.0%	8.0%
Machinery and transport equipment	205	1.6%	26.8%	36.9%	40.0%
Textiles & clothing	34	0.3%	4.9%	6.5%	6.7%
Other consumer goods & unspecified	13	0.1%	6.0%	9.2%	9.4%
All commodities	13207	100.0%	100.0%	100.0%	100.0%

Sources: UN Statistical Papers, Series D, 1989 and WTO: International Trade, 1995

Table VII: Comparisons of value of trade and tonne-miles in seaborne trade

Today more than 75% of the value of world trade is from manufactured goods. These commodity groups constitute only about 10% of the transportation work in seaborne trade. Shipping is, therefore, to a dominating degree transporting agricultural and mineral products, i.e. basic food, raw materials and energy products. These commodity groups constitute some 90% of world seaborne transportation work. **Figure 1** and **Figure 2** show the development over time.

To finally see the dominance of the 5 main bulk commodities, crude oil, oil products, iron ore, coal and grain, **Figure 3** illustrates the share of total tonne-miles for main groups of commodities. As indicated, the average share of transportation work for the five main bulk commodity groups has been around 75% for the entire period.

[1]SITC - Standard International Trade Classification - is the United Nation's international standard for classifying trade data. The classification has been undergoing 3 major revisions and contains at the lowest level of Revision 3 several thousand items.

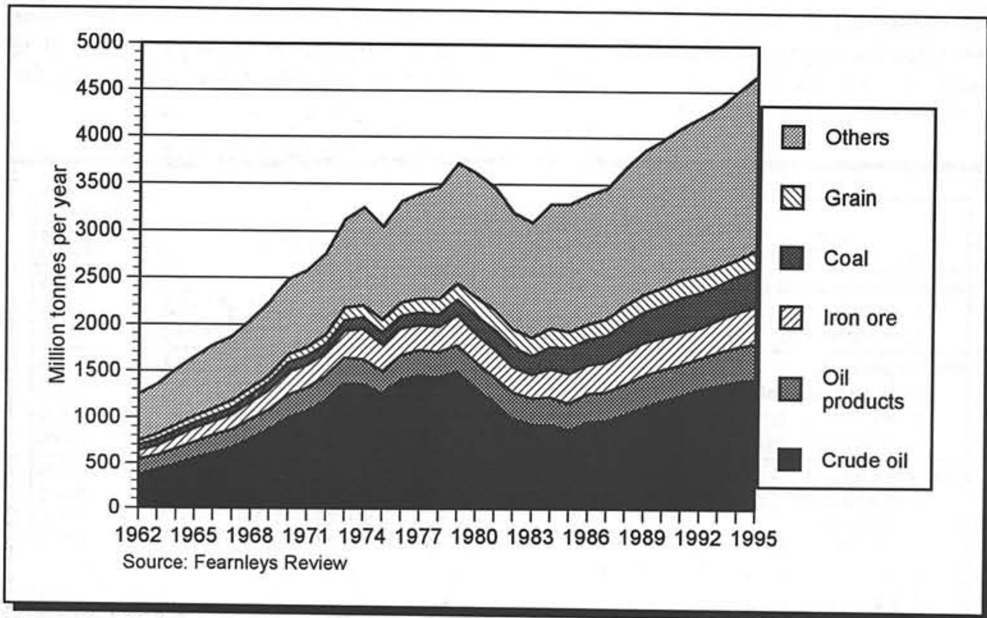

Figure 1: Main groups of seaborne trade commodities - million tonnes 1962-95

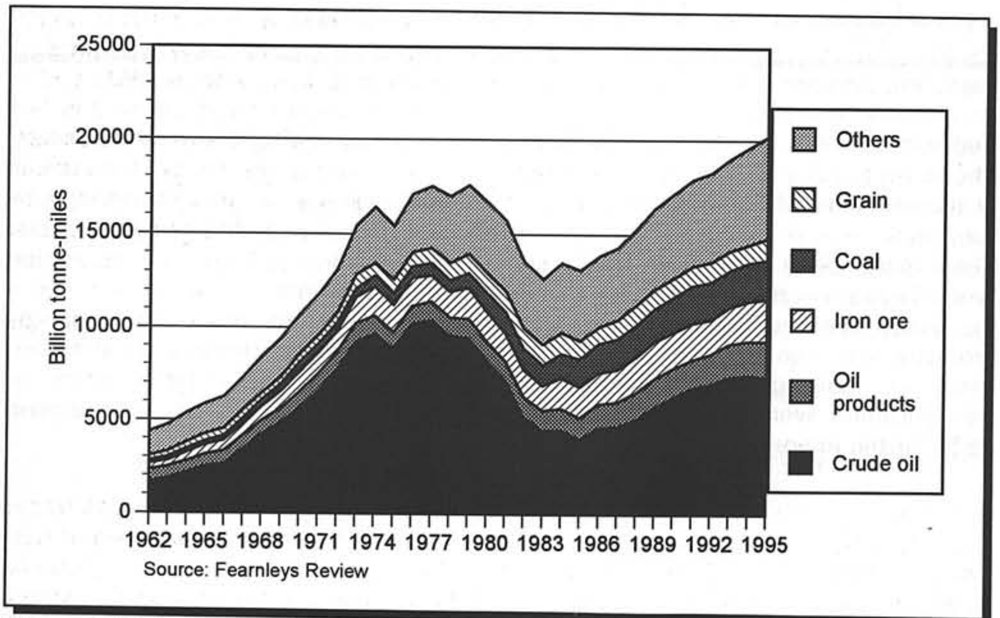

Figure 2: Main groups of seaborne trade commodities, billion tonne-miles

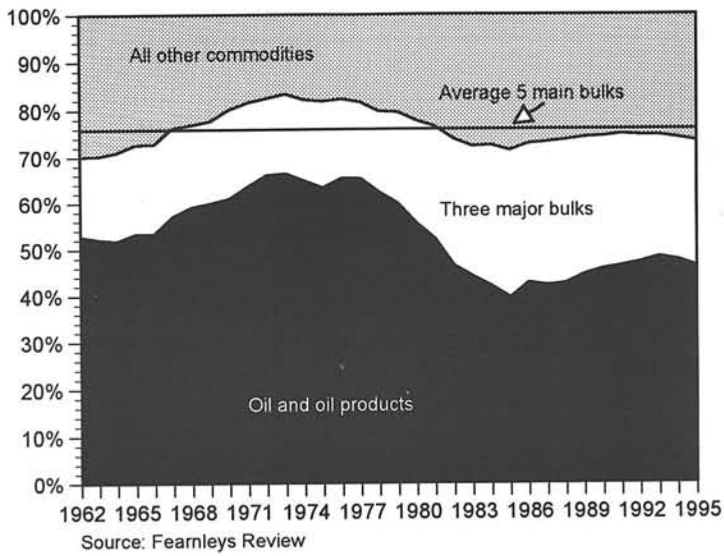

Figure 3: The share of tonne-miles for main commodity groups 1962-95

Even if shipping will remain an industry primarily dependent on bulk transportation, container traffic is growing at a rate that makes it natural to show the development in container transportation. Container transport is measured in TEUs and in most cases the ports provide the statistics on the number of containers that has been handled in a particular period. Some countries with a high level of re-export[1] like Hong Kong and Singapore, also report on containers in transit. As a container is always shipped between two ports, the actual number of units transported by container ships has to divided by two. **Figure 4** shows the growth of the container volumes (in TEU) handled by world ports in the period 1975-94. The recent impressive growth rates are likely to continue in the near future, as increasing economies of scale drives the freight rates down, which in turn make it feasible for lower value commodities to beshipped internationally by containers.

1.2 Parcel sizes and main types of shipping activities

It is clear from **Table III** to **Table V** that the commodities in world seaborne trades are most dispersed regarding the way they are shipped. To better understand how shipping deals with this problem, it is useful to think of each commodity group as having a special parcel[2] size distribution. Some cargoes have a very wide distribu-

[1]Re-export means that cargo is formally imported and then exported again, sometimes without any changes to the commodity.

[2]A parcel in this context can be defined as an individual consignment for shipping.

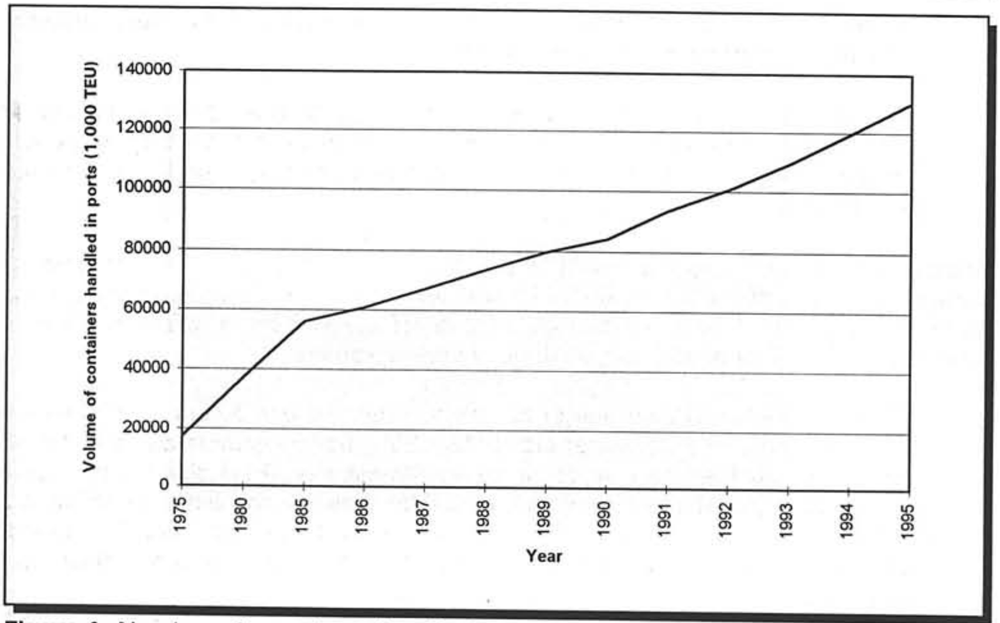

Figure 4: Number of containers handled by world ports 1975-1994

tion of parcel sizes, i.e. the individual shipments can vary from a few bags to whole shiploads. Grain would be an example of a commodity shipped in a variety of different ways. A main distinction is, however, between 'bulk cargo', where the parcel size is sufficient to fill a whole ship, and 'general cargo', where each parcel is too small, but where a combination of many parcels can fill up a ship.

To summarise this discussion of commodity groups, the following grouping of main commodities could be made:

There are four main areas of ***bulk shipping***:

- *Liquid bulks*, which require some form of tanker transportation. Crude oil is the main commodity and oil products, liquid chemicals, vegetable oils and wine are the main other commodity groups. In 1994, the shipments of crude oil constituted some 1403 million tonnes, and oil products some 368 million tonnes;

- *Major bulks*, which are shipped in fairly large bulk carriers. There are 5 main bulk commodities, with the tonnes shipped in 1994 as indicated: Iron ore (383 tonnes), coal (383 tonnes), grain (184 tonnes), bauxite & alumina (49 tonnes) and phosphate (29 tonnes);

- *Minor bulks*, all of which can travel in full shiploads. The most important ones are forest products and steel products, which in volumes are more important than the two smaller 'majors'. Other products are cement, ores of manganese, copper, nickel, zinc and chrome, tapioca, oil-cakes, potash, brimstone, limestone, salt, sand, etc.;

- *Special bulk cargoes*, which is a term used for cargoes presenting special cargo handling or storage problems. Motor vehicles and steel products could be such cargoes, prefabricated buildings and other large and bulky consignments would be other.

Transport of ***general cargo*** is another type of business altogether. The number of cargoes is very large, and they come in all shapes and sizes, but each parcel is too small to fill a ship. The main classes of general cargo from a shipping point of view would be based on the cargo handling considerations:

- *Containerised cargo*, i.e. cargo put inside standard containers. The standard measurements of a container are (8'*8'*20'), but containers can also be 40 instead of 20 feet long, or other sizes. Almost any small sized cargo could in principle be shipped in containers. Volumes of container handling are normally measured in TEUs (Twenty Foot Equivalent Units), i.e. the number of standard containers 20 feet long. One 40 feet container thus corresponds to 2 TEU.

- *Palletised cargo*, i.e. cargo packed onto a standard pallet for easy stacking and fast handling;

- *Pre-slung cargo*, i.e. smaller items such as planks of wood, plywood, etc. lashed together into fairly standard-sized packages;

- *Liquid cargo*, which is usually transported in liquid containers, deep tanks or drums;

- *Loose cargo*, which is individual items which must be handled and stowed separately;

- *Heavy cargo and awkward loads* - large parcels that might be both difficult to handle and difficult to stow. Some of the bulky offshore structures fall in this category and often require special ships;

- *Refrigerated cargo* - this is a special category that includes all perishable goods that must be shipped frozen or chilled in specially insulated holds or containers. The total imports of such goods amounted to as much as 65 million tonnes in 1993, and since many shipments of refrigerated cargoes are large enough to fill up a ship, it could as well be classified as special bulk. Special ships are designed (called reefers) to carry the main products, which comprise vegetables, meat, bananas, fish, citrus fruits, windfall fruit, dairy products and exotic fruit.

1.3 Trade routes in world seaborne trade

Shipping demand has three main dimensions: Cargo type, parcel size (and type) and the route along which the cargoes are carried. In general, each cargo has its own, unique trading pattern, determined by the location of producing areas with a surplus (the exporters) and consuming areas with a deficit (the importers). All standard demand analyses will have to study major exporters and importers.

1.3.1 Crude oil trades

With the exception of Japan, all importing regions have become less dependent on the Middle East as the main exporter. The changes in trading pattern, and particularly the balance between an exporter far from the importing areas and exporters close to importing areas, will have a dramatic influence on oil tanker demand.

Figure 5 illustrates this clearly. The figure shows how many large tankers (Very Large Crude Carriers (VLCCs) of average size 250,000 dwt would be required to ship 1 million b/d[1] of crude oil on the trade routes specified. If the USA, with a total import of about 7.7 mbd, of which about 2 million come from the Middle East, should substitute half of this imports with imports from the North Sea, this would imply a reduction in demand for tankers corresponding to 31 VLCCs, or more than 6% of the deadweight all available large tankers.

The volumes in crude oil trades have developed as shown in **Figure 6**. The rapid growth of the 1960s (12.7% per year 1962-73) was halted by the oil price shock of 1973/74. From 1976-79 another growth period followed (4.4% per year), but after the second oil price hike in 1979, the combined effects of energy savings and increased non-OPEC production made oil imports shrink at a rate of 11.1% per year 1980-83. The last decade (1986-95) has again experienced fairly stable growth at a rate of 5.1% per year.

The development for oil products has been somewhat different. **Figure 7** indicates that there has been a fairly stable underlying growth of around 3% per year on average for the whole period, with two short down periods after each oil price shock.

After the first oil crisis in 1973, non-OPEC producers have increased their share of world production. The reduction, in particularly Middle East OPEC production, and exports has affected oil tanker demand. This is very clearly illustrated in **Figure 8**. The figure shows the average length of haul for crude oil trades for all the years 1965-95.

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[1] 1 million b/d, or just mbd, means 1 million barrels per day. As a barrel of crude oil corresponds to 0.136 metric tonnes (1 tonne is 7.33 barrels), 1 mbd corresponds to 49.8 million tonnes per year

From: To	NW Europe	Mediterranean	North America	Japan	Others	Total
Middle East	98.1	66.1	97.5	175.4	277.5	714.6
Near East	7.8	10.2	2.0	0.1	0.3	20.4
North Africa	18.1	60.5	7.2	0.2	15.0	101.0
West Africa	19.1	31.9	71.9	0.8	17.2	140.9
Caribbean	9.3	9.6	132.3	4.6	21.1	176.9
SE Asia	0.1	0.0	12.8	43.5	20.0	76.4
Others	41.8	39.6	58.3	2.0	31.2	172.9
Total	194.3	217.9	382.0	226.6	382.3	1403.1
	Share of imports from exporting regions 1994					
Middle East	50.5%	30.3%	25.5%	77.4%	72.6%	50.9%
Near East	4.0%	4.7%	0.5%	0.0%	0.1%	1.5%
North Africa	9.3%	27.8%	1.9%	0.1%	3.9%	7.2%
West Africa	9.8%	14.6%	18.8%	0.4%	4.5%	10.0%
Caribbean	4.8%	4.4%	34.6%	2.0%	5.5%	12.6%
SE Asia	0.1%	0.0%	3.4%	19.2%	5.2%	5.4%
Others	21.5%	18.2%	15.3%	0.9%	8.2%	12.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Distribution of exports to importing regions 1994					
Middle East	13.7%	9.2%	13.6%	24.5%	38.8%	100.0%
Near East	38.2%	50.0%	9.8%	0.5%	1.5%	100.0%
North Africa	17.9%	59.9%	7.1%	0.2%	14.9%	100.0%
West Africa	13.6%	22.6%	51.0%	0.6%	12.2%	100.0%
Caribbean	5.3%	5.4%	74.8%	2.6%	11.9%	100.0%
SE Asia	0.1%	0.0%	16.8%	56.9%	26.2%	100.0%
Others	24.2%	22.9%	33.7%	1.2%	18.0%	100.0%
Total	13.8%	15.5%	27.2%	16.1%	27.2%	100.0%

From: To	NW Europe	Mediterranean	North America	Japan	Others	Total
Middle East	266.4	113.1	21.2	174.7	160.2	735.6
Near East	7.2	39.8	0	0	3.5	50.5
North Africa	69.5	56.2	10.2	0.2	24.1	160.2
West Africa	48.5	12.8	12.9	4.6	13.4	92.2
Caribbean	12.8	3.8	15.5	0.5	25.8	58.4
SE Asia	1.1	0.3	8.2	32.9	0.8	43.3
Others	16.2	16.2	0.2	0.7	5.6	38.9
Total	421.7	242.2	68.2	213.6	233.4	1179.1
	Share of imports from exporting regions 1972					
Middle East	63.2%	46.7%	31.1%	81.8%	68.6%	62.4%
Near East	1.7%	16.4%	0.0%	0.0%	1.5%	4.3%
North Africa	16.5%	23.2%	15.0%	0.1%	10.3%	13.6%
West Africa	11.5%	5.3%	18.9%	2.2%	5.7%	7.8%
Caribbean	3.0%	1.6%	22.7%	0.2%	11.1%	5.0%
SE Asia	0.3%	0.1%	12.0%	15.4%	0.3%	3.7%
Others	3.8%	6.7%	0.3%	0.3%	2.4%	3.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Distribution of exports to importing regions 1972					
Middle East	36.2%	15.4%	2.9%	23.7%	21.8%	100.0%
Near East	14.3%	78.8%	0.0%	0.0%	6.9%	100.0%
North Africa	43.4%	35.1%	6.4%	0.1%	15.0%	100.0%
West Africa	52.6%	13.9%	14.0%	5.0%	14.5%	100.0%
Caribbean	21.9%	6.5%	26.5%	0.9%	44.2%	100.0%
SE Asia	2.5%	0.7%	18.9%	76.0%	1.8%	100.0%
Others	41.6%	41.6%	0.5%	1.8%	14.4%	100.0%
Total	35.8%	20.5%	5.8%	18.1%	19.8%	100.0%

Source: Fearnleys World Bulk Trades

Table VIII: A comparison of crude oil trades 1994 with 1972

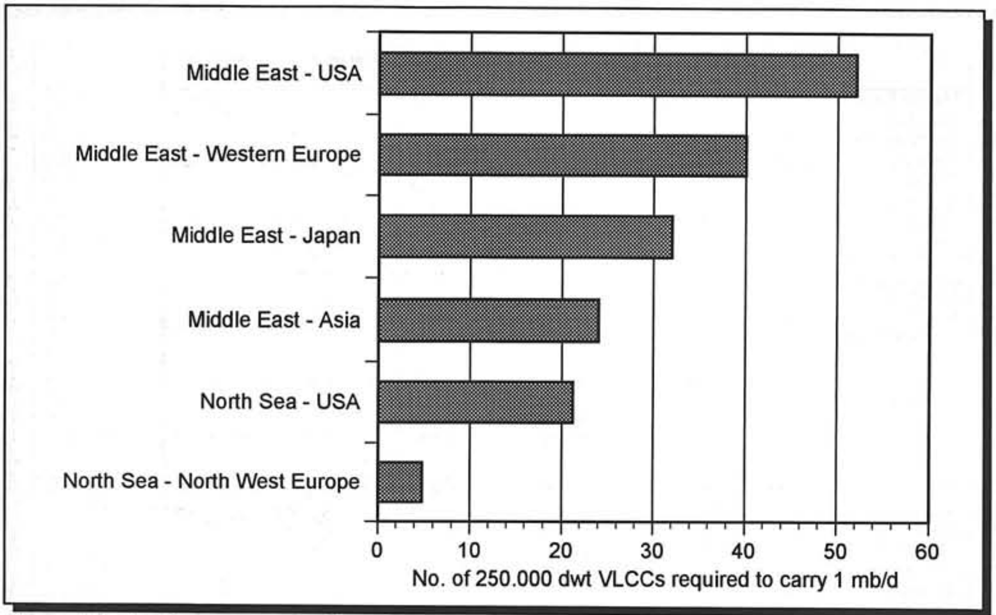


Figure 5: The importance of trade routes for large tanker demand

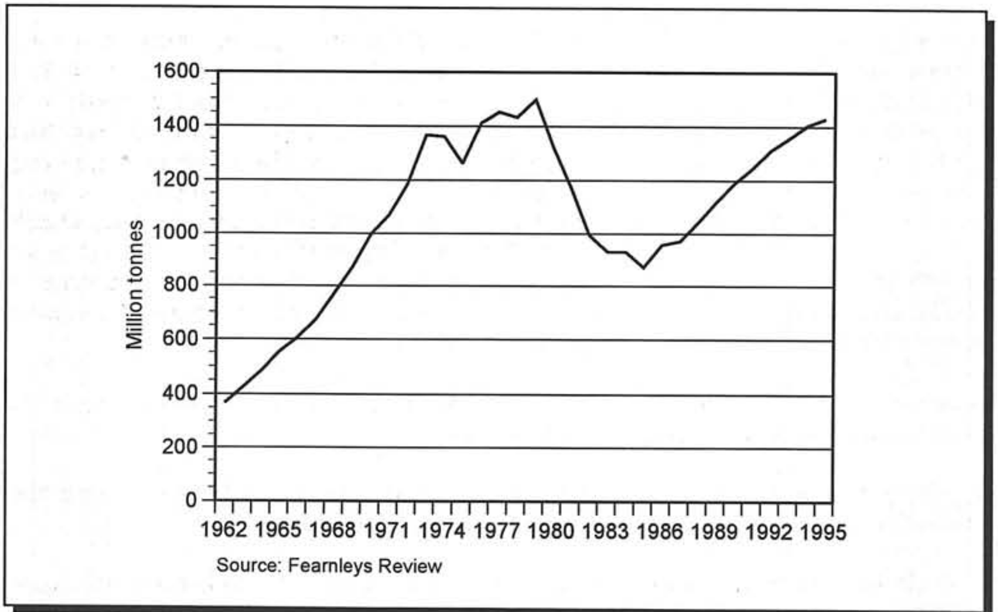


Figure 6: Seaborne trade of crude oil 1962-1995

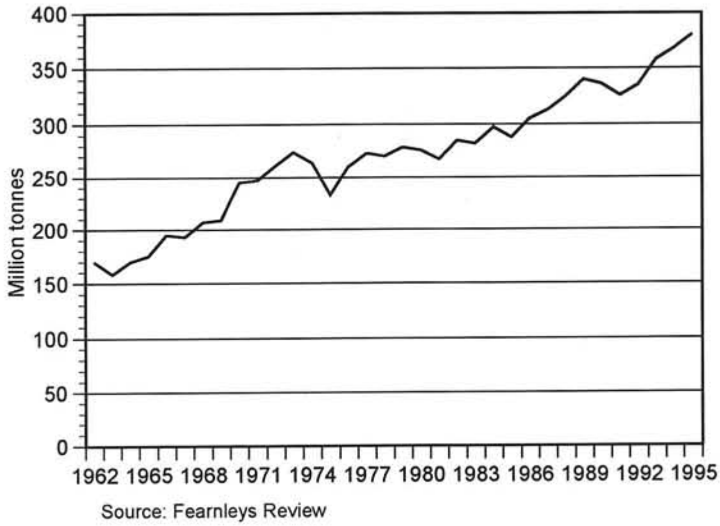


Figure 7: Seaborne trade of oil products 1962-1995

From a level of about 4,200 miles in the mid 1960s, the ALH increased to a level of more than 7,000 miles in the mid 1970s, then fell rapidly to a level of 4,600 miles in the mid 1980s. Since then, the average length of haul has increased to a level of over 5,400 in the beginning of the 1990s and is now down to less than 5,200 miles. **Figure 8** also clearly indicates the reason for the variation in average distances. The variation in OPEC market share of world oil production is very closely correlated to variations in average distances. After the first oil price shock in 1973, the USA in particular, but also European importers started to import more from other, non-OPEC sources, or increased their own production as is the case in the UK and Norway. This development was reinforced after the second oil price jump in 1979, and did not stop until the mid 1980s.

Variations in trade patterns for oil are, therefore, a most important factor in determining demand for crude oil transportation.

Regarding the parcel size distribution of crude oil trades, **Table IX** shows the distribution for all shipments made by vessels over 50,000 dwt.

As **Table IX** indicates, the exports from the Middle East and the imports to Japan are dominated by large consignments, whereas Caribbean exports are dominated by smaller parcels. In total about half of the crude oil trades are in very large parcels and about half in parcels below 150,000 tonnes.

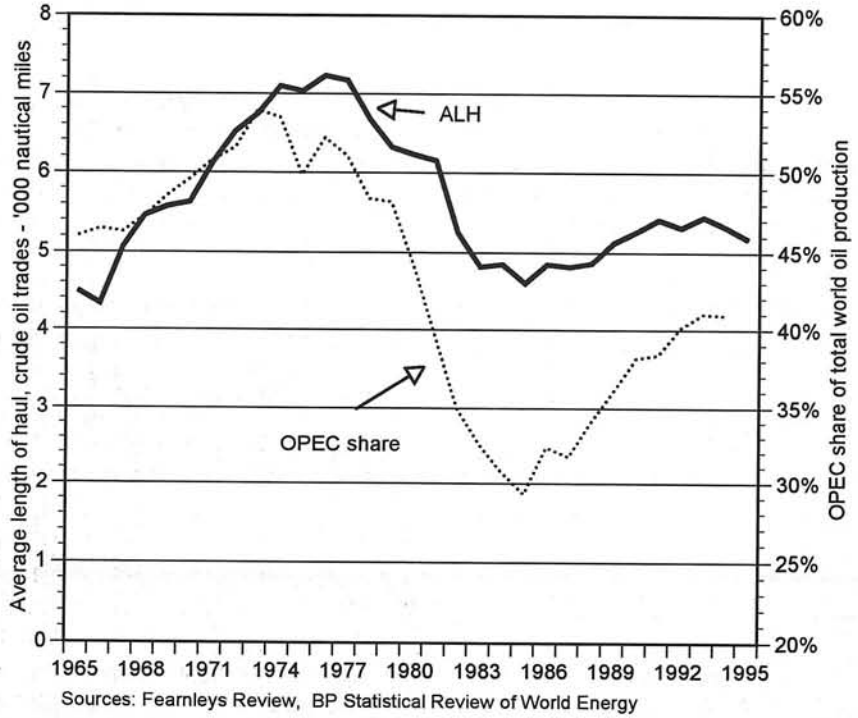


Figure 8: Length of haul in crude oil trades and OPEC's share of oil production

Area	Size groups of parcels in thousand tonnes				
	50-100	100-150	150-200	200-300	300+
Exports from the Middle East	9	7	2	63	19
Exports from the Caribbean	82	14	1	3	0
Exports from the North Sea	38	33	3	21	5
Imports to Northern Europe	26	16	3	38	17
Imports to North America	49	23	2	16	10
Imports to Japan	22	4	1	71	2
All trades 1994	34	19	3	35	9

Source: Fearnleys World Bulk Trades 1995

Table IX: Parcel size distribution crude oil trades 1994

1.3.2 Iron ore trades

Iron ore is mainly used as input for steel production. Coal is also an important raw material for steel production, but energy coal has other uses as well. The development of particularly the iron ore trade is, therefore, closely related to the development of steel production. The relationship is a fairly complex one, however, as some steel producing countries (like the USA) have local iron ore sources, while others (like Japan) must import all the iron ore from abroad.

From \ To	UK/ Cont.	Med.	Other Europe	USA	Japan	Other Far East	Other	Total 1994	%	Total 1986	%
Scandinavia	13971	49	2144	61		934	1887	19046	5.0	20276	6.3
Other Europe	1830	56	1516			207	8	3617	0.9	3714	1.2
West Africa	5820	2716	1227	124	61		50	9998	2.6	25077	7.8
Other Africa	3102	2089	3750		4579	5868	39	19427	5.1	9952	3.1
North America	14964	536	1204	6749	1375	1387	123	26338	6.9	27465	8.6
South Am. Atl.	44888	8538	8384	6446	28965	21929	14983	134133	35.0	102659	32.0
South Am. Pac.	1234			134	4089	7175	680	13312	3.5	9795	3.1
Asia	740	1905	615		20043	8266	1300	32869	8.6	33876	10.6
Australia	19097	2631	1654	675	56978	41098	1993	124126	32.4	87822	27.4
Total 1994	105646	18520	20494	14189	116090	86864	21063	382866	100		
%	27.6	4.8	5.4	3.7	30.3	22.7	5.5	100			
Total 1986	100452	23180	17896	12528	124512	26240	15828			320636	
%	31.3	7.2	5.6	3.9	38.8	8.2	4.9				100

Source: Fearnleys World Bulk Trades

Table X: The structure of seaborne iron ore trades 1994

The trading pattern for iron ore is given in **Table X**. From this table it is clear that the Atlantic Coast of South America (mainly Brazil) and Australia are the main exporting areas, while Europe, Japan and the other nations of the Far East are dominating on the import side. The structural changes that have taken place over the last decade are mainly that both Europe and Japan have reduced their importance on the import side and the other Far Eastern nations have correspondingly expanded. On the export side, the changes are smaller, but Australia has increased its importance as exporter, mainly because of increased exports to the steel producers of the Far East, and West Africa has become a much smaller exporter.

The total volumes of iron ore shipments are illustrated in **Figure 9**. The oil price shocks had a direct effect on steel production and thus iron ore imports, but since 1984 the underlying trend has been positive (average growth of about 4%), with a setback in 1986 and 1992.

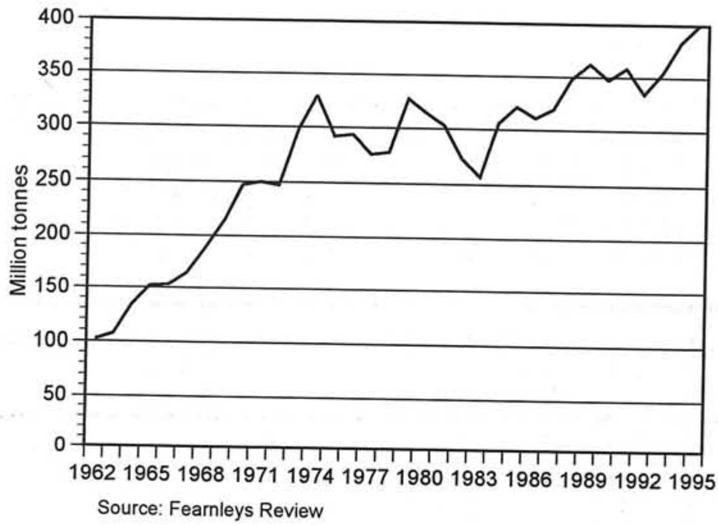


Figure 9: Seaborne trade of iron ore 1962-1995

In **Table XI** some data for the main steel producing regions are presented. A few observations can be made from these data. First one should note the rapid growth of other Far East producers. This is mainly due to an expansion of China from 47 million tonnes in 1985 to 92 million tonnes in 1994, but also Korea (from 14 to 34 million tonnes in the same period). From a shipping point of view the last column is perhaps the most interesting one, as it shows how different the various producers are with respect to dependence on iron ore imports. Japan must import all the ore they need, while the USA have local resources to draw upon. The relationship between steel production and iron ore imports has been fairly stable for Japan and the USA. For the other regions, the ore import per tonne of crude steel has gradually increased over the last decade, so that ore imports have been growing faster than steel production output.

The average distance in iron trades has been growing at a fairly stable rate over the last 30 years as indicated in **Figure 10**, but seems to be levelling out around 5,600 nautical miles.

Table XII shows the the parcel size distribution of iron trades distribution on some main routes.

	Crude steel production, million tonnes						Iron ore import		Iron ore imports per tonne crude steel
Regions	1985	%	1990	%	1994	%	1994	%	
Europe	218	30%	212	28%	198	27%	145	38%	0.73
USA	80	11%	90	12%	89	12%	14	4%	0.16
Japan	105	15%	110	14%	98	14%	116	30%	1.18
Other Far East	88	12%	128	17%	171	24%	87	23%	0.51
Others	228	32%	230	30%	168	23%	21	5%	0.13
Total	719	100%	770	100%	724	100%	383	100%	0.53

Sources: ISL, Shipping Statistics Yearbook 1995 and Fearnleys World Bulk Trades 1995

Table XI: Crude steel production and iron ore import

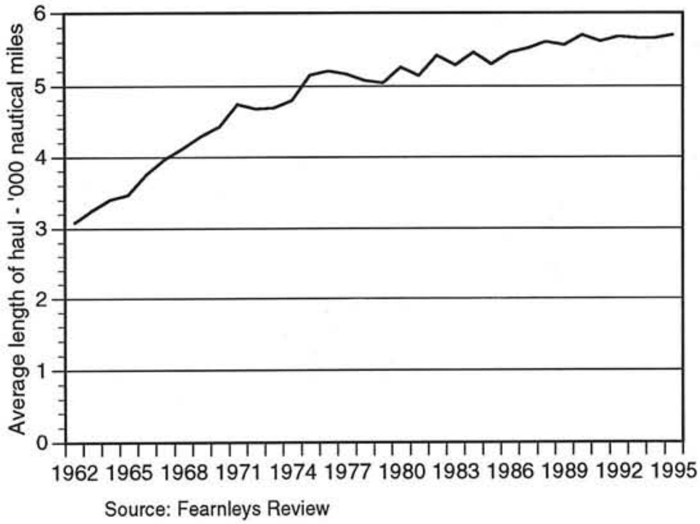


Figure 10: Average distances in iron ore trades 1962-1995

1.3.3 Coal trades

The trade pattern for coal is given in **Table XIII.** North America, Australia and South Africa account for more than 2/3 of world coal exports. North America has, however, reduced its importance compared to the 1985 situation. China and Columbia have emerged as important coal exporters, while Western Europe has become a very small exporter over the years.

Area	Size groups of parcels in thousand tonnes						
	<50	50-60	60-80	80-100	100-150	150-200	200+
Exports from Scandinavia	28	1	11	2	51	7	0
Exports from South America	2	2	12	3	28	23	30
Exports from Australia	7	3	7	0	28	28	27
Imports to Northern Europe	4	0	10	3	38	22	23
Imports to Japan	7	0	5	0	26	37	25
Imports to other Far East	6	5	12	1	33	20	23
All trades 1994	7	2	13	2	31	24	21

Source: Fearnleys World Bulk Trades 1995

Table XII: Parcel size distribution for iron ore trades 1994

From \ To	UK Cont.	Med.	Other Europe	South Amer.	Japan	Other Far East	Others	Total 1994	% 1994	% 1985
N. America	16171	9121	10878	7998	26364	12995	3816	87343	22.8	35.6
Australia	14658	4626	2397	5104	63395	28810	11328	130318	34.0	31.5
South Africa	14229	3931	11665	1593	5612	11703	4972	53705	14.0	16.2
South America	9590	742	3760	1008	51	1455	5092	21698	5.7	na
China	1373	389	57		7481	12741	2258	24299	6.3	na
Former Soviet	1080	2495	5606		4526	861	200	14768	3.9	
Other East Eur.	7198	663	10217	1158	300		99	19635	5.1	9.9
West Europe	977	14	1154				93	2238	0.6	2.9
Others	4580	329	1990		9866	11173	1477	29415	7.7	3.8
Total 1994	69856	22310	47724	16861	117595	79738	29335	383419	100	
% 1994	18.2	5.8	12.4	4.4	30.7	20.8	7.7	100		
% 1985	19.2	9.9	13.6	4.2	34.6	15.1	3.5			

Source: Fearnleys World Bulk Trades and ISL Shipping Statistics Yearbook 1995

Table XIII: Seaborne trade pattern for coal 1994

On the import side, Europe, Japan and the other countries of the Far East account for almost 90% of world coal imports. The main trade route is Australia - Japan which alone accounts for 16.5% of all trades (in tonnes shipped), other large routes are North America to Japan and Australia to the Other Far East countries.

The development of seaborne trade in coal is illustrated in **Figure 11**. Coal was not affected by the oil price shocks the same way as iron ore, because high oil prices made energy coal a viable alternative for many uses. This was particularly the case in 1979-80 when the total demand for coal increased by some 11-12% per year. After a setback in 1982-83, demand in 1984-85 increased by more than 17% per year. The last decade the growth rate has been more than 4% per year on average.

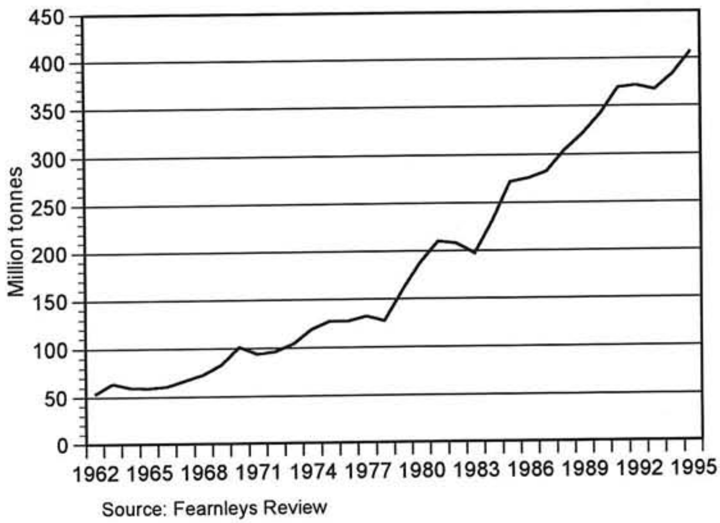


Figure 11: Seaborne trade in coal 1962-1995

The trade patterns for coal have changed somewhat over the past 30 years. **Figure 12** shows the development of the average length of haul in coal trades. The average distance has increased more or less steadily until 1987 when the ALH was 5,731 miles. After this, average distances have decreased, mainly due to relatively more export from Australia to countries in the Far East, where distances are about 4,400 nautical miles.

The parcel size distribution of coal is given in **Table XIV**. Comparing this to the distribution for iron ore, one can see that coal is generally shipped in smaller parcels, with a concentration around 60,000-80,000 tonnes, but the distribution is very wide, with as much as 20% in cargo lots smaller than 50,000 tonnes.

1.3.4 Grain trades

The term grain comprises a number of different cargoes, normally wheat, maize, barley, soya beans, sorghum, oats and rye. Wheat is the largest single commodity with a seaborne trade volume of 82 tonnes in 1994, followed by maize (52 million tonnes), soya beans (28 million tonnes), barley/oats/rye (15 million tonnes) and sorghum (7 million tonnes). In some publications rice and tapioca are included in

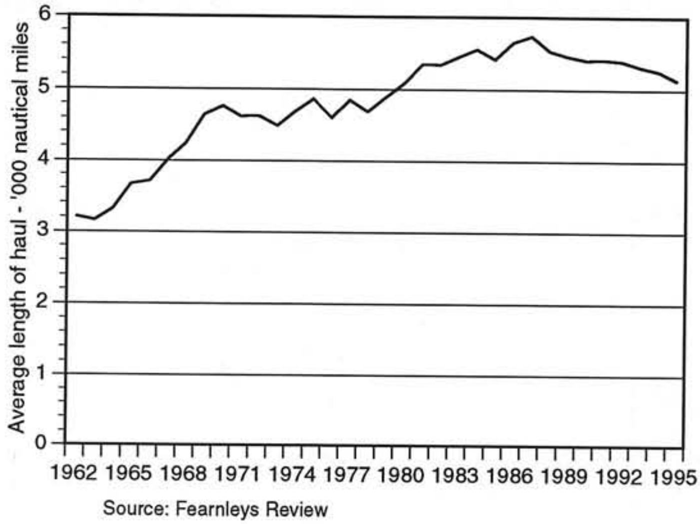


Figure 12: Average length of haul in coal trades 1962-1995

Area	Size groups of parcels in thousands tonnes						
	<50	50-60	60-80	80-100	100-150	150-200	200+
Exports from North America	3	3	29	9	35	18	3
Exports from Australia	9	1	33	6	29	20	2
Exports from South Africa	13	2	25	2	37	21	0
Imports to UK/Continent	18	2	22	6	37	15	0
Imports to Japan	16	1	31	9	21	21	1
Imports to other Far East	11	3	37	2	12	10	0
All trades 1994	20	3	31	5	26	14	1

Source: Fearnleys World Bulk Trades 1995

Table XIV: Parcel size distribution for coal trades 1994

the term grain. The seaborne trade volumes for rice were about 12 million tonnes in 1994, mostly short sea trades and tapioca constituted about 5 million tonnes.

The total world production of grain reached a total of 1521 million tonnes in 1994, of which 92% are the production of maize (38%), wheat (35%), barley (10%) and soya beans (9%). The total seaborne trade of grain was 184 million tonnes in 1994, or about 12% of the total production. **Table XV** presents the trade pattern in grain for 1994. There are 4 dominating exporters of grain. First of all the USA, which accounted for about 50% of all grain exports in 1994. Canada, Australia and Argentine are the three other main producers and exporters.

To / From	Europe	Africa	Ame-rica	Indian Ocean	Japan	Far East	Other	1994	% 1994
USA	12798	14025	17093	4997	20645	18858	3395	91811	49.8
Canada	1347	2099	4254	2666	2564	8213	124	21267	11.5
South America	7042	283	7706	231	1696	2045	249	19252	10.4
Australia	1116	1246	624	3872	2058	6706	424	16046	8.7
Others	4404	7609	4097	5774	3908	8671	1515	35978	19.5
Total 1994	26707	25262	33774	17540	30871	44493	5707	184354	100.0
% 1994	14.5	13.7	18.3	9.5	16.7	24.1	3.1	100.0	

Source: Fearnleys World Bulk Trades and ISL Shipping Statistics Yearbook 1995

Table XV: Seaborne trade in grain 1994 ('000 tonnes)

The development of seaborne trade volumes for grain is given in **Figure 13**. After a fairly stable growth period from 1962-1981, the volumes decreased in 1982-83 and again in 1985-86 as well as in 1993-94. Grain trades can show considerable variation due to quite unpredictable events, as bad weather and failed crops. The demand for grain is not affected by the business cycles as many other raw materials. This makes grain trades difficult to predict.

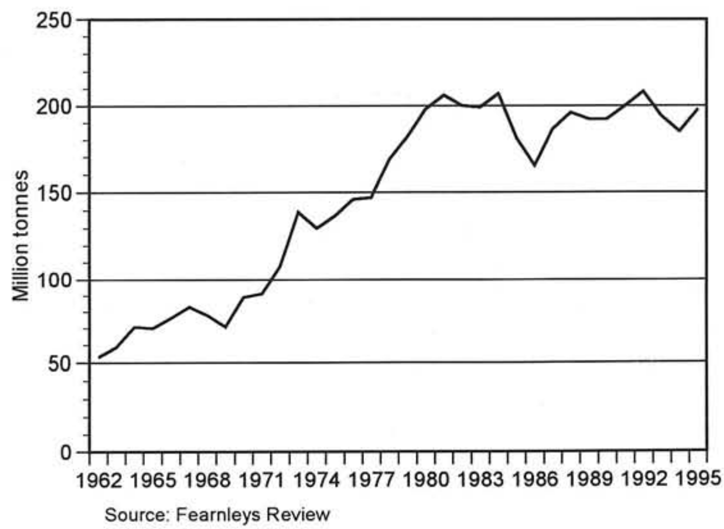


Figure 13: Seaborne trade of grain 1962-1995

The average length of haul in grain has been fairly constant as shown in **Figure 14**, mainly because there are only 4 dominating exporters of grain in the world.

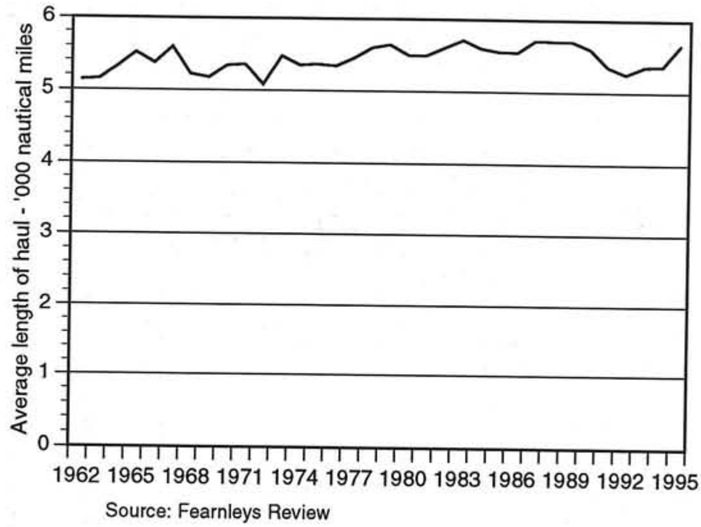


Figure 14: Average length of hauls in grain trades 1962-1995

The parcel size distribution of grain trades is given in **Table XVI**. Grain is shipped in a wide range of parcel sizes, but generally in smaller quantities than for coal.

Area	Size groups of parcels in thousand tonnes				
	<50	50-60	60-80	80-100	100+
Exports from USA	38	7	45	3	7
Exports from Canada	55	8	29	2	6
Exports from South America	40	11	38	0	11
Exports from Australia	78	4	17	0	1
Imports to Europe	54	9	24	3	10
Imports to Africa	75	4	20	1	0
Imports to Japan	41	3	52	1	3
Imports to other Asia	32	9	45	3	11
All trades 1994	51	7	33	2	7

Source: Fearnleys World Bulk Trades 1995

Table XVI: Parcel size distribution for grain trades 1994.

1.3.5 Main container routes

As previously shown in **Figure 4**, the growth of the shipments of containers has been enormous in the last 20 years, and more and more ports invest in facilities to handle containers efficiently. To better see the geographical development of container traffic, **Figure 15** may be instructive.

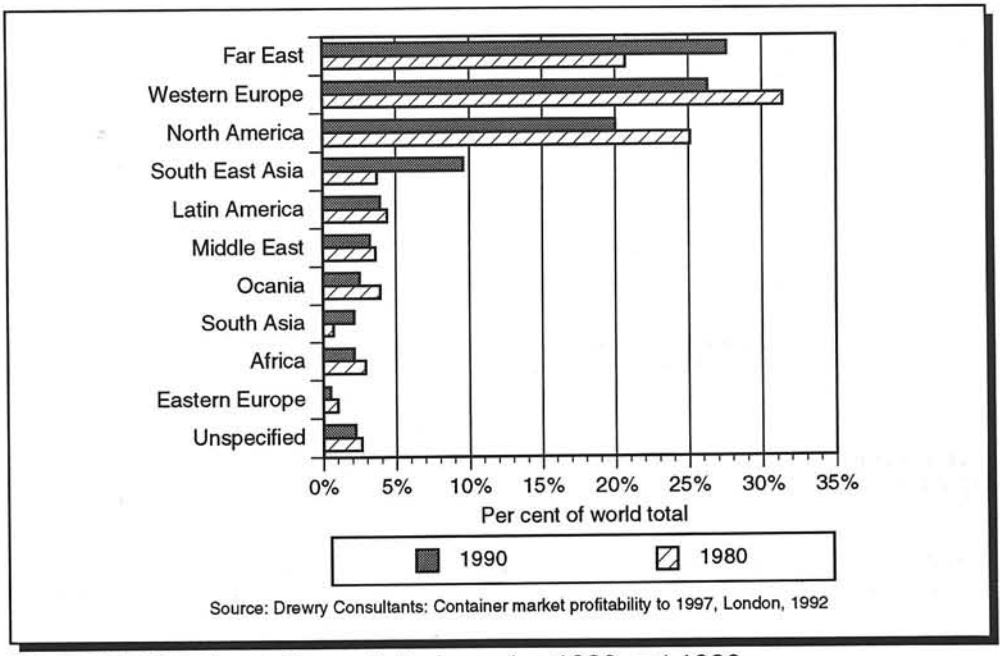


Figure 15: Global container activity by region 1980 and 1990

The figure clearly indicates that there are 3 main areas for container shipping - North America, Europe and the Far East. The main routes are, therefore, among these three economic blocs. **Table XVII** is an attempt of estimating the activity for main container routes in 1993[1].

1.3.6 Main regions in world trade

Looking at the main regions in the world, as given in **Table XVIII**, and their relative importance to world trade, one can conclude that Europe is the main trade area of the world and Europe's trade share of around 50% has been fairly constant since the 1920s. The decline in recent years is mostly due to the transition of the

[1]Various sources have been used. The figures are nett movements of loaded containers, not the total throughput of ports.

Trades	Million TEU 1993	Per cent
Transatlantic		
Eastbound	1.3	4.5%
Westbound	1.9	6.6%
Transpacific		
Eastbound	4.6	15.9%
Westbound	3.5	12.1%
Europe/Far East		
Eastbound	1.9	6.6%
Westbound	2.1	7.3%
Shortsea		
Europe	5.2	18.0%
Asia	3.5	12.1%
USA/Caribbean	1.1	3.8%
India/Mid.East	3.0	10.4%
Other seaborne trades	0.8	2.8%
Total seaborne	28.9	100.0%
Total container traffic	108.6	

Table XVII: Container traffic 1993

	Total Europe	Total America	Asia	Africa & Mid. East
1928	0.52	0.26	0.18	0.05
1958	0.49	0.28	0.13	0.09
1979	0.51	0.21	0.15	0.12
1990	0.51	0.21	0.21	0.06
1993	0.47	0.21	0.26	0.06

Sources: [Anderson & Norheim, 1993]. [GATT 1994]

Table XVIII: Regional shares of world trade

former centrally planned economies and the resulting dramatic reduction in trade both within that group and their trade with Western Europe. The fastest growing region is no doubt Asia, which in 1993 had a share of world trade of more than 25%, which is 5% more than America.

Shares of world trade do not, however, indicate the relative importance for shipping, since trade is measured in value terms, not in physical volumes. In order to better see the differences between trade in values and seaborne trade in volumes, the previously mentioned UN data for 1986 have been employed to produce the summary in **Table XIX**. The table clearly illustrates some of the main differences in the composition and geographical distribution of trade. Western Europe generated in 1986 43.5% of all exports measured in US$. This generated only 17.3% of world seaborne transportation. Far East Asia imported 8.8% of all imports in dollars, but this generated as much as 33.7% of the transportation work.

One USdollar of exports from the Middle East generates 53.5 tonne-miles while one USdollar of exports from Europe only generates 1.2 tonne-miles. One dollar of imports to the Far East generates on average 22.6 tonne-miles while one dollar of imports to Europe generates only 4.00.

Region	exp tonnes	exp tm	exp alh	exp val	tm/ US$	imp tonnes	imp tm	imp alh	imp val	tm/ US$
North America	13.8	16.4	4945	14.7	6.8	14.9	15.4	4329	21.0	4.3
Latin America	13.0	14.3	4581	4.3	20.4	4.9	4.9	4162	3.8	7.6
Western Europe	17.3	8.7	2108	45.35	1.2	35.5	28.7	3364	41.7	4.0
Eastern Europe	4.3	2.0	1872	7.8	1.5	2.5	1.8	2922	7.1	1.5
Africa	13.1	11.8	3748	2.9	25.1	2.9	2.8	4100	2.7	6.1
Middle East	15.6	21.1	5622	3.5	36.8	5.1	4.1	3376	4.0	6.0
South and Southeast Asia	8.3	8.2	4087	7.4	6.8	5.6	5.2	3814	7.4	4.1
CPEs of North Pacific	2.3	1.8	3268	1.4	7.8	1.9	2.1	4692	1.9	6.5
Far East Asea	4.1	4.0	4036	13.1	1.8	25.8	33.7	5455	8.8	22.6
Australia and Oceania	8.2	11.7	5958	1.3	53.5	1.0	1.3	5501	1.5	5.2
Average world			4167		6			4167		6

exp = exports from the region in the first column
imp = imports to the region in the first column
tonnes = total seaborne trade measured in metric tonnes
tm = total seaborne trade measured in tonne-miles (tonnes*alh)
alh = average length of haul, i.e. the distance in nautical miles that trade is carried on average
tm/US$ = tonne-miles per US$ value of trade, i.e. the transportation demand generated by an average trade US$

Sources: [UN, 1989], [GATT, 1994], [OECD, 1994]

Table XIX: Analytical data for main regions in world trade 1986.

The data from **Table XIX** are illustrated in **Figure 16** to **Figure 18**.

One should note that these calculations are only reflecting the mix of commodities and the geographical distribution of trade for this particular year. As trade patterns change, the transportation implications will also change. The figures should, therefore, be used with caution.

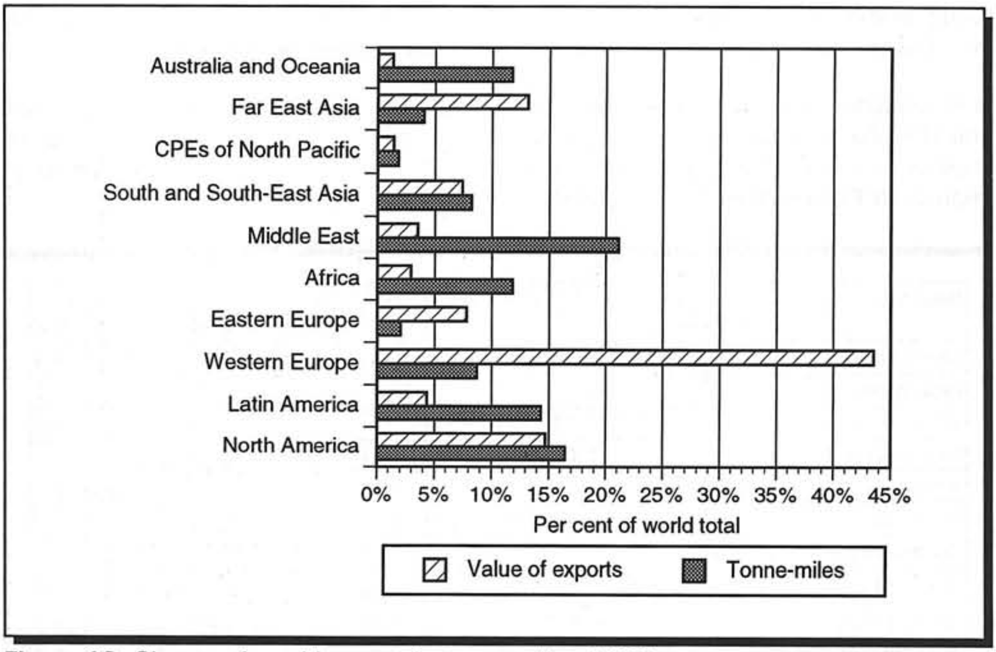


Figure 16: Shares of world export in tonne-miles 1986

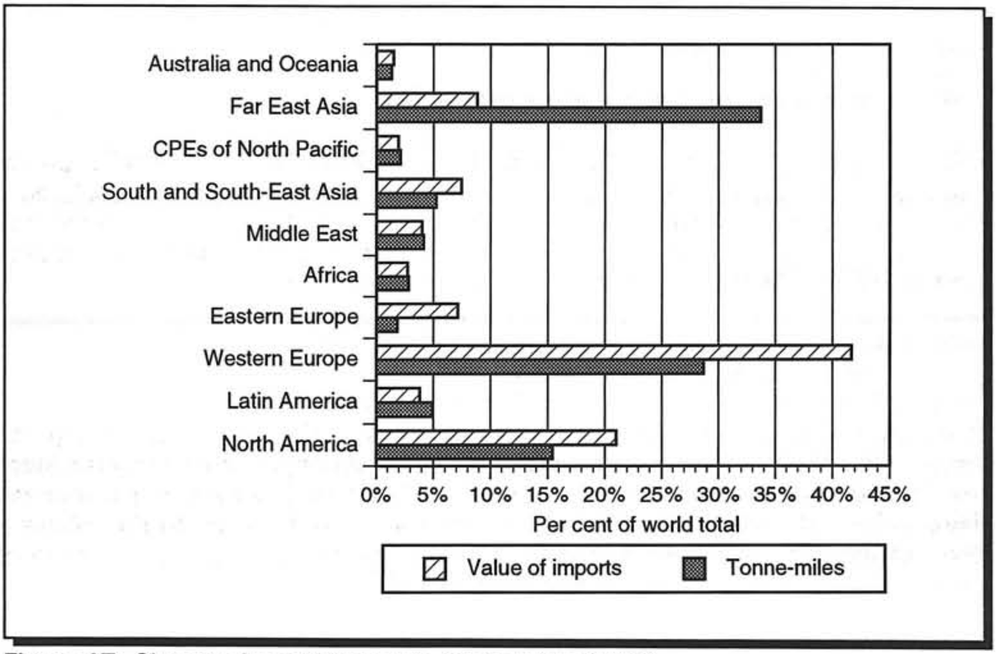


Figure 17: Shares of world import in tonne-miles 1986

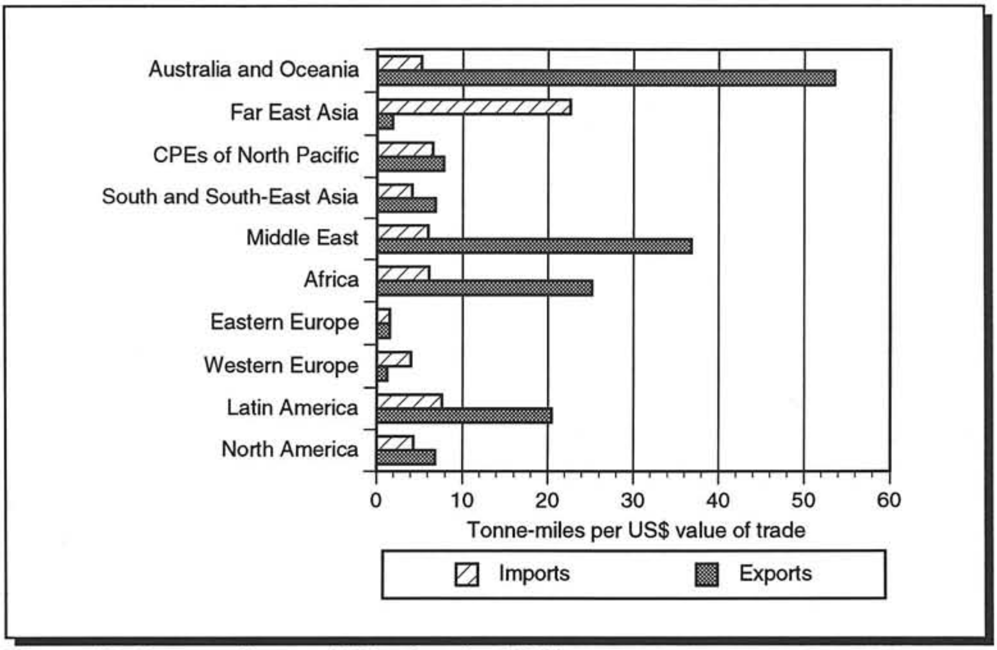


Figure 18: Tonne-miles per US$ of trade, 1986

1.4 The policy regime for international trade

Shipping is living directly from world trade. It is, therefore, important to understand how international trade is working. That is of course a topic that could be a book in itself. In this section, the emphasis will be on trade policies and how they affect world trade patterns and thus shipping, with some references to empirical work on potential structural changes in world production and trade.

1.4.1 A brief history of world trade policy

Sometimes looking back into history can be constructive for understanding the future. The development of world trade has a long and partly complicated story that is well beyond the scope of this section. One can, however, argue that the development of trade and trade policy regimes are closely linked to the role of a dominating nation in the world economy in main periods[1]: A very brief summary of the history of world trade is attempted in **Table XX**.

[1]The overview is based on various sources of which the two most important are [Hugill, 1993] and [Nordvik, 1995].

Many comments can be made to this table, but four observations are most interesting. First, the emergence of world trade is very closely related to the development of ships and shipping. The technological revolutions in transportation that came through the construction of the flat-bottomed cogs of the Hanseatic traders (high transport capacity), the cannon-armed caravel of the Portuguese (could protect themselves and they dared venture into unknown waters) and later the fluyt cargo vessel of the Dutch (which was a combination of an efficient cargo ship with revolutionary methods in business) had a great impact on international trade. Many wars have been fought for economic dominance and control of trade, and naval fleets have played a dominant role in this power game.
Second, in the early days of international trade, the trading was restricted to the citizens of the dominant nations, and there was no room for third country shipping operations. Within each bloc, however, trade was generally free.

Third, history indicates that the world trading regime has experienced only two main periods of massive and global trade liberalisation - in the 19th century and in the period after World War II. The development of a liberal, *global* trade regime was made possible because it was in the interest of a dominating hegemonial power; Britain in the 19th century (partially fuelled by the ideas of Smith and Ricardo) and the USA after 1950.
Four, the ever-occurring returns to more protectionistic tendencies are historically fuelled by two main forces - general economic decline and the breaking up of the hegemonial power of a leading nation.

1.4.2 GATT and WTO

Since the second world war, GATT[1] has been the main instrument for multilateral trade agreements. GATT has been organised as a series of trade talks, or rounds.

It has been a tendency that as time goes, the rounds become longer and more complicated. The last round was on the verge of failing many times, but eventually an agreement was reached in 1994, concluding that a new agreement should replace GATT from 1 January, 1995, called the World Trade Organisation. By December 1994, 80 countries had ratified the results of the Uruguay Round on Multilateral Trade Negotiations and approved membership in the WTO.

The earlier GATT rounds dealt mainly with the reduction of tariffs. In the Tokyo round, non-tariff barriers (NTBs) became an issue, while the Uruguay round has dealt with both NTBs, trade in services, trade in agricultural products and a new topic in trade policy terms, IPRs (intellectual property rights).

[1] GATT - The General Agreement of Trade and Tariffs - was established in 1947 after an attempt of creating a more powerful international organisation (ITO - The International Trade Organisation) was turned down by the US Senate.

Period	Hegemony	Competing nations	Main events	Trade regime
1256-1441	none		The Hanseatic League 1256	Regional free trade
1430-1588	Portugal	Spain, England, Holland and France	The cannon-armed caravel Treaty of Tordesillas 1494	Trade duopoly
1588-1670	Holland	England, Portugal, Spain and France	Failed Spanish invasion in England The English 'low-charged' galleon The Dutch fluyt cargo vessel and Calvinism English Navigation Act 1651 Three Anglo-Dutch Wars	Competing global trading blocs
1670-1815	England	Holland, France, America	Dutch monarc's accede to English throne 1688 Bank of England 1694 Act of Union with Scotland 1707 The industrial revolution Adam Smith - The wealth of nations 1776 American independence 1783 Napoleon wars Gradual end to mercantilism in Europe	From empire trading blocs towards trade liberalisation
1815-1880	Britain,	USA, German states	German customs union - *Zollverein* 1834 Abolition of the Corn Laws 1846 Abolition of the Navigation Act 1849 The Cobden-Chevalier agreement 1860 and the principle of MFN (most favoured nation) Germany unified in 1871	Further liberalisation towards Global free trade after 1850
1880-1914	Tripolar	Germany, Britain, USA	Renewed protectionism in continental Europe World War I	Free trade with elements of protectionism
1918-1945	Multipolar	US, Britain, Japan, Germany	The Great Depression Surge of protectionism globally World War II	General protectionism
1945-	USA	Japan, (EU)	The GATT 1947, the WTO 1995	Trade liberalisation

Table XX: Main historical periods of international trade policy regimes

Many authors have been concerned with the outcome of the Uruguay round and have argued strongly in favour of a strong GATT/WTO. One of the main arguments is that unless the world has a multilateral framework for trade, with the most favoured nation (MFN) clause[1] as a basis, the door is open to bilateral arrangements with much discrimination. The future world trade would then be dominated by what is called 'managed trade'. Over the last few years, the term 'unfair trade practices' is used more and more frequently by nations to justify measures against trading partners, and if institutions as WTO are losing power, there is a real danger of a world wide increasing protectionism. It could be added that also the formation of Regional Trading Arrangements (RTAs), although allowed according to article XXIV of the former GATT, might conceal elements of protectionism, as RTAs make it possible to discriminate between importers. This is a complicated debate that is beyond the scope of this chapter, but the possibility that extensive use of RTAs could erode the multilateral role of WTO must be emphasised.

1.4.3 Regional trading arrangements (RTAs)

It is a fairly common assertion that the current tendency to form regional trading blocs (EU, NAFTA, etc.) will lead to relatively less demand for shipping services in the future, because the countries within the blocs will trade more with each other and less with other regions. This affects shipping negatively both because longer hauls are substituted by shorter ones and intra-regional trade is reduced.

Figure 19 sums up all the regional trade arrangements (RTAs) that have been listed by the GATT since 1947. As the figure indicates, the number of agreements has surged in the beginning of the 1990s, but this is mainly a reflection of the many agreements being signed among the former Eastern European countries and between these countries and Western European countries. As many as 20 of the 32 agreements are between one Eastern European country and one Western partner, 4 agreements are between Eastern European countries and the remaining 8 are all other types, including NAFTA (The North American Free Trade Agreement) and the EC-Accession of Austria, Finland and Sweden.

Some of the most important RTAs are listed in **Table XXI**. They range in deepness of integration from free trade areas through customs unions to common markets or economic communities. In 1990 these arrangements accounted for more than 80% of world trade. Extensive literature exists on the effects of such trade arrangements, but the conclusions are somewhat ambiguous. A major issue is whether the trade creation effect of increased integration is generally higher than the trade diversion effect of the trade arrangements. **Figure 20** shows the development for 8 RTAs. Of the 8 RTAs shown, only the EU shows unambiguously increased regional trading and at the same time increased importance in world trade. For RTAs like ANZCERT, LAFTA, CACM and ECOWAS the general picture

[1]The most favoured nation clause simply says that if a country gives special trade benefits to another country, this benefit should automatically be given to all other participating nations.

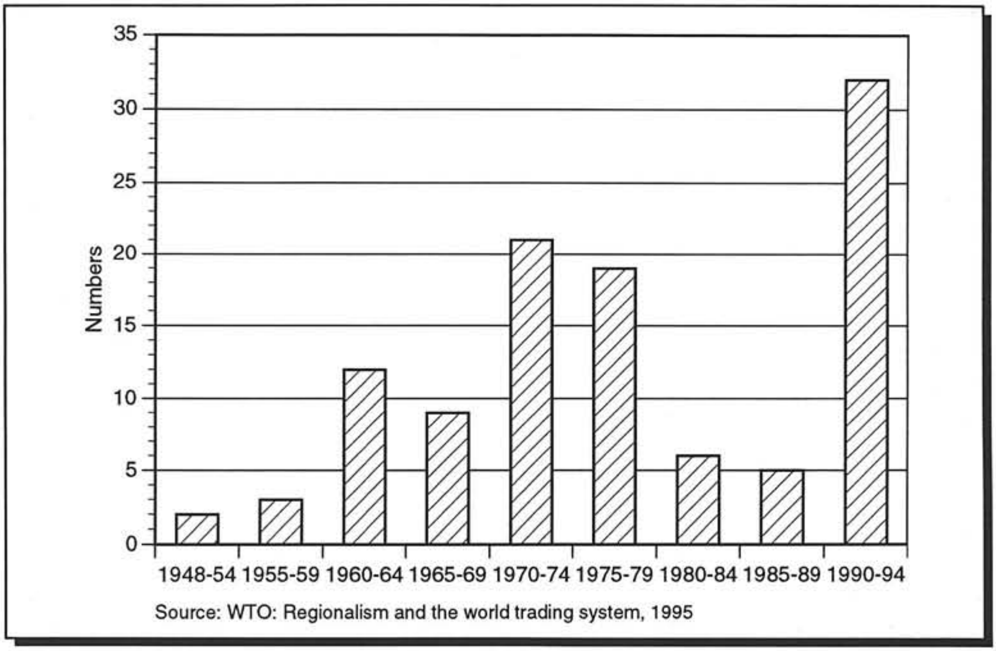


Figure 19: Number of regional integration agreements notified to GATT

is that the agreements have some initial, but not lasting effects and the regions are participating less in total world trade. The intra-regional trade share within ASEAN was 21% in 1960, but 18.6% in 1990. Within CACM, the share has been reduced from 25.7% in 1970 to 14.8% in 1990, while LAFTA countries have a regional trade share of 10.6% in 1990, which is only slightly higher than in 1970. This is mainly due to political and other factors making the schemes not working as planned[1]. Two conclusions, that seem to have general support in the literature are, therefore:

- Free trade arrangements among 'natural neighbours', i.e. where the initial intra-regional trade share is already high, and where the initial total share of world trade is also high, are welfare increasing for the world as a whole;
- In free trade arrangements between developed and developing countries, the trade diversion effect seems to dominate the trade creation effect. This is due to higher tariffs in developing countries becoming effective for the trade union and thus creating competitive advantages for the developed countries within the trade arrangements [Langhammer, 1992]

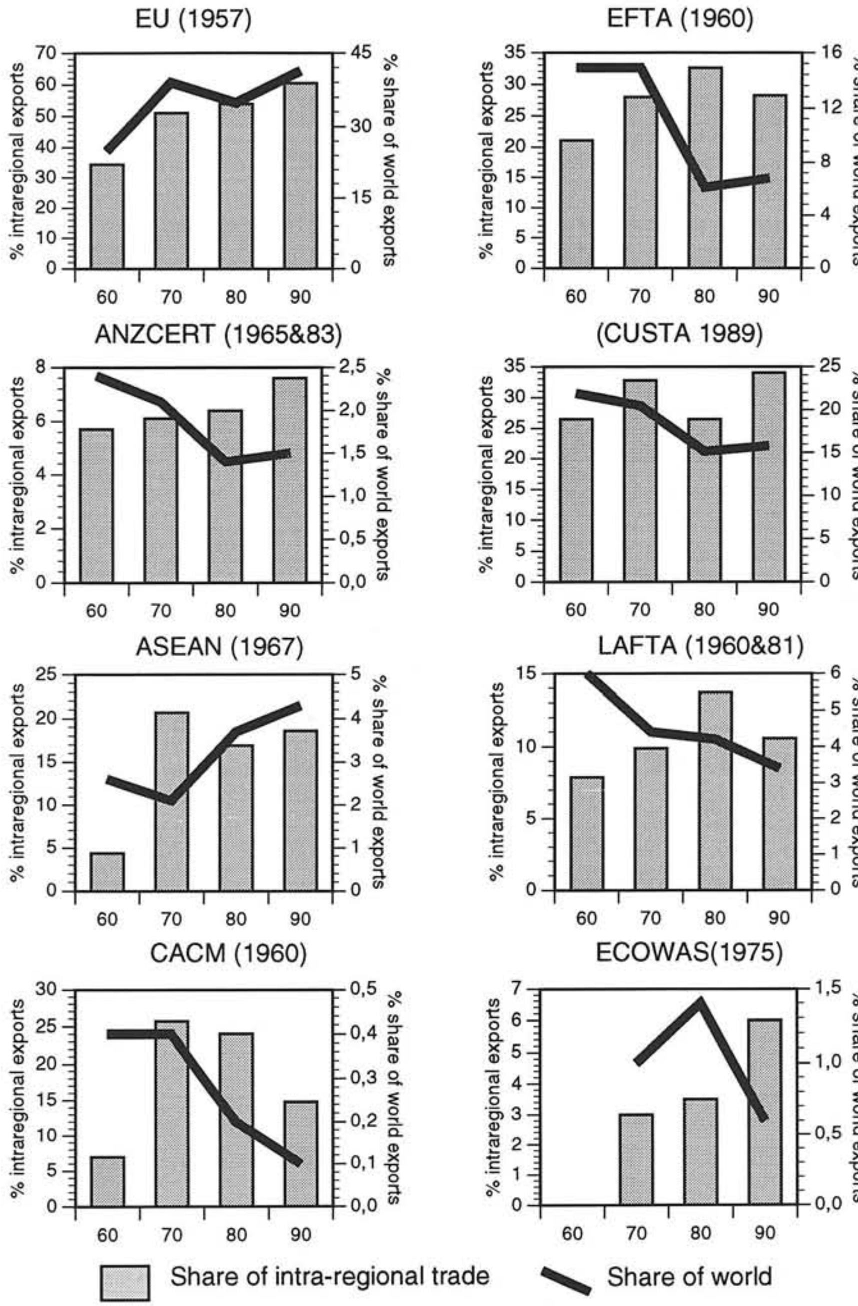
It is not straight forward to measure the effect of trade arrangements, and one often will have to use formal numerical models to simulate the effects. It is not sufficient just to study regional trade shares as above, since many factors will influence this simple measurement.

[1]See [Langhammer and Hiemenz, 1990] and [Langhammer, 1992]

Year	Abbre-vation	Name	Type of agreement	Participating countries	% world trade
1957	EC (EU)	European Community (Union)	Common market	Belgium, Denmark, France, Greece, Ireland, Italy, Luxembourg, Germany, The Netherlands, Portugal, Spain, United Kingdom	41.0
1959	CEAO	Communauté Economique de l'Afrique de l'Ouest	Customs Union	Benin, Burkina Faso, Ivory Coast, Mali, Mauritania, Niger, Senegal	0.2
1960	EFTA	European Free Trade Area	Free trade area	Austria, Finland, Iceland, Liechtenstein, Norway, Sweden, Switzerland	6.7
1960	CACM	Central American Common Market	Customs union	Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua	0.2
1960 1981	LAFTA ALADI	Latin American Free Trade Association	Free trade area	Argentina, Bolivia, Chile, Colombia, Ecuador, Mexico, Paraguay, Peru, Uruguay, Venezuela	3.0
1964	ACM	Arab Common Market	Common market	Egypt, Iraq, Jordan, Lebanon, Libya, Mauritania, Syria	1.0
1965 1983	ANZAFTA ANZCERT	Australia - New Zealand Free Trade Agreement	Free trade area	Australia, New Zealand	1.5
1967	ASEAN	Association of South-East Asian Nations	Free trade area	Indonesia, Malaysia, Philippines, Singapore, Thailand, Brunei	4.4
1969	ANCOM	Andean Common Market	Common market	Bolivia, Colombia, Ecuador, Peru, Venezuela	0.7
1969	SACU	Southern Africa Customs Union	Customs union	Bophuthatswana, Botswana, Ciskei, Lesotho, Namibia, South Africa, Swaziland, Transkei, Venda	0.7
1973	CARICOM	Caribbean Community and Common Market	Common market	Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Montserrat, St. Kitts-Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago	0.2
1973	MRU	Mano River Union	Cust. un.	Guinea, Liberia, Sierra Leone	0.1
1975	ECOWAS	Economic Community of West African States	Common market	Benin, Burkina Faso, Cape Verde, The Gambia, Ghana, Guinea, Guinea Bissau, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria Senegal, Sierra Leone, Togo	0.6
1989	AMU	Arab Magreb Union	Common market	Algeria, Libya, Mauritania, Morocco, Tunisia	0.9
1989	CUSTA	Canada-US Free Trade Agreement	Free trade area	Canada, United States	16.6
1991	MERCOSUR	Southern Cone Common Market	Common market	Argentina, Brazil, Paraguay, Uruguay	1.1
1994	NAFTA	North American Free Trade agreem.	Free trade area	Canada, Mexico, United States	17.8

Source: Based on [Haaland & Wooton, 1993] and [Fielke, 1992]

Table XXI: Regional trade arrangements



Source: Jaime A. deMelo and Panagariya: The new regionalism in trade policy, 1992

Figure 20: Experience of some main RTAs

Other measurements have, therefore, been proposed and some recent studies, [Anderson and Norheim, 1993].and [Norheim, 1992], point out the usefulness of the terms *intensity to trade* and the *propensity to trade extra-regionally*. Both measures have been proposed to overcome the problems inherited by the use of just the share of total trade, where both the number of countries matters as well as the size of the country groups involved[1].
Some measures for Europe are given in **Table XXII**. The figures indicate clearly that the intensity to trade intra-European has increased substantially and the intensity to trade extra-European has decreased. The propensity to trade extra-European has, however, not decreased as much.

Year	Share of trade that is intra-European	Intensity of trade: intra-European	Intensity of trade: extra-European	Propensity to trade extra-European
1830	0.67	1.06	0.90	0.08
1870	0.69	1.03	0.93	0.22
1910	0.64	1.11	0.85	0.25
1948	0.52	1.27	0.81	0.27
1990	0.76	1.51	0.49	0.22

Source: [Anderson & Norheim, 1993]

Table XXII: Trade shares and the intensity of regionalisation in Europe

Since the main purpose of this section is to indicate whether regional trade arrangements lead to less trade with other regions, **Table XXIII** could be instructive. It summarises the indices of propensity to trade extra-regionally for all main regions of the world. There is no marked tendency that the world as such has become extremely regionalised. The overall tendency of the table is one of remarkable stability and even a slight tendency to increase the shares of extra-regional trade.

This is somewhat in contrast to other studies that indicate that the various trading blocs are indeed becoming increasingly bloc-like. This is particularly argued in a study where the term 'neutral trade' was defined as the trade that took place among the trading partners in 1948. Then the intra-regional trade shares were calculated for 1990 and compared to the share of world trade of the region. If intra-regional trade had increased more than the total world market share, the

[1]The intensity to trade measures the share of the country's export to another country i, divided by the share that country i has in world imports, while the propensity to trade extra-regionally measures the country's export to another country, divided by total GDP and then divided by the share that country has in world imports. The intensity to trade will be independent on the size of the country (or country group), while the propensity to trade is affected by the size of country. The latter should thus be used for comparisons over time and not across various groups. The intensity to trade will be 1 if the share of a country's trade with another equals that country's share in world trade. An index larger than 1 indicates the two groups are trading more than average with each other.

Regions/Years	1928	1938	1948	1958	1968	1979	1990
Western Europe	0.30	0.21	0.31	0.26	0.21	0.28	0.23
Eastern Europe	0.25	0.23	0.14	0.11	0.16	0.20	0.24
Total Europe	*0.26*	*0.19*	*0.27*	*0.24*	*0.21*	*0.26*	*0.22*
North America	0.09	0.06	0.09	0.07	0.07	0.15	0.14
Latin America	0.43	0.27	0.27	0.27	0.18	0.22	0.25
Total America	*0.10*	*0.07*	*0.08*	*0.07*	*0.07*	*0.14*	*0.14*
Asia	0.21	0.16	0.18	0.18	0.15	0.19	0.19
Japan	0.14	0.10	0.04	0.13	0.12	0.15	0.13
Australasia	0.37	0.31	0.45	0.29	0.23	0.27	0.28
Developing Asia	0.25	0.21	0.18	0.20	0.22	0.30	0.35
Africa	0.56	0.48	0.49	0.45	0.37	0.48	0.47
Middle east	0.57	0.49	0.41	0.52	0.35	0.56	0.51
World total	**0.21**	**0.16**	**0.19**	**0.16**	**0.15**	**0.23**	**0.21**

Source: [Anderson & Norheim, 1993]

Table XXIII: Index of propensity to trade extra-regionally 1928-90

actual trade in 1990 was higher than the 'neutral trade' that would have taken place if the countries were trading relatively as much with each other as in 1948. The study concludes that the EC (of 12 countries) was trading 23% more with each other in 1990. Similar numbers were 10% for CUSTA and the CACM, while the ASEAN shows a different development with a *reduction* of 13% since 1972. The conclusion is that most trade blocs are becoming more bloc-like, but important regional groupings like the ASEAN, the EFTA, LAFTA, CACM and ECOWAS are showing signs of becoming actually *less* bloc-like over the last years.

An OECD study concludes that with the exception of trade in agricultural products, there is weak evidence of growing regionalisation of world trade.

The overall conclusion is, therefore, that although the world as an average becomes more regionalised, this has not been completely at the expense of trade with other regions. It is almost surprising that the world trade is not more regionalised given the many trade arrangements that influence world trade.

1.4.4 Trade policy case 1: Trade implications of European integration

The case of Europe is of course of major interest since Europe accounts for about 50% of the world trade. The current process of integration in Europe, the so-called 1992 Programme, consists basically of two different aspects related to trade. First, the 1992 Programme consists of measures to significantly reduce all sorts of trade barriers among the member countries to reduce real trade costs. Second, the 1992 Programme aims at fully integrating the various economies. One aspect of this is a complete abolishment of price discriminatory practices. The phenomenon of 'dumping', or effective price discrimination in market segments is not in compliance with one, integrated market, so the case of Fiat selling their cars cheaper in Hamburg than in Rome should be eliminated. Using a general equilibrium model of world production and trade, estimates have been made of the changes in total trade volumes that can be contributed to lower trade costs in the EEA (European Economic Area) only, and to the combined effect of lower trade costs and full market integration. Some illustrative figures are given in **Table XXIV.**

(Percentage change in the value of total trade)

Lower trade costs in the EEA	EC	EFTA	USA	Japan
EC	19.6	16.5	-0.5	-0.5
EFTA	17.9	15.3	-1.0	-0.8
USA	-4.5	-6.8		0.0
Japan	-4.8	-6.6	0.0	
Full market integration in the EEA	**EC**	**EFTA**	**USA**	**Japan**
EC	7.8	3.5	-3.5	-3.4
EFTA	1.9	-2.9	-5.7	-5.4
USA	-6.2	-9.7		0.2
Japan	-5.4	-4.2	0.1	

Source: [Haaland & Wooton, 1993]

Table XXIV: Potential trade effects of European integration

Several interesting observations can be made from this table. The first half of the table gives the expected result that lower trade costs within the EEA will lead to increased trade by as much as around 15-20%. The exports from the USA and Japan will go down by around 5%, while European exports to the USA and Japan are only slightly influenced. The second half of the table is more interesting, however. Abolishing price discrimination will have a clear negative effect on trade flows within EU. The reason is, of course, that producers in the absence of the possibility to sell cheaply abroad will concentrate more on the home market and trade flows (as traditionally measured) will be reduced. In some cases this effect is strong enough to completely offset the positive effect of lower trade costs as shown by the figure for internal EFTA trade, which will actually be reduced by almost 3%. The aggregate implications of these numbers are that although lower trade costs would have given the world trade a positive shift of 12-13%, the combined effect of lower trade costs and market integration shows a total trade increase of only 3%, with inter-European trades increasing by some 6% and the intercontinental routes decreasing by some 3.5%. If these simulations prove to be right, the combined effect is obviously negative from a shipping point of view.

The same type of model has also been used to assess possible effects on the pattern of production in the world as a result of the integration process in Europe.

Some numbers are given in **Table XXV**. The numbers indicate changes from the base year 1989.

(Percentage change compared to 1989)

	Industry	EC	USA	Japan
Capital intensive	Metals	0	0.15	0.44
	Chemicals	1.6	-0.03	0
	Food products	1.2	0.08	0.07
	Paper	0.3	0	0
Skill intensive	Production machinery	-0.1	-0.07	-0.10
	Office machinery	5.0	-0.20	0.08
	Electrical goods	1.7	0	-0.01
	Transport equipment	3.4	-0.04	-0.06
Labour intensive	Metal products	0.6	0.01	-0.01
	Textiles etc.	1.1	0.10	0.01
	Timber	1.2	0.10	-0.03
	Plastics	1.1	0.03	-0.01

Source: [Haaland & Norman, 1992]

Table XXV: Potential total effects on production of EC integration and EEA

An obvious observation from these numbers is that the rest of the world needs not fear European integration in the sense that this will bring about large structural changes in production patterns in other countries. The main changes likely to take place within Europe are growth within skill intensive sectors and chemicals and moderate to low growth in other sectors.

The integration process in Europe will, however, quite likely have strong inter-regional effects as well. This is because there are big differences in factor price levels between various regions in Europe and with free capital and labour mobility, there is a scope for exploiting such differences. In [Haaland & Norman, 1995] this question is examined in a model framework where a distinction is made between EFTA, EU-South and EU-North[1]. The main conclusions from the simulations are that a complete product market integration combined with free capital mobility will lead to substantial capital exports (15-20% of all capital in the tradables sectors) from EFTA to EU-South and a corresponding increase in industrial production in EU-South, particularly in capital intensive sectors (like metals, food processing, chemicals, paper and printing). The EU-North and EFTA will have an expansion mainly in skill-intensive production (like machinery, office machinery and electrical goods), but the increases in industrial production are lower than for the EU-South.

[1] EU-South consists of Spain, Portugal, Greece and Ireland, EFTA consists of Austria, Finland, Norway, Sweden, Switzerland and Iceland and is assumed to be fully integrated with the rest of the EU. EU-North consists of all the other current EU-members.

The implications for trade in these simulations are that increased capital-intensive production in the EU-South will reduce trade, while increased skill-intensive production in EFTA will create trade. Again the implications for shipping are negative: Capital-intensive production is generally more dependent on seaborne transportation than skill-intensive production. A general increase in the production of capital-intensive products in Europe will, on the other hand, lead to more imports of raw materials, which is beneficial for shipping. It is difficult to assess the total effect without much more detailed studies.

A possible conclusion as to European integration is, therefore, that it will lead to moderate growth in European trade, possibly negative growth in the trade between Europe and other main trading partners and moderate structural changes in global production patterns, but substantial changes in industrial structure within Europe.

1.4.5 Policy trade case 2: Trade implications of WTO success in liberalisation

The previous mentioned study [Haaland & Wooton, 1993] of European integration also simulated the combined effects of a full European integration with two scenarios as to the outcome of the Uruguay Round; GATT success or failure. In a more recent report [Haaland & Tollefsen, 1994], using essentially the same, but an improved version of the model, similar scenarios were examined. Success and failure are modelled in a fairly simplistic way. GATT success is taken to be a situation where tariff barriers and non-tariff barriers are coming down by 33% from the base case. GATT failure was stipulated as a 10% increase in all non-tariff barriers. Although this is a very crude attempt at arriving at estimates of potential outcomes of the Uruguay Round, the results can at least give some indications of the order of magnitude involved.

The results are summarised in **Table XXVI**. This table clearly indicates that what happens on the multilateral scene is potentially much more important to world trade than the current integration process in Europe. The simulation of success implies an *increase* of world trade of 10%, while the simulation of a failure implies a *reduction* in world trade of 9.1%.

It is difficult to estimate what the actual outcome of the Uruguay Round will lead to, and without an extensive agreement for agricultural products it is doubtful that the actual outcome of GATT will prove as positive as in the scenario above. Nevertheless, that the Uruguay round ended with an agreement at all and that the new WTO is already approved by 80 states, will no doubt stimulate world trade in the years to come and is thus very important to shipping.

GATT success	EC	EFTA	USA	Japan
EC	-3.3	-3.6	36.2	57.5
EFTA	-3.3	-3.2	30.0	56.3
USA	35.1	30.7		53.6
Japan	40.6	35.6	39.6	
GATT failure	**EC**	**EFTA**	**USA**	**Japan**
EC	7.6	8.8	-57.3	58.4
EFTA	7.7	7.2	-54.7	-59.5
USA	-51.2	-49.5		-56.3
Japan	-51.4	-50.3	-52.8	

Source: [Haaland & Tollefsen, 1994]

Table XXVI: Potential trade effects of GATT scenarios, % change from base case

1.4.6 Shipping implications of trade cases

All simulations of trade as given above deal with trade measured in values. As previously stated, shipping lives from volumes, not values. Hardly ever do trade studies of the kind referred to above address transportation implications.

The figures from section 1.3.6 could be used to translate trade scenarios as in the two cases above.
Although it is not correct to use 1986 data for future projections, lack of better data prevents a more accurate estimation. The 1986 data on seaborne trade have, therefore, been employed to generate a 'translation' of the trade data given in previous tables from trade in USdollars to trade in tonne-miles. This is shown in **Table XXVII**. The data have been benchmarked against the data used in the simulations referred to above.

	Europe	EFTA	USA	Japan
Europe	1.0	0.1	3.0	4.0
EFTA	0.1	0.7	1.3	2.7
USA	6.0	3.0		21.8
Japan	1.2	1.6	2.0	

Source: [UN. 1989], own calculations

Table XXVII: TM/US$ conversion factors for trade scenarios

The aggregated consequences of the simulations referred to in **Table XXIV** and **Table XXVI** are summarised in **Table XXVIII**.

Scenario	% change value of world trade 1993	% change in seaborne tm demand 1993	Extra dwt required in addition to the 1993 fleet of 652.4 million
Reduction of trade costs in EEA. no product market integration	12.6	0.6	4.2
Reduction of trade costs in EEA. plus full product market integration	3.4	0.03	0.2
Full integration in EEA and GATT success	10.0	5.3	34.4
Full integration in EEA and GATT failure	-11.1	-6.3	-40.9

Table XXVIII: Shipping demand implications of trade scenarios

The table clearly indicates that although the 1992 programme will have some effect on world trade in values, the shipping implications of this trade are very limited indeed. The table also clearly indicates that the shipping industry should be very concerned about the success of WTO. If new RTAs are not formed for protectionistic reasons, but rather in the spirit of the Uruguay Round agreement, then international shipping will greatly benefit from this.

1.5 Other driving forces behind shipping demand

1.5.1 Energy consumption

The distribution of energy resources and the pattern of energy consumption is one of the main driving forces for international shipping. In **Table XXIX** some main figures regarding the overall resource picture for proven oil reserves are given. As the table indicates, most of the proven oil reserves in the world are in OPEC member countries. The members of OPEC are given in **Table XXX**. OPEC had more than 3/4 of all reserves by the end of 1994. Comparing this with the 1979, the proven reserves of the world have actually increased, although the world has produced and consumed 362 billion barrels since then. This shows that resources are very difficult to measure precisely. Technological advances and changes in relative prices will change the resource picture over time. This does not necessarily mean that one should not worry about the resource base, but one should also be aware of the dynamics of resources. The R/P ratio is defined as the current proven reserves divided by the current level of actual production. The number indicates how many more years the reserves will last if exploited at the current rate without new resources being discovered.

In **Table XXXI** the regional oil consumption distribution in 1994 is given together with an estimate of the population distribution. North America and Europe account for over 50% of the total oil consumption, although the two regions constitute

Region	Billion barrels end 79	R/P ratio & %	Billion barrels end 94	R/P ratio & %
World	641	29 years	1009	43 years
OPEC	436	68.0%	770	76.4%
Former USSR & EE	70	10.9%	59	5.8%
Others	135	21.1%	180	17.8%

Source: BP Statistical Review

Table XXIX: Proven oil reserves 1979 and 1994.

Region	Country	Reserves end 1994	% of total OPEC	Million b/d produced 94	% of total OPEC
Middle East	Iran	89.3	11.6%	3.6	13.2%
	Iraq	100	13.0%	0.5	1.8%
	Kuwait	96.5	12.5%	2.1	7.7%
	Quatar	3.7	0.5%	0.5	1.8%
	Saudi Arabia	261.2	33.9%	9.0	33.0%
	United Arab Emirates*	98.1	12.7%	2.5	9.2%
North Africa	Algeria	9.2	1.2%	1.3	4.8%
	Libya	22.8	3.0%	1.4	5.1%
West Africa	Gabon	1.3	0.2%	0.3	1.1%
	Nigeria	17.9	2.3%	1.9	7.0%
Asia	Indonesia	5.8	0.8%	1.6	5.9%
Latin America**	Venezuela	64.5	8.4%	2.6	9.5%
Total OPEC 1994		770.3		27.3	
Non-OPEC 1994		239		39.4	

* UAE consists of Abu Dhabi. Dubai and the Northern Emirates: Ras-al-Khaimah and Sharjah
** Ecuador used to be a member, but withdrew at the end of 1992
Source: BP Statistical Review of World Energy

Table XXX: Membership of OPEC and their reserves and production 1994

12% of the world population. The fast growing economies in Asia are expected to increase their share of oil consumption in the decades to come, although their share of the total consumption is lower today than in 1985 (17.6%).

In **Figure 21** the development of crude oil consumption is given for the period 1965-1994. As the figure indicates there was a rapid growth of almost 8% per year until the first oil price increase in 1973, after which the oil consumption contracted, then rose again until the second oil price shock that had a longer lasting negative effect on oil consumption. Since 1986 the oil consumption has been growing at an average rate of little less than 1.5% per year.

Region	Oil consumption mbd 1994	% of world consumption	% of world population
North America	20.3	30.4%	5.3%
South and Central America	4	6.0%	8.4%
Western Europe	13.8	20.7%	7.1%
Eastern Europe	5.9	8.8%	7.0%
Middle East	3.8	5.7%	1.4%
Africa	2.1	3.1%	12.6%
Asia	16.9	25.3%	58.2%
World	66.7	100.0%	100.0%

Sources: BP Statistical Review of World Energy, UN World Economic and Social Survey, 1985

Table XXXI: The distribution of oil consumption and population 1994

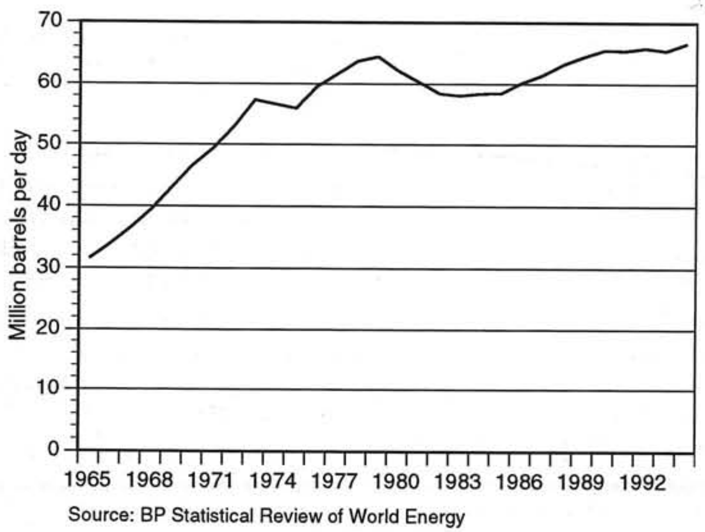


Figure 21: Development of crude oil consumption 1965-1994

The resource picture for the other fossil fuels, natural gas and coal, is indicated in **Table XXXII**, with the situation at end 1994.

Although OPEC also has a lot of gas, the largest reserves are to be found in the former Soviet Union. The current R/P ratio for gas is 66 year, and a very high 235 years for coal. The main coal reserves are in a limited number of countries. Again the former Soviet Union has large reserves. It is also interesting to note that China has a lot of reserves, and probably a lot more, not yet proven.

Region	Gas reserves trillion m^3	R/P ratio
World	141	66 years
OPEC	57.6	40.9%
Former USSR & EE	56.7	40.2%
Others	18.9	18.9%
Region	**Coal reserves billion tonnes**	**R/P ratio**
World	1044	235 years
North America	250	23.9%
Former USSR & EE	315	30.2%
Germany	80	7.7%
South Africa	55	5.3%
Australia	91	8.7%
China	115	11.0%
India	70	6.7%
Others	68	6.5%

Source: BP Statistical Review

Table XXXII: Gas and coal reserves at the end of 1994

The total consumption of commercial energy in the world in 1994 amounted to 7,924 million tonnes oil equivalents[1]. The distribution of total energy consumption in 1994 is illustrated in **Figure 22**.

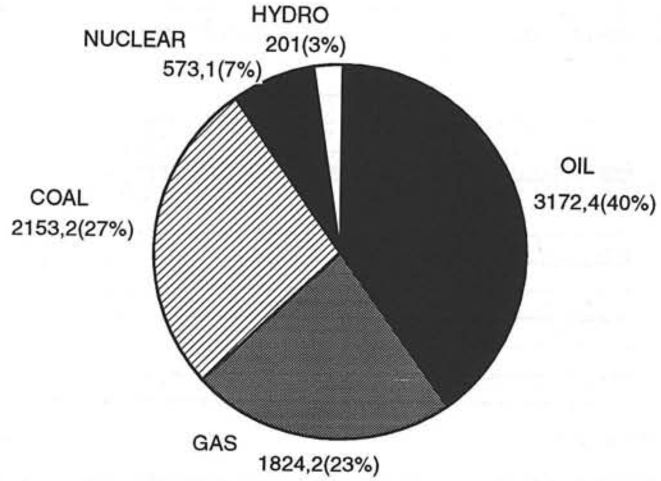
From this it is clear that 90 per cent of all energy is fossil fuel. The various fuels utilise international shipping quite differently, however, as shown in **Table XXXIII**. More than 40% of all crude oil are transported by ship. For gas and coal these percentages are very much smaller. This implies that only minor changes in the balance between total consumption and production for coal and gas can have a significant impact on the shipping market.

Energy source	Unit	Production 1994	Seaborne trade	% seaborne
Crude oil	Million tonnes	3209	1403	43.7%
Natural gas	Billion m^3	2082	88	4.2%
Coal	Million tonnes	4451	383	8.6%

Sources: BP Statistical Review of World Energy 1995 and Fearnleys World Bulk Trades 1995

Table XXXIII: Production and seaborne trade of main energy sources

[1]One million tonnes of oil equals about 1,5 million tonnes of coal, 3 million tonnes of lignite, 1,111 million cubic metres of natural gas and 12,000 million kWh.



Figures in mill. tonnes oil equivalents (and per cent)

Source: BP Statistical Review of World Energy 1995

Figure 22: Distribution of total energy consumption 1994

Another aspect of energy consumption is that the distribution is not regionally uniform. **Figure 23** indicates clearly that there are big differences both in the fuel consumption in the various regions and the overall level of consumption. Some developing countries, like India and China, use much coal and have own coal reserves. Japan has more than 50% of its total consumption as oil imports, and also Europe and North America use a lot of oil. The former Soviet Union is the only region with a very high percentage of energy consumption as natural gas.

The burning of fossil fuels is essential to the industrial world. In recent years the fear of the so-called greenhouse effect has gradually put global environmental concerns on the political agenda regarding energy consumption. Global environmental concerns should indicate that a change towards more use of natural gas and a reduction in both oil, but especially coal consumption is desirable.

To see the global dilemma more clearly, **Figure 24** and **Figure 25** could be illuminating. In **Figure 24**, the per capita consumption of total energy is indicated for main regions and key countries.

There are enormous differences in energy intensity of the countries. Every North American citizen is consuming almost 10 times as much as each Chinese and almost 27 times as much as each citizen of India. If the developing countries shall experience a reasonable economic growth, they will no doubt have to consume more energy per capita than they do today.

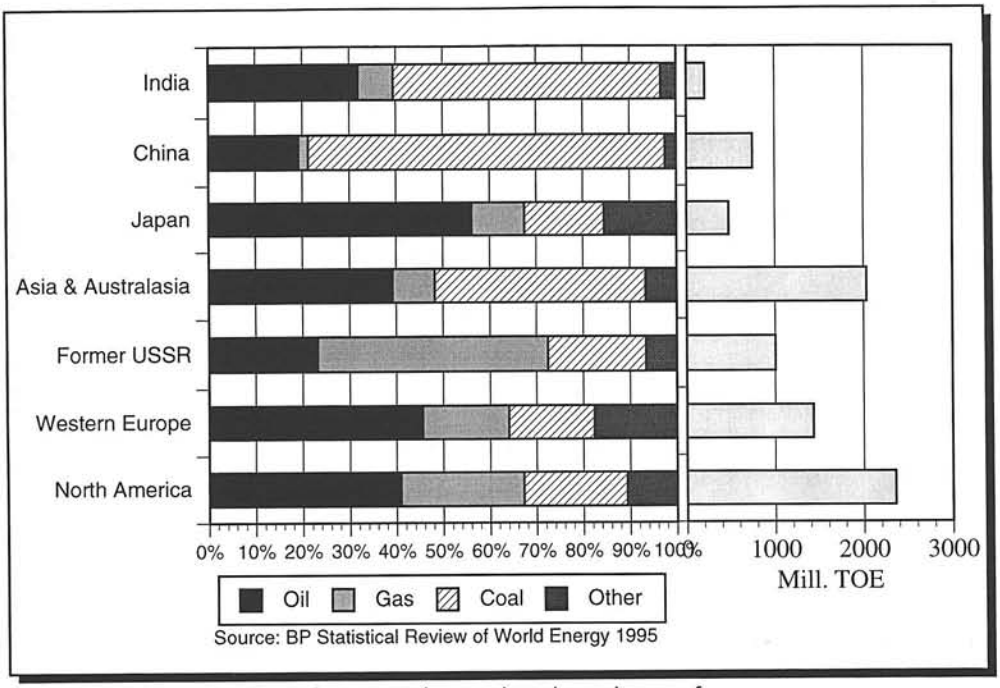


Figure 23: Composition of energy demand and total use of energy

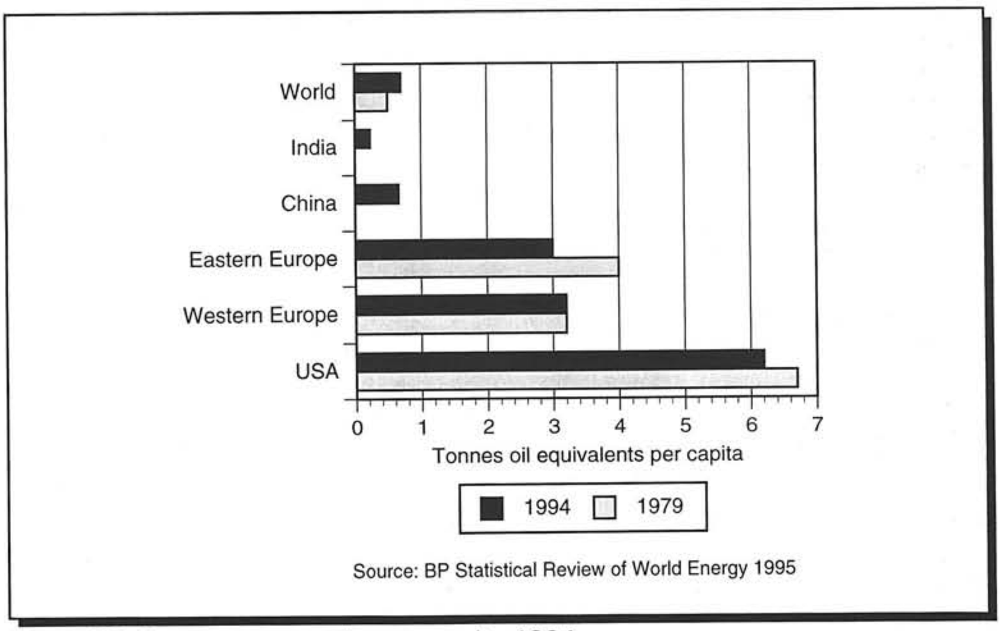


Figure 24: Energy consumption per capita 1994

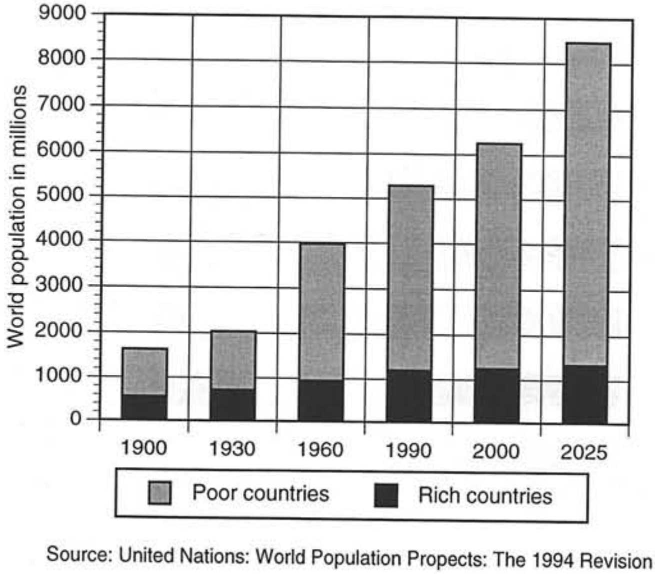
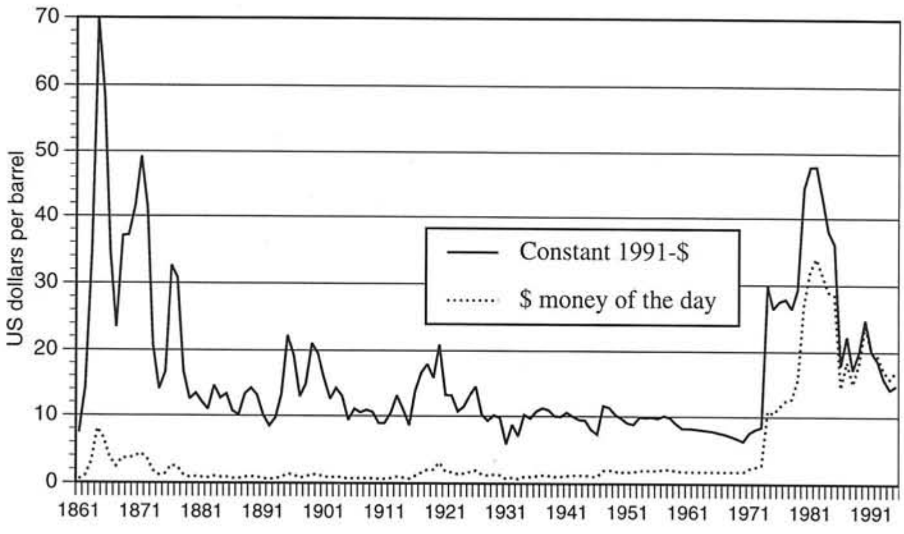


Figure 25: World population development 1900-2025

With a population outlook as given in **Figure 25**, the prospect is to have more than 7 billion people living in poorer countries in the year 2025. If their average energy consumption goes up to 1, from the current level of about 0.6, this will amount to an *increase* in total energy demand of 2800 million TOE or 35% of the current level of consumption. The general prospects for shipping are good, however. For many more years the world will be needing oil, gas and coal. Environmental policies might affect the overall growth rates, but will hardly be able to reduce energy consumption substantially.

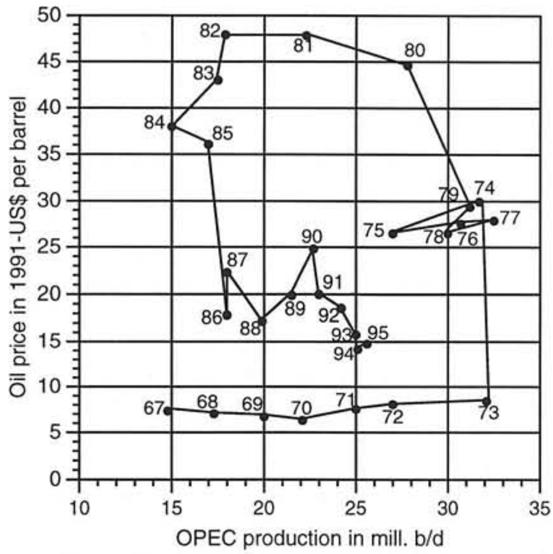
1.5.2 The oil price

One key variable that in the past has led to fairly dramatic structural changes in the energy markets is the oil price. After the formation of OPEC and their successful embargo for oil in 1973, OPEC has been, to a large extent, responsible for the oil price development. Today one seems to regard the oil price as a phenomenon before and after OPEC. In a historical perspective, one should remember that high oil prices have been seen before. **Figure 26** shows the oil price development both in nominal and real terms, and in real terms the oil price has been fairly high in several periods in the past.
It is, however, natural to concentrate on current times, and then there is no doubt that OPEC plays a dominant role in influencing the oil price. **Figure 27** sets out to explain what has happened to the oil price in the latest 30 years. The figure correlates the oil price in constant 1991-US$ with the actual production of OPEC.



Sources: BP Statistical Review of World Energy, Petroleum Intelligence Weekly

Figure 26: Historical oil prices 1861 - 1995



Source: Petroleum Intelligence Weekly

Figure 27: OPEC production and oil price development 1967-1995

In the 1960s the oil price was low and generally falling, as OPEC constantly increased their production to meet world oil demand. Then, in 1973, OPEC decided not to continue the production increase, but to offer the 1973 level of production also in 1974. The effect was that the oil price increased 255% in real terms. In the following years OPEC tried to maintain this high oil price by adjusting the member quotas. Even with a cut of 5 mbd from 1974 to 1975, OPEC was unable to hold the price, simply because world demand had responded to the higher prices. In 1979 world demand had picked up again, and OPEC decided another cut in production, which sent the oil price to a new and much higher level (a real price increase of 52% from 1979 to 1980). This had a fairly marked effect on oil demand, and at the same time non-OPEC producers started to increase their production. The result was that OPEC had to cut their production drastically with as much as 10 mbd from 1980 to 1982, which reduced OPEC's total revenues by some 13% in 1981 and 20% in 1982. Many OPEC members were unwilling to cut their quotas sufficiently in this period and the largest producer, Saudi Arabia, functioned as a swing producer that had to bear the burden of the entire organisation. Even further cuts in production in 1983 and 1984 could not prevent the oil price from dropping and in 1986, Saudi Arabia was unwilling to cut production further and the oil price dropped to a level between the 1973 and the 1974 price. After this, OPEC has increased their production more or less at the same rate as demand to keep the oil price at this new level. In 1990 Kuwait was invaded by Iraq and the oil price increased somewhat, but much less than most experts expected at the time. The other OPEC members increased their production to fill the gap of Kuwait and after 1990 the price has again fallen to a level of 15 91-US$ per barrel.

OPEC will most likely continue to increase their production in line with world demand development. It is a question, however, what might happen when OPEC, again, comes close to their expected maximum production capacity. Although the OPEC share of world oil production is lower today than in 1973, OPEC still holds the key to oil price developments.

1.5.3 The business cycle

As the main commodities for international shipping mostly are raw materials and energy input to industrial processes, one would expect a close relationship between industrial activity and demand for shipping services. Martin Stopford has examined the relationship between industrial production cycles and demand for shipping and concludes that there is an obvious relationship.

Figure 28 shows the relationship between industrial production and crude oil trade. By using a 5 year trend as a moving average and measuring the deviationfrom the trend, a business cycle variable is created, when above the trend, a boom situation occurs, when below, a bust situation exists.

Figure 28 makes it easy to conclude that crude oil trades follow the industrial cycles quite closely.

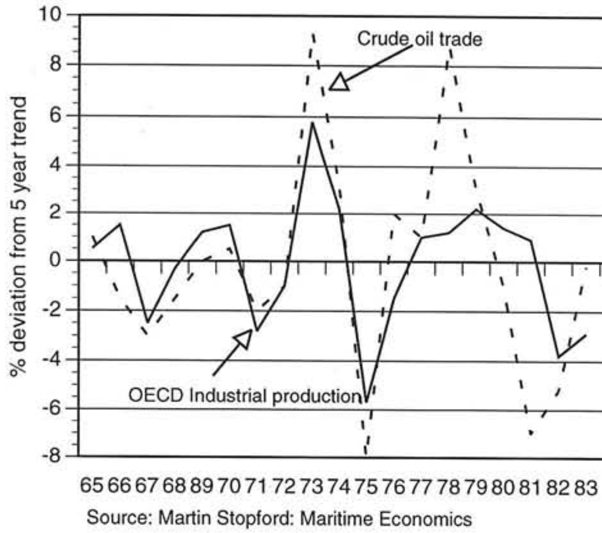


Figure 28: Industrial production cycles and demand for crude oil transportation

In **Figure 29**, the same relationship is examined for dry bulk trades, and again there seems to be a close relationship, but this time with a small time lag. An obvious reason for such time lags is that dry bulk shipping transports raw materials as input to production and such purchases must be planned well in advance. It might, therefore, take some time before a slowdown of production spills over into raw materials imports.

Stopford also investigated if there is a close relationship between demand and the freight rate. In **Figure 30** this relationship is illustrated for tankers. The conclusion must be that sometimes, but not always, do freight rates follow demand movements. A similar relationship for the dry bulk sector is examined in **Figure 31**. Here the conclusion seems quite clear: freight rates follow demand quite closely.

1.5.4 Unexpected political events

Besides all the fundamental issues that have been presented above, a word must be said about unexpected events and their impact on shipping. As shipping is directly living from carrying international trade, any political or other event that disturbs the international economy will be important to shipping.

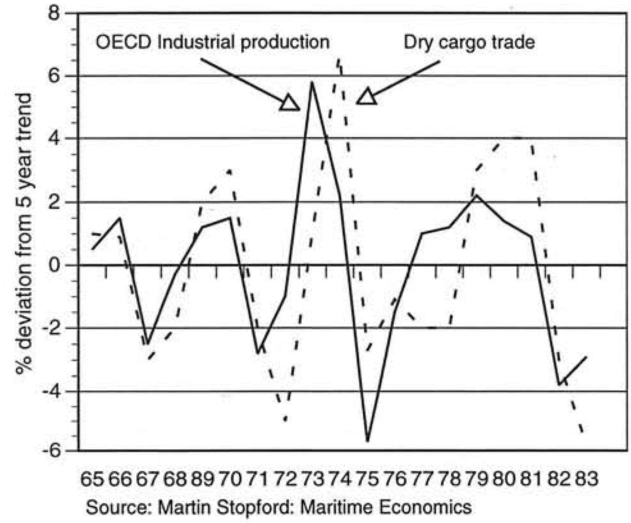


Figure 29: Industrial production cycles and demand for dry bulk transportation

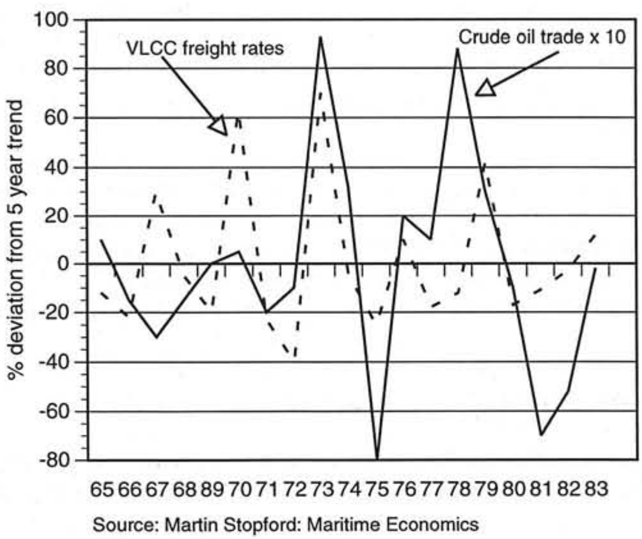


Figure 30: Oil trades and freight rates

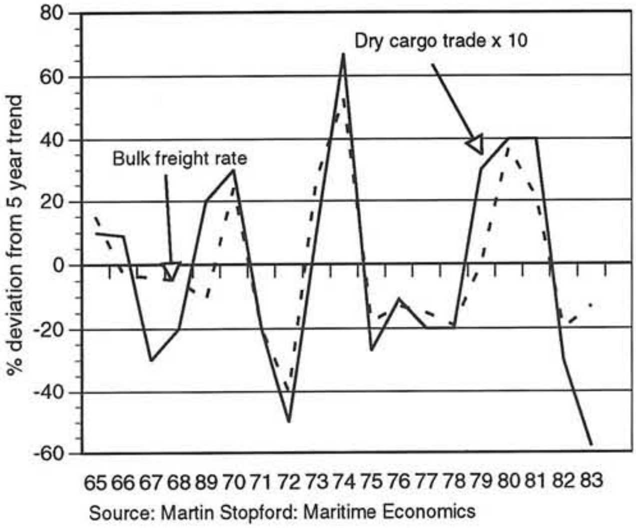


Figure 31: Dry bulk trades and freight rates

It could be argued that for shipping, some sort of crisis is 'normal', rather than the exception. **Figure 32** might illustrate this. The figure shows the freight rate development for Panamax bulk carriers from 1947-94. All the peak periods of the market are closely related to events that must be labelled unexpected, or at least difficult to foresee. The Korean War sent freight rates booming due to a wave of stock building. The closure of the Suez Canal increased average trading distances that made the freight rates booming again in 1956, and the reopening sent the rates way down again. Then in 1967 during the Six Day War between Israel and Egypt, the Suez Canal was again closed and freight rates rose.

In 1971-72 an unprecedented growth in seaborne trades sent freight rates booming. In 1973-74 a combination of the Yom Kippur War and OPEC oil embargo sent freight rates plummeting again. After the second jump in oil prices in 1979-80 energy coal demand soared as many plants started to substitute oil with coal. This led to a congestion problem in the only port that could cater for the higher demand, Hampton Roads, in Norfolk on the US East Coast, and again freight rates soared. The Iraq invasion of Kuwait in 1990 had again a negative impact on freight markets.

In total, the whole period after the second world war has been characterised by a series of events that have had a great impact on the freight market - events that hardly could have been predicted. It is reasonable to believe that this will continue to happen in international shipping.

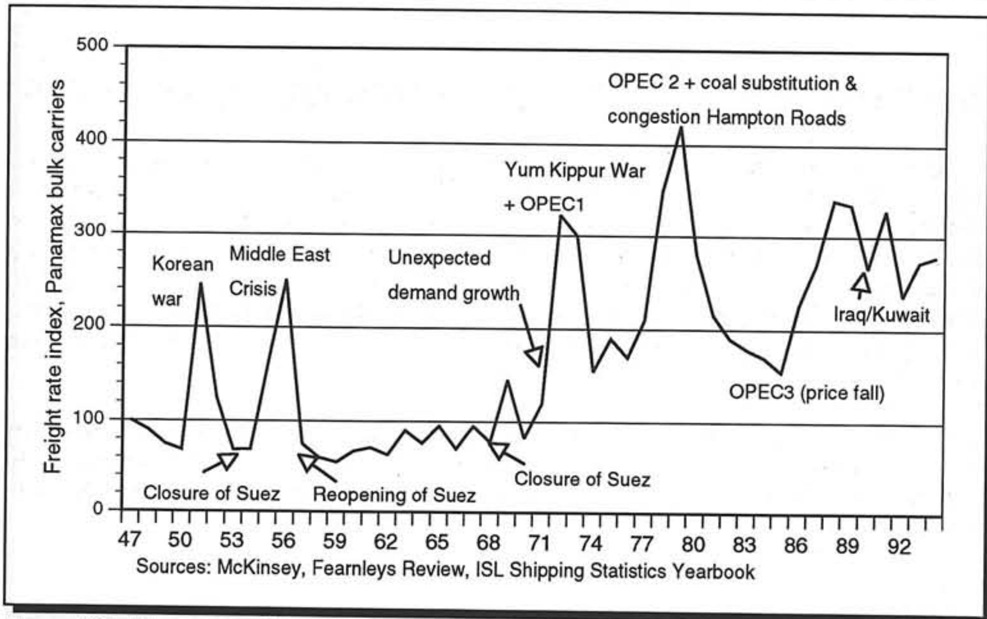


Figure 32: Unexpected events and dry bulk shipping

CHAPTER 2: SHIPPING SEGMENTS AND SHIP TYPES

Through the ages many different ship types have been developed. The first cargo ships were suitable to transport general cargo. Liquid cargo was transported in amphorae or barrels. Later general cargo ships were developed, sometimes with special provisions for e.g. liquid cargo. Nowadays many types of cargo, which are transported in sufficient quantities, have their own ship type. W.V. Packard in *"Sea-trading: The ships"* distinguishes around 250 different ship types, comprising cargo ships, passenger ships, fishing ships and industry ships. It does not include Navy vessels.

This chapter shows examples of many different ships, categorised on the basis of the cargo they carry, their duty or their specific attributes. The chapter only describes a few types of the large number of different industry vessels. The categories are:

- Tankers;
- Bulk carriers;
- Container ships;
- General cargo ships;
- Heavy lift vessels;
- Ro-ro vessels;
- Cruise vessels;
- Fishing vessels;
- Tugs and offshore supply vessels;
- Fast vessels.

2.1 Tankers

The number of different liquids transported by tankers is enormous. Roughly they can be divided into crude oil, oil products, chemicals, gases (LPG, LNG) and others (e.g. bitumen/pitch). Many ships are built specifically for one type of cargo, but there are also ships designed for a combination of cargoes. For example, ships can be suitable for carrying oil products as well as chemicals, or for carrying chemicals as well as gases.

2.1.1 Crude oil tankers

Crude oil tankers are used for transport of crude oil from the areas where it is found to the areas where it is processed. Crude oil tankers are very large vessels with a deadweight up to about 550,000 dwt. The largest tanker was built in Japan in 1979, and was named *Happy Giant* with a total deadweight of 564,763 tonnes. The world fleet comprises around 10,000 tankers, of which 2,666 were over 10,000 dwt as of 1 January 1996.

Until the early seventies, most of the crude oil was won in the Middle East and transported in large quantities to e.g. Europe and America. Ships became bigger and bigger and ultimately Ultra Large Crude Carriers (ULCC) of about 500,000 dwt were built. In the early seventies, there were even plans to build tankers up to a deadweight of 1,000,000 tonnes.
After the first oil crisis other oil fields, like in the North Sea, were developed and also energy saving was encouraged. The transport distances and quantities decreased and ULCCs became unprofitable. Nowadays hardly any tankers over 300,000 dwt are built, most of them were built in the 1970s. This section shows examples of four characteristic oil tanker sizes: The Aframax, the 102,352 dwt *Neptune Auriga*, built in 1993, (**Figure 1**), the Suezmax, the 156,835 dwt *Samuel Ginn*, built in 1993 (**Figure 2**), the Very Large Crude Carrier, the 300,364 dwt *Tarim*, built in 1993 (**Figure 3**) and the ULCC, the 553,662 dwt *Batillus*, built in 1976, (**Figure 4**).

The Aframax tanker used to be a ship of 79,999 dwt, because this represented the largest vessel included in the 'large range 1' category (40,000-79,999) of the AFRA (Average Freight Rate Assessment), which was made by the London Tanker Brokers' Panel. Today the term is used in a wider sense. Drewry Consultants normally include all vessels from 75,000 to 99,999, but sometimes even larger vessels are called Aframax.
The Suezmax is the maximum tanker size that is able to pass the Suez Canal, where draught typically is the restriction. The draught of the Suez Canal is 16.2 metres, and in loaded conditions this means that ships up to about 150,000 dwt can pass.

2.1.2 Products tankers

Products tankers are used for the transport of refined oil products, like petrol, diesel and kerosene. They transport oil products from the refinery to the customer. The average products tanker is considerably smaller than the average crude oil tankers. They have a deadweight up to 150,000 tonnes. Products tankers have a relatively large number of tanks, so that they are able to load many different cargoes at the same time. Therefore, they have a complicated piping system. No two different cargoes may be loaded by the same pipes. Some products tankers can also transport chemicals.

Figure 5 shows an example of a small double-hulled, 6,416 dwt products tanker designed to IMO category II, the 1994-built *Steersman*. The ship is designed for carrying cargoes with flashpoints below 60°C and trade in Northern European waters. The cargo area is divided into ten tanks, five at each side. The pumping arrangements enable the vessel a five-grade discharge.

Figure 6 shows an example of a 41,000 dwt products tanker, the 1995-built *Torm Alice*. The double-hulled vessel is able to carry crude oils, dirty petroleum products, and solvents such as benzene, toluene, xylenes, and methyl tert-butyl ether. The ship has eight tanks at each side, each provided with a heating system

2.1.3 Chemical tankers

Chemical tankers are designed for 'noxious liquids', as described in the treaty on 'Maritime Pollution' (MARPOL). The definition of noxious liquids is determined by the following factors:

- Bioaccumulation: The quantities in which living organisms absorb substances and the threat they, because of this, directly of indirectly are, for the life in the sea and the health of men;
- The toxicity for the organisms that live in the water;
- The threat for the health of people, who take in the polluted water;
- The threat for recreation areas or other sea activities.

The 'Group of Experts on the Scientific Aspects of Marine Pollution' (GESAMP), developed, by orders of the IMO, a guideline for every factor. With these guidelines the GESAMP classified the noxious liquids into four product categories. It divided the products in A, B, C and D-substances. A-substances are the most toxic and D-substances are the least toxic. A, B and C-substances must be carried out by chemical tankers. Some oil-alike liquids (C and D) can be transported by products tankers. Some D-substances can be transported in deep tanks of dry cargo ships. This means:

- A-substances require ship type I or II;
- B-substances require ship type II or III;
- C-substances require ship type III;
- D-substances have no requirements concerning ship types.

Chemical cargo tanks are constructed from either mild steel or stainless steel. The mild steel tanks must be protected by a coating, of either: Epoxy, zinc silicate, polyurethane, phenolics or rubber. Stainless steel tankers are very expensive, but can handle all cargoes. The distinction between stainless steel chemical tankers and vessels with coated tanks can be important.

The deadweight of chemical tankers varies up to 50,000 tonnes. The world fleet comprises about 975 chemical tankers and 150 Chemical/oil tankers.

Figure 7 shows an example of a small, type II chemical tanker, with a deadweight capacity of 9,500 tonnes, called *Equinox*. The ship was built in 1993. It has a double-hull and twelve cargo tanks. The tank walls, tanktops, bulkheads and deckheads are made of mild steel and treated with a coating. The vessel is designed for cargoes with a maximum density up to 1.6 tonnes/m^3. Each tank is equipped with heating coils. The heating system has a capacity of 2,100 kW.

Figure 8 shows the 17,000 dwt chemical/oil tanker, the *Rheinstern*, built in 1993. The ship has eighteen cargo tanks, of which two are of type I and the rest of type II. The type II tanks can carry cargoes with specific gravities from 0.63 tonnes/m^3

up to 1.55 t/m³, and the type I tanks up to 1.84 tonnes/m³. The ship is strengthened for ice.

2.1.4 Gas tankers

According to the regulations there are three types of ships allowed to carry liquefied gases. IG, IIG/IIPG and IIIG for progressively less dangerous products. The transportation condition of liquefied gases is determined by the pressure and the temperature at which the gases are transported. Three conditions can be distinguished:

- Fully-pressurised:
  The cargo is kept liquid using pressure only. The temperature of the cargo is equal to the surrounding temperature;
- Semi-pressurised:
  The ship keeps the cargo pressurised and cools it at the same time;
- Fully refrigerated:
  The ship cools its cargo and carries it under atmospheric pressure. Therefore, the tanks can have a regular form and the available cargo space can be better utilised.

There exist many different tank type configurations. The choice for the tank configuration is determined by the types of cargoes to be transported, the transport condition, the hull form, etc.

General gas carriers can transport several products: Liquefied Petroleum Gas (LPG), ammonia and other chemical gases. Liquefied Natural Gas (LNG) is carried by a different type of gas carriers. LPG carriers go up to 70,000 dwt, LNG carriers up to 85,000 dwt.

This section shows three example gas carriers, two LPG carriers and one LNG carrier. **Figure 9** shows the 1993-built, 5,954 dwt LPG/chemical gas carrier *Jadegas*, type IIPG. The vessels is specially designed to transport 2,765 tonnes at a temperature of -47°C of propylene cargo and at a draught of 5.20 m. The maximum draught for the heaviest gas VCM (Vinyl chloride Monomer, density 0,972 tonne/m³) is 7.00m.
Figure 10 shows the 1991-built, 28,870 dwt LPG carrier *Sombeke*. The LPG carrier has a tank capacity of about 34,000 m³, enabling her to carry a full load of ammonia and a part load of VCM.
Figure 11 shows the 1993-built, 48,817 dwt LNG carrier *Polar Eagle*. The ship has a cargo capacity of 89,880 m³.

2.1.5 Bitumen tankers

Figure 12 shows the 5,200 dwt Bitumen/pitch carrier *Theodora*, built in 1991. The ship has been specially designed for the carriage of boiler oil, bituminous products and for coal tar products, including pitch. The temperatures at which the products are carried range from 40°C to 250°C and no limitations have been put on the flash point value of the cargoes. Cargo densities vary between 0.94 and 1.032 at 15°C. The coefficient of expansion per degree Celsius is 0.0006.

2.2 Dry bulk carriers

Dry bulk carriers are used for the transport of bulk cargoes, like grain, ore and cement. The deadweight of bulk carriers varies from small coastal vessels to ore carriers of about 350,000 dwt. The largest ore carrier is *Berge Stahl* of 364,768 dwt, built in Japan in 1986.
There exist general bulk carriers designed for two or more types of cargoes or combination carriers like the Ore-Bulk-Oil carrier (OBO), but also specialised bulk carriers like cement carriers. Combination carriers have the advantage that they are easier to employ, since they are suited for different types of cargo and, therefore, can operate in different markets. Also ballast voyages can be reduced. The main disadvantage is the higher building cost. The largest combination carrier is *Docefjord* of 310,712 dwt, built in Brazil in 1986.
Ore carriers distinguish themselves from the other bulk carriers mainly by their construction. They are strengthened for heavy cargo. **Table I** shows the stowage factors for a large number of bulk cargoes.

Bulk carriers are rather versatile vessels, which can be adapted to many purposes. The ships are constructed with only one (main) deck. The bridge and machinery are usually located aft. Some ships are fitted with derricks or cranes (geared), or are self-unloading. Many, mostly larger ships, do not have cargo handling equipment (gearless). Most bulk carriers have sloping upper wing-tanks. The holds have a double bottom and lower wing-tanks called hopper tanks. The tanks help preventing the shifting of cargo and facilitate unloading.

This section shows three examples of typical general bulk carriers, a Handysize, a Panamax and a Capesize bulk carrier. A Handysize bulk carrier has a maximum breadth of 23 metres and a length of 222.5 and is therefore able to so sail the St. Lawrence Seaway to the Great Lakes of North America.
The Panamax bulk carrier has the maximum size for passing the Panama Canal, which is restricted to a width of 32.25 m. Larger ships are called Capesize, because they cannot use the Panama Canal and have to sail around the Cape.
This section also shows one example each, of a small self-discharging ore carrier, a cement carrier and an OBO carrier.

Figure 13 shows the 33,343 dwt Handysize bulk carrier *Futura*, built in 1995. The ship is of the Futura-32A design of which many ships have been built yet. The ship has long cargo holds to accommodate two bays of 40-foot cargoes, and

Product	Stowage factor Bulk (m³/tonne)	Product	Stowage factor Bulk (m³/tonne)
Alumina	0.73 - 0.91	Manganese ore	0.48 - 2.26
Ammonium sulphate	1.19 - 1.27	Nitrate	0.96 - 1.08
Barley	1.47 - 1.64	Oats	1.84 - 2.12
Bauxite	0.74 - 0.91	Phosphate	0.93 - 1.00
Cement	0.62 - 0.65	Pig iron	0.28 - 0.42
Chrome ore	0.34 - 0.42	Potash	0.93 - 1.07
Coal	1.19 - 1.36	Pyrites	0.85 - 0.93
Coke	1.98 - 2.83	Rye	1.41 - 1.55
Fish meal	1.47 - 1.53	Salt	1.02 - 1.13
Ilmenite	0.37	Soda ash	1.08 - 1.13
Iron ore	0.34 - 0.42	Sugar	1.13 - 1.27
Lead	0.34	Sulphur	1.08 - 1.13
Maize (corn)	1.38 - 1.41	Wheat	1.27 - 1.41

Table I: Stowage factor of bulk cargoes

wide, flattop hatch openings, which can be modified for loading deck cargoes such as timber or containers. The ship is equipped with four 25-tonne deck cranes. The ship also has the capacity of loading heavy cargo, alternately in holds no. 1, 3 and 5.
Figure 14 shows the 70,165 dwt Panamax bulk carrier *Royal Pilot*, built in 1994. **Figure 15** shows the 150,966 dwt Capesize bulk carrier *Universal Spirit*, built in 1994. The vessel is designed to carry coal, ore and grain in bulk.

Figure 16 shows the 3,150 dwt self-discharging ore carrier *Aburri*, built in 1995. The vessel has a very full shape, with a block coefficient of 0.83. The ship is used to lighter cargo from shore to anchored bulk carriers 15 miles offshore. The cargo is loaded at a single point entry onto a conveyor belt suspended, under the cargo hold roof, and then distributed on board by a plough mechanism. The loading rate is 1,050 tonnes/hour. Once alongside an anchored freighter, the ship transfers its cargo using a bucket wheel system, feeding a cascading conveyor and then a slinging boom conveyor that is moveable the full length of the ship's hold, again with a loading rate of 1,050 tonnes/hour.

Figure 17 shows the 12,340 dwt cement carrier *Asia Cement no. 5*, built in 1993. The ship is equipped with its own cement loading and unloading system with a loading capacity of 700 tonnes/hour and an unloading capacity of 660 tonnes/hour. The system can shift and load cement into the fore and aft corners of the cargo hold with a dispersal screw conveyor arranged under the upper deck. The arrangement has almost eliminated cement handling equipment from upper deck surfaces. The cement control room is arranged on the upper deck amidships for centralised control of cement loading and unloading.

Figure 18 shows the 45,000 dwt, open-hatch forest products carrier *Star Hidra*, built in 1995. Forest products are e.g. lumber, sawn timber, linerboard, plywood, woodpulp and paper. The ship is of the open-hatch type, which means that the length and the breadth of the hatches match the dimensions of the box-shaped holds exposed when the pontoon hatch covers are removed. This concept facilitates the efficient and safe stowage of unitised cargoes (timber and woodchips in box-shaped packages), containers and general dry bulk cargoes. The covers on the crane protect the open holds form the weather, during loading.

Figure 19 shows the 66,715 dwt OBO carrier (Ore-Bulk-Oil) *Sibohelle*, built in 1993. The ship features nine cargo holds/oil tanks with small top and bottom wing tanks. Oil cargoes are handled by nine hydraulic submerged pumps fitted in the double skin of the transverse bulkheads, with suction provided through grilles in the tanktop adjacent to the bulkhead. All cargo piping is arranged on deck.

Figure 20 shows the 6,000 dwt COB carrier (Container-Oil-Bulk) *Alcor*, built in 1991. The ship is designed for carrying paper, pulp, containers, oil products and bulk cargoes in the Scandinavia-Northern Europe area and the Mediterranean. The vessel has a double-hull and has the facilities to cope with ice conditions during two or three months each year, having ample thrust at low speeds, a bulbous bow with ice cutting knife edges above and below the forefoot and the shrouded controlabe pitch propeller protected against ice floe damage. Since cleaning of the hold is very important between two non-compatible cargoes, stainless steel has been used for all holds, valves and cargo pumps and a special cleaning system has been installed.

2.3 Container ships

Containers are boxes that can be filled with cargo for transport. Containers can easily be transshipped from one modality to another. Using containers has the following advantages compared to transport of the pieces of cargo separately:

- Reduction of the port time, (un)loading speed increases because the units are bigger and stowing is faster;
- Less personnel is required for transshipment of the cargo;
- The cargo is better protected against damage during loading, unloading and transport as well as against theft.

Containers are standardised by the Internal Standardisation Organisation (ISO). The most used containers have a length of 20 ft (TEU) or 40 ft (FEU), a width of 8 ft and a height of 8 ft or 8.5 ft. Also other dimensions occur, like the 45 ft container, the Bell container with a width of 2.5 m. and the high cube container with a height of 9.5 ft.

For transport of containers, there are special container ships and special container terminals. Container ships have box-shaped holds, fitted with cell guides, which are used for guiding and fastening of the containers. Container terminals are equipped with special container cranes, which facilitate and speed up loading and unloading.

The carrying capacity of container ships is measured by the number of 20 ft containers (TEUs) they can carry. On basis of their size they can be classified into the following categories:

- Feeder (100 - 400 TEU);
- 1st generation (400-1,000 TEU);
- 2nd generation (1,000 - 1,600 TEU);
- 3rd generation (1,600 - 3,500 TEU);
- 4th generation (>3,500 TEU).

Most containers are used for general cargo. However, there are also specialised containers like tank containers and reefer containers. Tank containers are used for liquid, often dangerous, cargoes. Reefer containers are used for transport of cooled or frozen cargo. They require extra facilities on board of the ship, because they need electricity to keep their temperature. Even bulk cargoes can be transported by container.

2.3.1 Container ships

The typical container ship has box-shaped cargo holds fitted with cell guides. The hatches have the same width as the holds. The ships have a large depth, for storing as much containers as possible in the cargo holds. On the deck and hatches more containers can be stored. Storing containers on deck increases the capacity of container ships significantly. The container capacity on deck can even be up to 70% of the total capacity. The number of containers on deck is limited by the stability of the ship and the weight of the containers.

This section shows three examples of container ships. The first one is a feeder container ship, the second one a second generation container ship and the third one a fourth generation container ship. A feeder container ship is used to distribute containers delivered in a main port by a large container ship to smaller ports in the same area.

Figure 21 shows the 266 TEU container ship *Muuga*, built in 1995. The ship is specifically designed for the carriage of dry cargo, containers and also dangerous goods. The ship can carry three tiers of containers on deck, with a total capacity of 186 TEU. The holds have a capacity of 80 TEU. The ship has been designed to carry containers of 8 ft wide as well as 2.5 m. wide.
The hold has by folding hatch covers. The hatch covers are designed for uniformly distributed loads of 1.75 tonnes/m^2 and container stack loads of 50 tonnes for TEUs and 75 tonnes for FEUs.

Figure 22 shows the 1,391 TEU container ship *Nantai Venus*, built in 1994. The ship can carry up to 60 reefer containers and has its own handling gear.

Figure 23 shows the 4,743 TEU container ship *Nyk Altair*. The ship is of post-Panamax size, which means that the breadth of 37.10 m. is too big for passing the Panama Canal. From the total capacity of 4,743 TEUs, 2,264 TEUs are carried in the holds, the other 2,479 are carried on deck in five tiers (four on the forward part of the ship). The ship can carry 400 reefer containers, 252 on deck and 148 in the holds.

2.3.2 Open-hatch container ships

A significant disadvantage of the typical container ship is that when a container stored in the hold has to be unloaded, all containers stored on top of the hatch of that hold, have to be removed first. This makes planning very difficult and brings about extra work and extra costs. Therefore, the open-hatch container ship has been developed.
The open-hatch container ship does not have hatch covers and cell guides extend themselves above the main deck, till the most upper tier. Because of the open hatch the holds are more susceptible for weather and environmental influences. Therefore the depth and freeboard of these ships are bigger than the depth of general container ships. Also, the ship has a large water outlet capacity for carrying off water from the holds.

Figure 24 shows the 588 TEU open-hatch container ship *Reestborg*, built in 1994. The accommodation of the ship is situated on the foreship between hold no 1 and no 2. The engine room is situated aft. The ship has a raised forecastle fitted over the forward part of the D-deck, accommodating the upper part of hold no 1. The container guides in the open holds extend from the tanktop or hold bottom up to about 16 m. above base, i.e. the top of the sixth tier. The first hold is not open, but has hatch covers.

Figure 25 shows the 1,472 TEU open-hatch container ship *European Express*, built in 1993. The accommodation is situated on the foreship. All the holds are behind the accommodation

Figure 26 shows the 4,112 TEU open-hatch container ship *Nedlloyd Hongkong*, built in 1994. With its breadth of 37.75 m., the ship is of post-Panamax size. The accommodation is situated aft, between holds number 5 and 6. There are two holds behind the accommodation. The ship has no hatch covers, except for holds no 1 and no 2, which have pontoon hatch covers.

2.3.3 Barge carriers

Barge carriers are not of the container ship type, but they use the same principle of unitised cargo. Instead of containers, they carry barges. The characteristic difference between containers and barges is that barges have the ability to float.
Barge carriers are especially suitable for use at places where no sophisticated (un)loading equipment is available, for example in Africa, or at places with a

shallow draft. The barge carrier unloads its cargo on open sea and the barges are then transported to the harbour. Here the barges can be unloaded, while the barge carrier loads new barges, which have been loaded earlier. Barge carriers have the following advantages:

- For small ports they can be bigger than normal cargo ships, because, they do not have to enter;
- (Un)loading time is reduced significantly;
- (Un)loading is independent of port equipment;
- The barges can sail to inland ports.

Barge carriers, however, do have considerable disadvantages:

- Barge carriers and (un)loading equipment require high investments;
- The barge carrier depends very much on the reliability of its (un)loading equipment;
- The types of cargo the ship can transport are restricted by the size of the barges;

Because of these disadvantages the barge carrier never became successful. Especially the high investment cost is a considerable disadvantage. Hardly any barge carriers have been built lately.

Four different types of barge carriers can be distinguished:

- Lighter Aboard Ship (LASH);
- Seabee;
- Barge Aboard Catamaran (BACAT);
- Barge container Liner.

The differences are based on the way of loading (lift on-lift off, float on-float off), size and design of the barges (from 140 to 850 dwt), and design of the ship (mono-hull, catamaran)

Figure 27 shows an example of a barge carrier according to the Seabee system. The ship is the 37,850 dwt barge carrier *Yulius Fuchik*, built in 1978. It has a capacity of 26 barges, each with a maximum deadweight of 1,070 tonnes.

2.4 Heavy lift vessels

Heavy lift vessels are vessels especially designed for the transport of heavy or large pieces of cargo. It is difficult to exactly define heavy lift shipping, but usually is concerns cargo that is voluminous, has a large weight or is difficult to handle. The designs of heavy lift vessels are very diverse, and they can be divided into three categories:

- *Conventional heavy lift ships*;
  The conventional heavy lift vessel is equipped with at least one heavy crane to take the heavy cargo aboard according to the lift-on lift-off principle. The ships are equipped with sufficient ballast capacity to ensure safe stability and satisfying seagoing behaviour.

- *Semi submersibles*;
  This type of ships does not have crane capacity as the conventional heavy lift ships. They work according to the float-on float-off principle. The ship takes ballast to get the required draught. Then the cargo is positioned above the ship and the ballast tanks are emptied, so the ship rises again.

- *Dock lifts with heavy cranes*;
  This ship is a combination of the previous types. The ship can load its cargo according to the float-on float-off principle, but also has heavy cranes that are able to handle the cargo.

The cargo transported by heavy lift vessels is also very diversified. The heavy lift transport sector can be divided into four main categories:

- *Offshore*, like Jack-up rigs, semi-submersible rigs, work barges, offshore modules, drill tenders, jackets and mooring systems;
- *Maritime infrastructure*, like dredging equipment, dry docks, bridges, tunnels, container cranes/transtainers and floating cranes;
- *Industrial infrastructure*, like onshore modules, floating plants;
- *Other*, like floatels, accommodation units, etc.

This section shows four examples of heavy lift ships, from the four Dutch or former-Dutch heavy lift shipping companies. **Figure 28** shows the 5,200 dwt *Jumbo Spirit*, built in 1995. The design is according to the conventional heavy lift type, and the ship has one derrick and one mast crane with a combined lifting capacity of 500 tonnes. The ships has been specially designed for the carriage of heavy and voluminous project cargoes such as locomotives, power plants, refineries and their components. The vessel has a box-shaped cargo hold which can be horizontally subdivided into an upper and a lower hold by pontoon-type hatches. In order to control the ship's heel and trim during loading and discharging operations, a ballast water heeling control system has been installed. This system incorporates two 200 m^3/h ballast pumps and a 425 m^3/h direct-reversible anti-heeling pump.

Figure 29 shows the 9,700 dwt heavy lift ship *Dock Express 20*, built in 1983. The ship's design is according to the dock lift with heavy cranes principle. The ship has been especially designed for the transportation of heavy cargo and cargo units of extreme dimensions and volume. This cargo can be taken on board by the two heavy gantry cranes. It can also be rolled on board using the stern door as a ramp or the cargo can be floated into the docking section and 'drydocked' inside the ship.

Figure 30 shows the 23,800 dwt heavy lift ship *Mighty Servant 1*, built in 1984. The ship is of the semi-submersible type and has been purpose designed to transport a wide range of fragile, awkward, heavy or bulky cargoes. Such a requirement demands conflicting hull designs: A slender vessel for seakindly motion characteristics for carrying the light, but bulky modular equipment, or a wide ship with extra stability and buoyancy for the heavy cargo. Therefore, the vessel is designed with a slender underwater hull form, which is submerged to WL1 when carrying lighter cargoes, but with increased water plane area and stability provided by the flared freeboard wings for transporting heavy lifts at WL2. The ship can be loaded according to the ro-ro and the flo-flo principle. During a flo-flo operation, stability and buoyancy is ensured by the two cases aft.

Figure 31 shows the 13,740 dwt heavy lift ship *Happy Buccaneer*, built in 1984. The ship is of the heavy lift ro-ro type with two revolving mast cranes with a capacity of 550 tonnes each. The hatch covers can be taken out and put back at any place, which makes it possible to load voluminous cargoes. During loading sufficient ballast capacity is available to control the heel and stability during the hoisting operations without external stabilisers.

2.5 General cargo ships

The category general cargo ships, comprises the multi-purpose ship that is designed for the transport of all types of cargo, but also some purposely built ships, like the reefer ship. General cargo ships are often relatively small ships. The size of most general cargo ships is restricted by the (un)loading speed and the port time. General cargo ships have a size up to about 25,000 dwt.
Many older-style general cargo ships were capable of carrying extra passengers, were fitted with tanks to transport, and if necessary, heat small quantities of liquids such as vegetable oil or latex. Nowadays most passengers travel by aeroplane, liquids are transported by chemical or products tankers and a lot of cargo is loaded into containers and transported by container ship.
The modern general cargo ship is the multi-purpose ship. These ships are often equipped with cranes or derricks for loading and unloading the cargo. This gives them the ability to handle cargo in ports that are not well equipped. Many of these vessels are fitted with their own lashings etc., for securing containers. Multi-purpose ships can be divided into single-deck and multi-deck ships (tweendeckers). The latter category of ships has one and sometimes more tweendecks. Engine room and superstructure of the modern multi-purpose ship is located aft. The cargo spaces tend to be as square as possible to facilitate stowing of containers, boxed and palletised cargo, whilst on deck most designs allow for storage of containers.

Figure 32 shows the 3,270 dwt multi-purpose cargo ship *Tertius*, built in 1995. The single deck vessel has a raised forecastle and a quarterdeck aft. The cargo hold consists of one box shaped hold with side ballast tanks arranged in the double hull and bottom ballast tanks. The obstruction-free cargo hold can be subdivided into separated parts by means of two moveable grain bulkheads. This allows the carriage of a variety of cargoes including grain and other bulk cargoes, containers and/or a combination of these cargoes. The pontoon type hatch covers enable the carrying of 15-tonne containers on deck. The cargo hold can be stowed with 76 TEUs. In addition 40 TEUs can be stowed on deck.

Figure 33 shows the 12,750 dwt multi-purpose cargo ship *Edisongracht*, built in 1995. The tweendecker has been designed as a multi-purpose dry cargo vessel for the carriage of all kind of dry cargoes, including: Heavy cargoes, timber deck cargoes, containers and break bulk cargoes. On deck the vessel features facilities for the carriage of refrigerated containers.

Refrigerated or reefer ships, are specifically designed for cargoes that would deteriorate in ordinary hold temperatures and conditions, such as meat, fish, vegetables, fruit and dairy products. The ships have numerous insulated tweendecks and can, if necessary, be used for the carriage of non-refrigerated goods like bagged, baled and palletised cargoes, and sometimes containers on deck. They cannot carry bulk cargoes. Most reefer ships are fitted with light cargo gear, 5-tonne cranes or derricks sufficing to handle most pallets in place or in addition to forklift trucks. Containers need to be lifted on and off with shore equipment.

Figure 34 shows the 7,455 dwt reefer ship *Cool Express*, built in 1994. The ship has four decks and four holds. Every second tweendeck is insulated, so eight different cargoes, with eight different temperatures can be loaded. A small number of containers can be carried on deck (42 TEU, of which maximally 20 reefer containers). The holds are cooled by circulating air. Meat can be transported by a temperature of -25 °C. The ship has 4 deck cranes, with a lifting capacity of 8 tonnes each and a reach from 3.05 to 18 m.

Figure 35 shows the 3,714 dwt livestock carrier *Bison Express*, built in 1995. The vessel is especially designed for the worldwide transport of livestock, particularly cattle and has a capacity of about 1,700 pieces of cattle. The ship has 4 decks, 3 tweendecks and the tanktop, each with a height of 2.40m. The animals are housed in stables with aluminium gates, separated from each other by passageways. Loading and unloading takes place with special ramps. These ramps feature separate paths for cattle and personnel. The vessel has five ramps.
A ventilating system takes care of 45 air refreshments per hour in the cargo holds. On the main deck, two cranes have been fitted, one amidship and on in front of the engine room. These cranes handle the ramp and the gangway to shore, and eventually, are used for the loading and discharging of animals via the 'camel hatches'. The aft deck crane has a lifting capacity of 5.2 tonnes, the amidship deck crane of 3 tonnes.

Figure 36 shows the 4,300 dwt ro-ro/lo-lo forest products carrier *Ortviken*, built in 1991. The ship has been designed for the transport of wood products, like pulp, board, newsprint and packaged timber. The ship can be loaded by the ro-ro method, where a lift truck can carry the cargo into the holds. The main deck is entered via a stern ramp/door, which is dimensioned to fit the floating pontoon that is used as a linkspan.

2.6 Ro-ro vessels

Ro-ro vessels are vessels that have the ability to drive cargo on and from board. Many ships built according to the roll-on roll-off principle, are ferries that transport cars and lorries over sea, often accompanied by the drivers and other passengers. There are, however, many other types of ro-ro vessels. These are, for example, the rail ferry that transports trains, the ro-ro container vessel that combines ro-ro cargo in the holds with containers on deck. Also the pure car carrier, used for the transport of new cars from the area of manufacturing to the area of sale, works according to the ro-ro principle.

The ro-ro ferry is often custom built to serve a particular route, fitting comfortably into available berths. Extensive terminals are often required, in order to handle the traffic and to provide the modern facilities expected by the present day travelling public and the authorities concerned. Rail ferries are capable of transporting whole railway trains. These ships are fitted with rails throughout with massive ballasting ability to enable the lining up of the rail-deck with shore side tracks.

Figure 37 shows the 5,215 dwt cargo ro-ro vessel *Island Commodore*, built in 1995. The vessel, which can carry 95 trailers of 12 m. length, plus cars, is employed on a freight service on the canal island routes. It is equipped to carry 12 drivers/passengers, accommodated in single berth cabins. The vessel features two ro-ro decks, a double bottom, a stern ramp and two fixed internal ramps of which the ramp to the tanktop is equipped with a watertight cover. The engine room is located aft.

Figure 38 shows the 5,285 dwt ro-ro passenger/cargo vessel *Isle of Innesfree*, built in 1995. The *Isle of Innesfree* was built for the route Dublin - Holyhead, but is designed in a way that it is no problem using it on other routes. For this purpose the vessel is also strengthened for ice. Because the route the ship is designed for is very short, fast loading and unloading are necessary. Therefore, there are only two car decks, which can be loaded and unloaded independently of each other. The ship can be loaded and unloaded via the stern door and the bow door. The accommodation is sufficient for 1650 passengers, but because of the short sailing time, there are only cabins for a small part of the passengers. The ship has a capacity of 108 trailers or 60 motor cars.

Figure 39 shows the 6,250 dwt ro-ro container vessel *Oleander*, built in 1990. The ship can carry containers as well as cars. All holds have been fitted with container guides arranged for TEUs and extending to the tank top. The tank top has been strengthened in way of the container corners. The container guides are adjustable for loading the larger-sized FEUs. A hoistable car deck has been installed in the ro-ro space for the stowage of passenger cars. The sections measure 19 * 6 m. and 14 * 6 m. On the main deck in way of the ro-ro space aft and the stern the permissible uniform load is 5 tonnes/m^{2,} while the ramp is constructed for 40 ft mafis of up to 60 tonne displacement for an axle of 18 tonnes. The hatches of holds numbers 4 and 5 take ro-ro cargoes of up to 40 tonnes and maximum axle loads of 15 tonnes, while the hoistable car decks take private cars of up to 1 tonne per axle.

Figure 40 shows the 9,700 dwt rail ferry *Railship II*, built in 1985. The vessel is used to carry wagons between Travemunde, Germany and Hanko, Finland, a distance of 535 nm. The ship has a capacity of 85 wagons and is able to load wagons on three decks. This is possible due to the double-deck lift, which forms the centre piece of the vessel's loading and distribution system. A capacity load can be embarked/disembarked in six hours. Provision is made for carriage on the aft part of the elongated forecastle deck of about 80 standard length motor cars. These are loaded and unloaded by the lift-on lift-off principle.

Pure car carriers are specialised ships used to transport motor cars around the world. Large car carriers are capable of transporting up to 5000 cars or more. The first car carriers were conversions of existing bulk carriers, but now there are specialised car carriers, gearless and fitted with fixed deck. Access is via various side doors/ramps. Loading and discharging is very fast. Since the car carrier is capable only of carrying motor cars, ships sail in ballast often.

Figure 41 shows the 4,050 dwt car carrier *Asian Prosperity*, built in 1994. The vessel is designed for carrying motor vehicles such as passenger cars, lorries, forklifts, trailers, etc. on six decks, and has a capacity of 709 cars. Two of the car decks are liftable, to ensure a required overhead clearance for large vehicles. The stern shore ramp at starboard side and the fixed or movable rampways in the hold give access to the cargo space.

Figure 42 shows the 16,000 dwt car carrier *Fides*, built in 1993. The ship has a capacity of 2,400 motor cars or cars mixed with 605 trucks or trailers, but is also capable of transporting containers and general cargo. Containers are rolled into the vessel, on deck 1 and 3. The container capacity is 504 TEU. The ship is loaded on the main deck by a stern quarter ramp. The cars are distributed in the ship by ramps inside the cargo holds.

2.7 Cruise vessels

Until some decades ago transport of people over large distances was often done by (large) passenger vessels. First this was the only available way of transport, later when the aeroplane appeared it was the cheapest way. Nowadays this type of passenger transport has almost ceased to exist and has been taken over by aviation. Passenger transport over short distances is mainly carried out by ro-ro ferries.

Now most passenger ships are cruise vessels. They carry passengers, who like to sail for their enjoyment. They, e.g., sail in the Mediterranean or the Caribbean, and

visit tourists ports. The ships are often very luxurious. They resemble holiday villages with swimming pools, restaurants, bars, discos, gymnasiums, casinos, all kinds of entertainment, luxurious cabins, etc.
The ships are designed with the utmost attention, to prevent any possible discomfort for the passenger. For example, special attention is paid to reduction of noise and vibrations by the engine room and extra stability provisions to reduce rolling. The engines of cruise vessels often have large power to make it possible to sail with a high speed and for a good manoeuvrability in port, so the ship can berth and unberth unaided where necessary, with only limited assistance from tugs. Ships are equipped with controllable pitch propellers together with bow and/or stern thrusters. This is especially important in more exotic locations where few harbour facilities are available.

Figure 43 shows the 6,600 dwt cruise vessel *Statendam*, built in 1993. The ship has been designed and constructed as an ocean going cruise vessel for world wide cruising, suitable for Panama and Suez Canal transits. The 13 deck ship is able to carry 1,264 passengers. There are 633 staterooms onboard, comprising one penthouse suite and 28 other suites and 120 deluxe rooms. The passenger suites and deluxe cabins have a balcony and facilities with Jacuzzi type baths. Public rooms comprise a 745-seat dining room on two levels and two other dining rooms, each with seatings for 44 persons, 3 lounges, two bars and a casino.
To ensure optimum manoeuvrability during berthing and unberthing, but also comfortable stability when cruising, the vessel has been fitted with two electro-hydraulic rotary vane steering gears and Hinze flap type rudders. Manoeuvring is enhanced by three side thruster units, two fitted forward and one aft and controllable pitch propellers.

2.8 Fishing vessels

Fishing vessels are used for catching fish and other sea animals, but also to transport the fish from the fishing ground to the destination port. This distance can range from a few nautical miles to more than 10,000 nm. The design of fishing vessels depends very much on the: Type of fish, fishing area and fishing method. Ships fishing close to their home port, are often small vessels, about 40 m. of length, with limited fish processing facilities. Fish is stored in the ship's hold, in ice. Bollard pull is an important feature for these ships, so they have a relatively high main engine power. They are very seaworthy and have very good manoeuvring capabilities.

Large fishing vessels, with a length up to about 110 m., are used to fish at places farther from their home port. They have complete facilities for processing and storing the fish, before they return home. Most vessels fish from the aft. A number of vessels have a slipway aft, which enables them to pull the net from the water onto the deck without lifting it. Other ships have a crane aft, and lift the net from the water or can pump the fish from a net by a fish pump.
When the fish is on board it is first collected into storage tanks, called Refrigerated Sea Water tanks, where the fish is cooled down. The fish is

processed mechanically. When the fish has cooled down, it is pumped out of the tank, sorted by size and frozen. Then it is wrapped up in cardboard boxes and stored into the ship's hold.

Figure 44 shows the 3,174 dwt beam trawler *Doggersbank*, built in 1992. The ship has a length of 32.90 m. and a deadweight of 3,174 tonnes. The fishing equipment includes a portal bipod mast with heavy fishing derricks and rigging, a 107 kW eight drum trawl winch and an elected winch to off-load the catch. The fish processing plant has been arranged with collapsible bins, a chute in the working deck area, an offal chute, a fish chute, the entrance to the fish hold arranged under the steel canopy, a fish elevator, a sorting belt, one rinsing plant, and the high pressure cleaning system.

Figure 45 shows the 6,011 dwt fishing vessel *Frank Bonefaas*, built in 1994. The ship has been designed for pelagic fish species, like mackerel and herring, and can operate worldwide. It can stay at sea for about two months. The ship is designed for fishing at a depth of 600 to 1,000 metres. The capacity of the fish processing installation is 270 tonnes a day and is determined by the capacity of the 38 freezers.

2.9 Tugs and offshore supply vessels

Tugs can be divided into two types: Harbour tugs and seagoing tugs. Harbour tugs are used for manoeuvring and moving ships in harbours, but sometimes also for fire fighting and icebreaking. Therefore, harbours tugs must be robust and have very good manoeuvring capabilities. Seagoing tugs are used for salvage and towing of ships, jack-ups, offshore platforms and others. Assistance and salvage of ships in distress require a high speed. Because these ships often have to work in rough weather, they must be very seaworthy and must have a high reliability. A very important characteristic of tugs is their bollard pull, which is the thrust they can develop when they have no speed.

Figure 46 shows the 265 dwt seagoing tug *Lamnalco Sable*, built in 1992. The ship has a raised forecastle on which a compact deck house and command centre have been installed. This creates a large working deck area aft.

Supply vessels are specifically designed for the transport of materials to offshore units. Sometimes they also transport people, but only in areas where the transfer from ship to platform is safe. Supply vessels have a characteristic layout. They have a large forecastle and the superstructure is positioned in the front of the ship. The rest of the ship consists of a large, plain deck for the transport of deck cargo, like containers or casings. The hull is filled with tanks, for liquid cargo and other bulk cargoes, like cement.
Aside from vessels specially designed for material transport, there is a large number of supply vessels that are also suitable for other activities like: Rig moves, anchor handling, fire fighting and oil recovery. When supply vessels are equipped

for these task, they can do activities where otherwise tugs would be required. Therefore, these vessels have many similarities with real tugs.

Figure 47 shows the 2,530 dwt offshore supply vessel *Smit-Lloyd Fame*, built in 1995. The ship is designed for material supply only. It has facilities for many types of cargo: Deck cargo like drill pipes, casings, containers and tools; liquid cargoes like fuel oil, potable and liquid mud; dry bulk cargoes like cement, barite and bentonite.

2.10 Fast vessels

Most fast vessels are used for passenger transport, only a few are used for cargo transport. This is because fast vessels are relatively expensive. This goes for both the building and the running costs. Also, most fast vessel types have only a small carrying capacity, which means they can only be profitable if they carry high value cargo.

Fast vessels often deviate strongly from the conventional ship types. Speed can be achieved by installing very much power compared to conventional ship types. However, this solution is very expensive and does not pay off. Therefore, fast vessel designs are based on three different lift principles:

- Static lift (displacement vessels);
- Dynamic lift (hydrofoils);
- Powered lift (air cushion vessels);

2.10.1 Displacement vessels

For conventional ships (displacement vessels) the resistance increases rapidly by increasing the speed. Therefore, conventional ships at high speed demand an unreasonably high level of power and have a high fuel consumption. Resistance can be decreased by increasing the slenderness of the hull and/or by planing.

The slenderness of the ship is restricted by its stability and is expressed by the slenderness ratio:

$$\textit{Slenderness ratio} = \frac{L}{\Delta^{\frac{1}{3}}}$$

Where:
L = Length;
Δ = Displacement.

Ships with a speed over 30 knots have hull lines with a slenderness ratio of approximately seven. Mono-hulls with a slenderness ratio of twelve do not have sufficient stability. To effectively apply such a slender form, it must be used in multi-hull type ships, like catamarans or a SWATHs.

Figure 48 shows the fast mono-hull vessel *Quizzo*, built in 1993. The ship is propelled by water jets, and has a service speed of 40 knots. The ship has a carrying capacity of 126 cars and 450 passengers.

A catamaran is a vessel with two hulls of symmetric or asymmetric form, connected by a bridging structure, clear from the water surface. The ship type is very reliable. This, in combination with a large deck area compared to the lightship weight, makes the ship utterly suitable for passenger transport. Catamarans have very thin waterlines, which ensures a low resistance. The catamaran can be operated at high speeds and still have an acceptable fuel economy. The catamaran does not have the stowage and stability problems that many slender mono-hulls have. The added resistance of large catamarans is low and seakeeping is good. Catamarans operate at speeds between 25 and 40 knots.
Besides the conventional catamaran, there is also the *wave-piercing catamaran*. The wave-piercing catamaran are designed with special hull forms, to drive through the wave crests rather than responding to them. The craft is designed for operation in short period waves. The speed range of the wave-piercing catamaran is 35 to 50 knots.
Figure 49 shows the fast catamaran *Nordblitz*, built in 1994. The ship is built for passenger transport and is able to carry 188 passengers. The ship can reach a speed of 38 knots and the two main engines combined have a power of 1,470 kW. The ship is made of aluminium, to reduce the weight of the ship.

A very special type of catamaran is the SWATH (Small Water plane Area Twin Hull). The under water part of the hull is wider than the breadth of the water plane. Therefore the vessel hardly responds on the waves, it sails in. This ensures an extremely good seakeeping in rough water. This is why these ships hardly need to reduce their speed in rough water, the ship is very reliable to keep its schedule. In calm water the resistance of SWATHs is higher than the resistance of conventional vessels. **Figure 50** shows the SWATH *Radisson Diamond*, built in 1992. The ship is a cruise liner with a passenger capacity of 354.

2.10.2 Hydrofoils

A hydrofoil craft is a mono-hull ship that uses submerged or partially submerged foils to lift the hull from the water surface when it reaches high speed. The vessel is reliable in service and gives a high level of comfort to its passengers. Hydrofoils are relatively small, which explains the loss of market share during the last ten years. Most ships operate at speeds of 30 to 45 knots. This speed is in foilborne mode and hardly influenced by sea conditions. If the hull gets into the water, the speed collapses. This in combination with the small size means that the hydrofoil craft is not suitable for severe sea conditions.

Figure 51 shows the hydrofoil *Emerald Wing*, built in 1994. The ship has a foilborne speed of 45 knots with a water-jet propulsion system and fully submerged hydrofoils that lift the hull completely out of the water. The ship can ride out waves as high as four meters.

Another type of hydrofoil is the foilcat, a twin-hull ship with foils. **Figure 52** shows the foilcat *Penha*, with a passenger capacity of 403 passengers. The ship is able to achieve a maximum speed of 52 knots. The Foilcat makes the transition from hullborne to foilborne operation at approximately 30 knots, normal service speed is 45 knots.

Two newly developed ships, and at the moment only built as models scaled down to 1/2 and 1/6 of the actual size, are the techno-superliners *Hisho* and *Hayate* shown in **Figure 53**. The *Hayate* has a hydrofoil hybrid hull. The *Hisho* has an air cushion hybrid hull. The TSL is supposed to satisfy four main requirements: A speed of 50 knots, a payload capacity of 1,000 tonnes, a cruising range of 500 sea miles and the ability to safely navigate rough seas of up to about sea-state six without a drop in speed. The TSL is likely to be designed and built as a container carrier, passenger vessel or car ferry.

The *Hayate* is a hydrofoil hybrid type ship. The hull system comprises an upper hull, a lower hull responsible for the buoyance, a fully submerged hydrofoil creating the lift, and struts joining the upper hull, the lower hull and the hydrofoil. Propulsion is accomplished by gas turbine-driven water jet pumps.

The *Hisho* has a main hull with a lower part consisting of a pair of side hulls and bow and stern seals. The bow and stern seals are intended to prevent the air, blown in the space between the side hulls by uplift fans, from leaking out. The propulsion system consists of two gas turbine-driven water jets, one each installed in the tow side hulls.

2.10.3 Air Cushion Vehicles (ACVs)

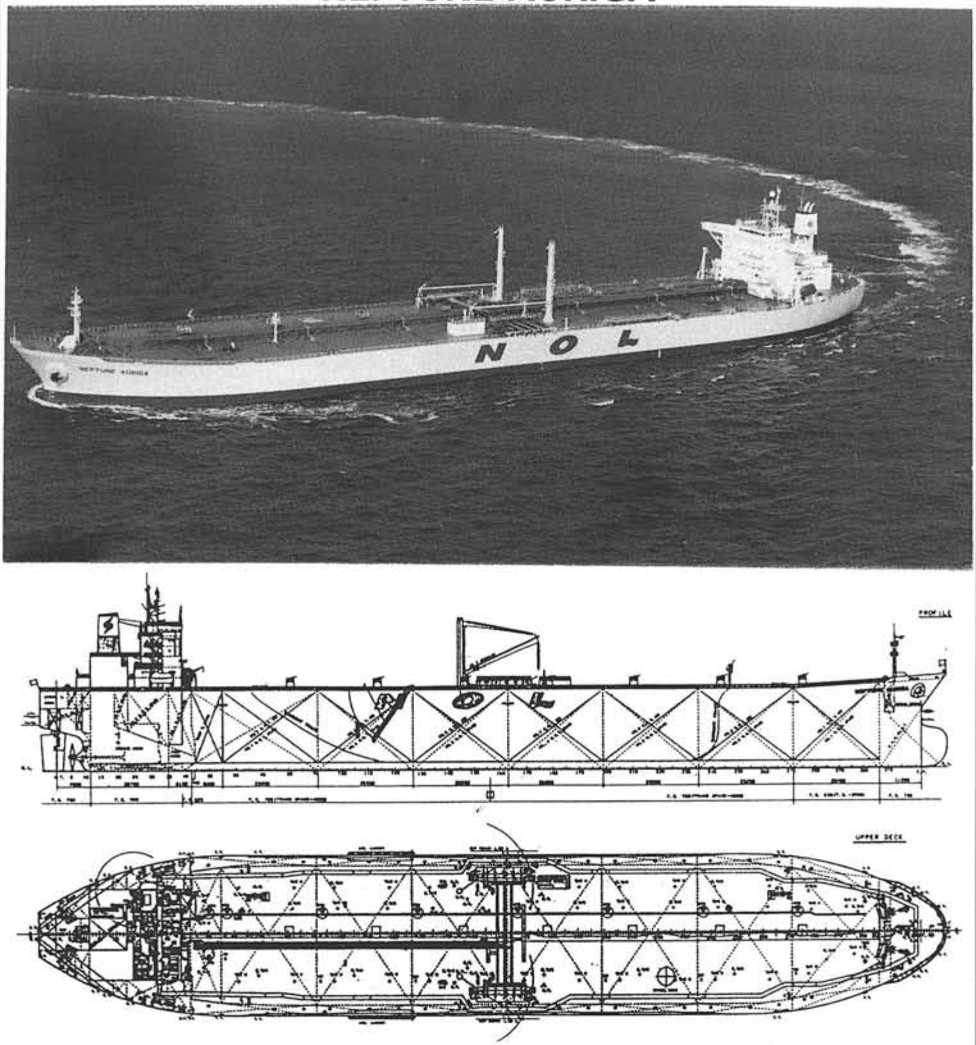
Air cushion vessels use a low pressure air cushion to lift the hull clear from the water. The periphery of the air cushion is contained by flexible seals or skirts. ACVs are the fastest high speed light craft. They mostly operate at speeds between 35 and 65 knots. Large ACVs can operate in heavy weather. However, then the speed reduction is considerable. Two ACV types are the: Hovercraft and the Surface Effect Ship (SES).

The hovercraft uses flexible seals to prevent the air from escaping. The SES is similar to the hovercraft, but in the sides it has rigid skirts instead of flexible seals. The rigid skirts make the ship a bit similar to the catamaran.

Figure 54 shows the hovercraft *Sumidagawa*, built in 1989. The ship has a maximum speed of 30.4 knots and a passenger capacity of 80.

Figure 55 shows the Surface Effect Ship (SES) *Agnes 200*, built in 1990. The ship is designed in the form of a basic air cushion platform for both civil and military versions. The ship has a capacity of 78 passenger and a maximum speed of 40 knots.

NEPTUNE AURIGA



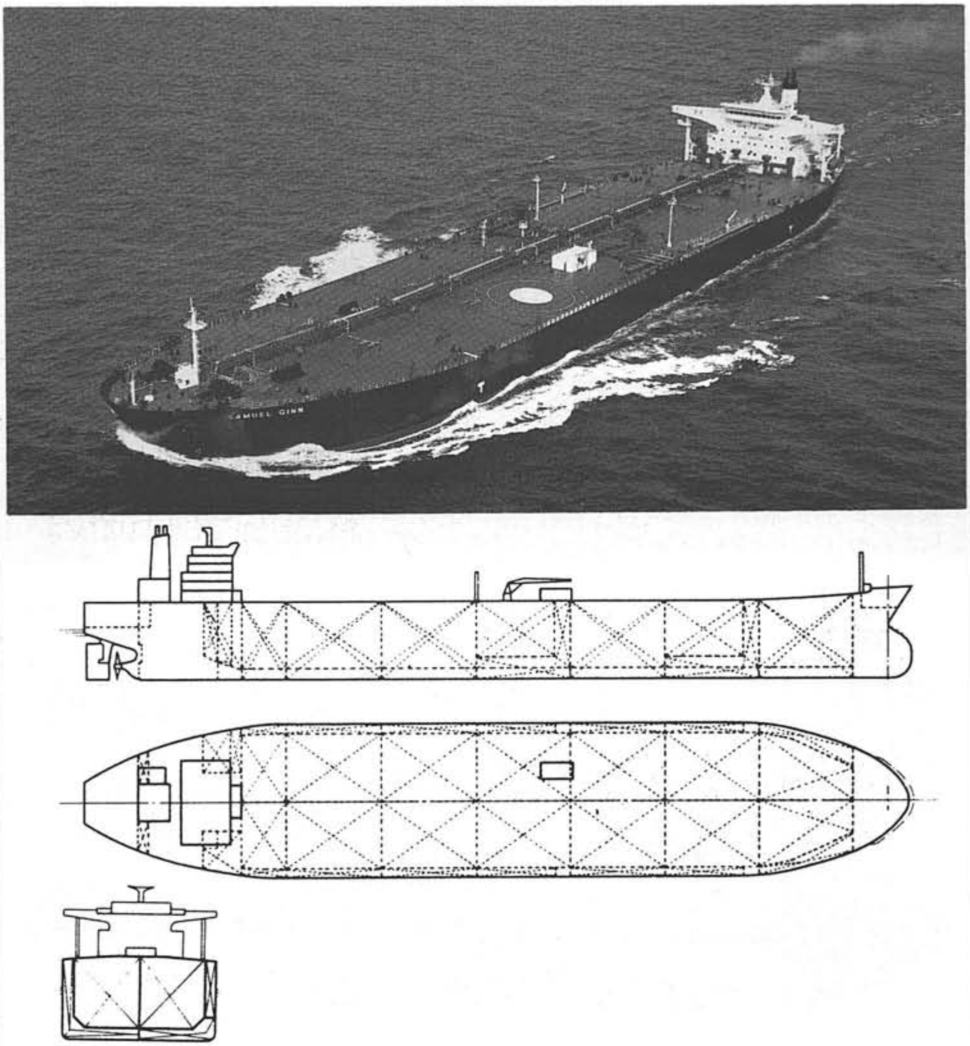
Principal particulars

Length, oa	241.44	m	Deadweight	102,352	t
Length, bp	230.00	m	Main propulsion	B&W 7360WC	
Breadth	42.00	m	Output (MCR)	14,900	PS
Depth	21.00	m	Trial speed	15.87	kn.
Draught	14.57	m	Cargo capacity	120,952	m^3
Gross tonnage	55,962	gt			

Source: Shipbuilding and Marine Engineering in Japan 1995

Figure 1: Aframax crude oil tanker *Neptune Auriga*

SAMUEL GINN



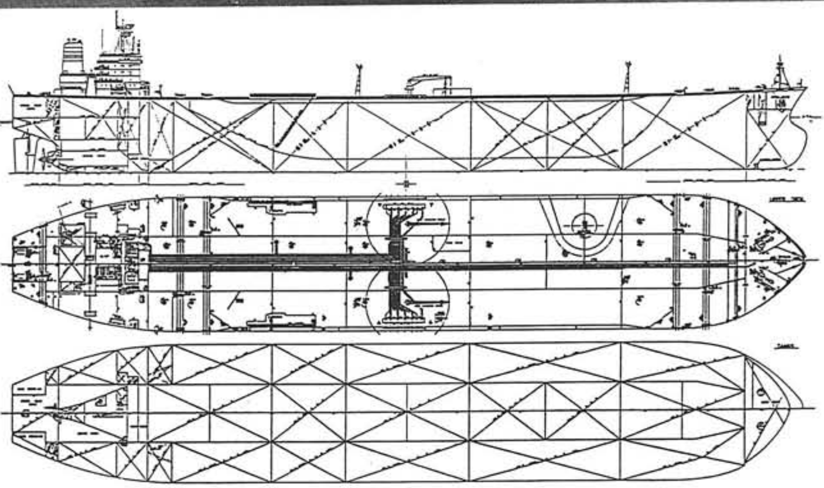
Principal particulars

Length, oa	274.50	m	Deadweight	156,835	t
Length, bp	261.00	m	Main propulsion	DU-Sulzer 6RTA72	
Breadth	50.00	m	Output (MCR)	21,200	PS
Depth	25.10	m	Trial speed	17.22	kn.
Draught	17.18	m	Cargo capacity	183,400	m^3
Gross tonnage	88,919	gt			

Source: Shipbuilding and Marine Engineering in Japan 1995

Figure 2: Suezmax crude oil tanker *Samuel Ginn*

TARIM



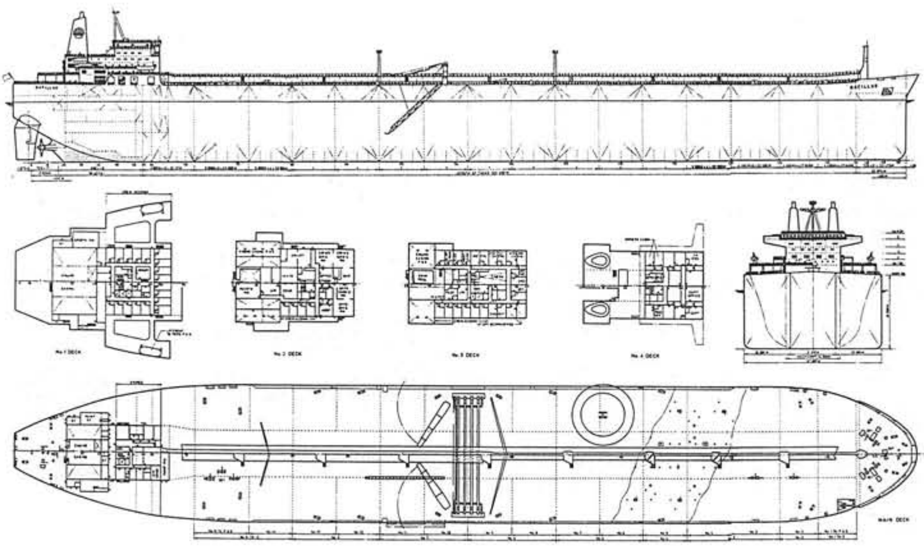
Principal particulars

Length, oa	328.05	m	Deadweight	300,364	t
Length, bp	315.00	m	Main propulsion	B&W 7S80MC	
Breadth	57.00	m	Output (MCR)	28,900	PS
Depth	30,80	m	Trial speed	16.00	kn.
Draught	22.15	m	Cargo capacity	330,716	m^3
Gross tonnage	156,837	gt			

Source: Shipbuilding and Marine Engineering in Japan 1995

Figure 3: Very Large Crude Carrier *Tarim*

BATILLUS



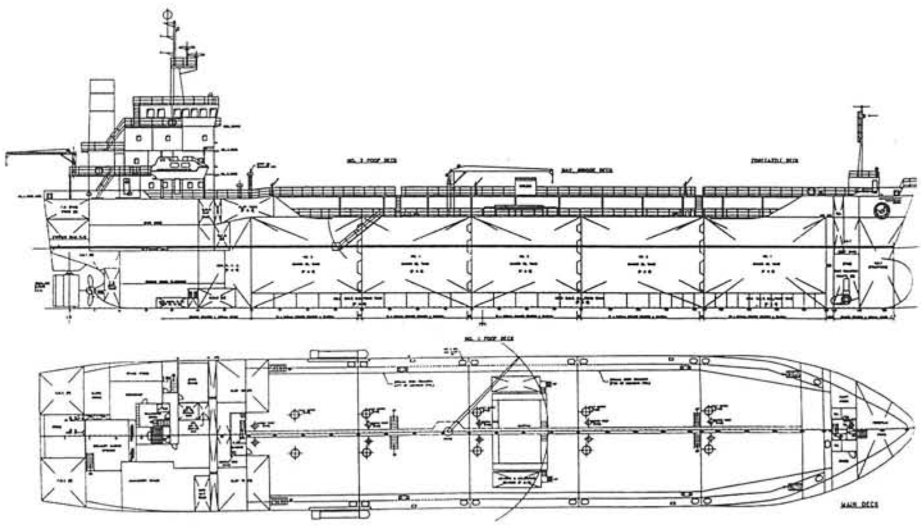
Principal particulars

Length, oa	414.22	m	Gross tonnage	274,000	gt
Length, bp	401.08	m	Deadweight	553,662	t
Breadth	63,00	m	Machinery output	47,650	kW
Depth	35,90	m	Service speed	16.70	kn.
Draught	28,60	m	Cargo capacity	667,300	m^3

Source: Shipping world & Shipbuilder july 1976

Figure 4: Ultra Large Crude Carrier *Batillus*

STEERSMAN



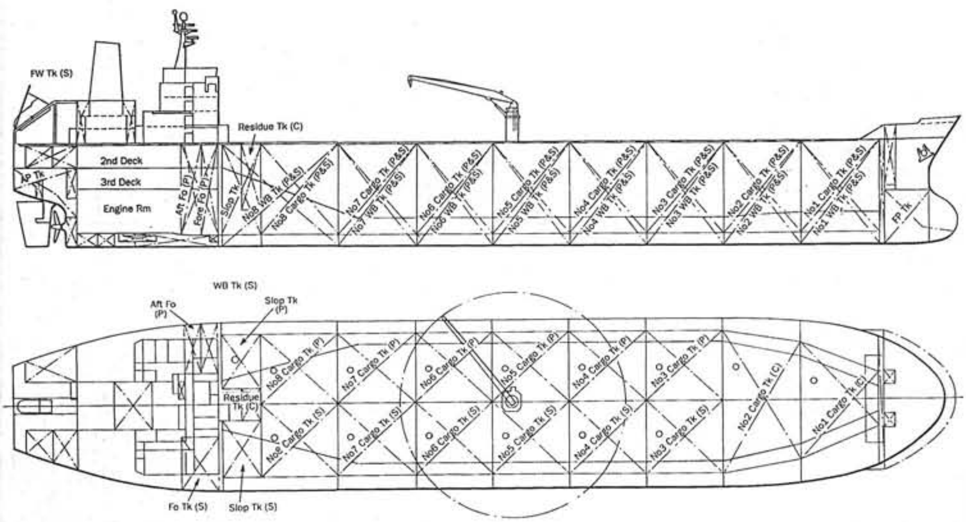
Principal particulars

Length, oa	101.60	m	Main propulsion	Mirrlees Blakstone ESL16 MkII	
Length, bp	95.64	m			
Breadth	17.50	m	Output	2,610	kW
Draught	6.85	m	Speed	12.5	kn.
Gross tonnage	4,842	gt	Fuel consumption	12.5	t/d
Net tonnage	1,808	nt	Range	9,000	NM
Deadweight	6,416	t	Cargo capacity (at 98%)	8,280	m^3

Source: The motorship, may 1995

Figure 5: Small products tanker *Steersman*

TORM ALICE



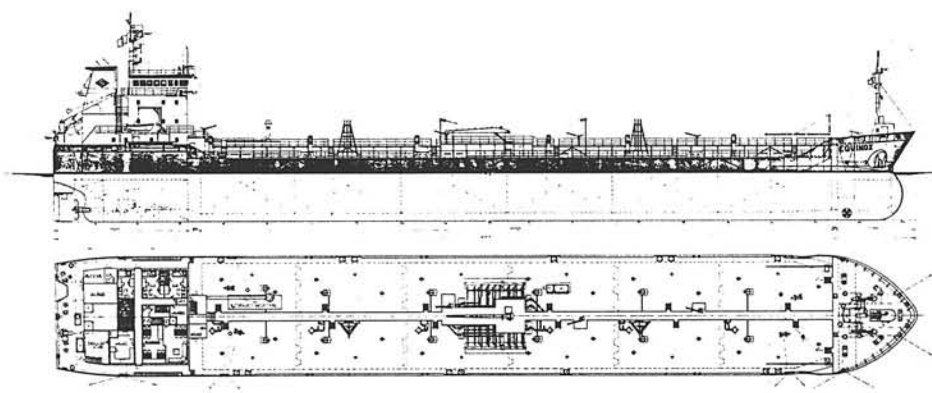
Principal particulars

Length, oa	182.84	m	Main propulsion	MAN-B&W 6S50MC	
Length, bp	172.00	m	Output	8,560	kW
Breadth	32.20	m	Trial speed	16.4	kn.
Depth	19.21	m	Range	16,500	nm
Draught (design)	11.50	m	Cargo capacity	53,750	m^3
Deadweight	41,143	t			

Source: The Motor Ship, August 1995

Figure 6: Products tanker *Torm Alice*

EQUINOX



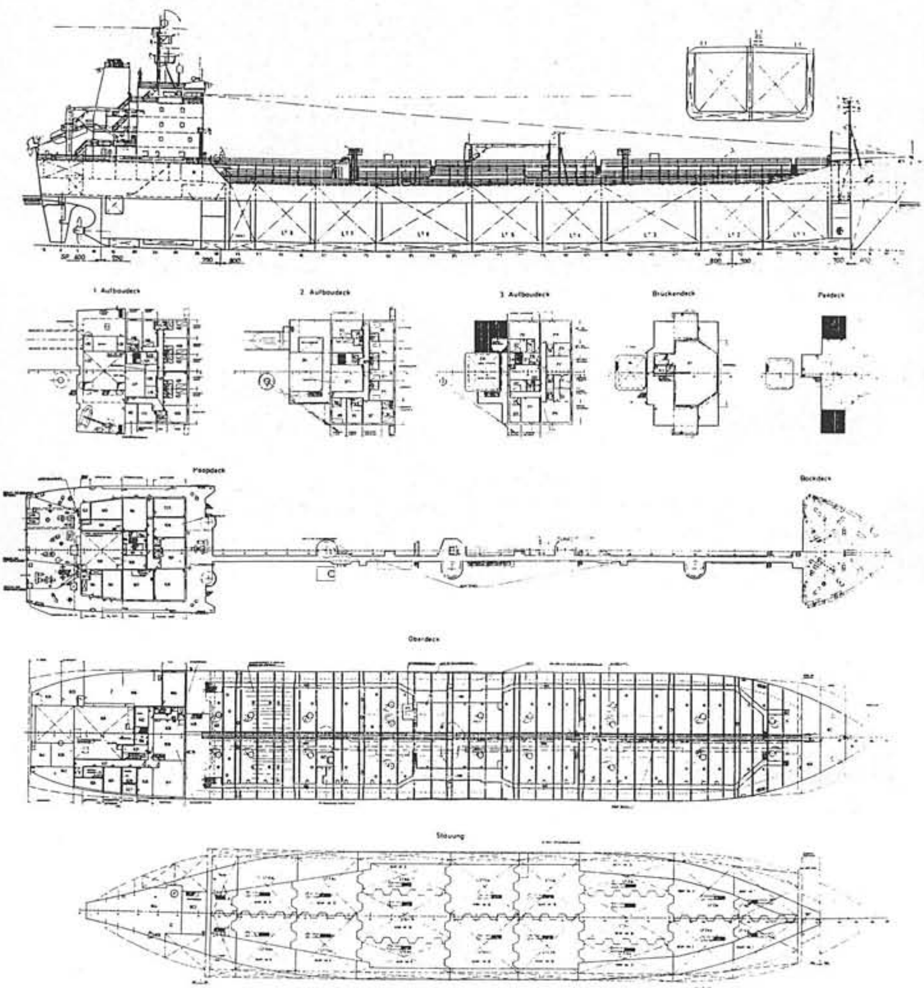
Principal particulars

Length, oa	122.81 m	Deadweight	9,500 t
Length, bp	117.71 m	Main propulsion	MAK 8M453C
Breadth	16.70 m	Output	2,940 kW
Depth	8.95 m	Cargo capacity	10,090 m^3
Draught	6.77 m		

Source: HSB International May 1993

Figure 7: Small chemical tanker *Equinox*

RHEINSTERN



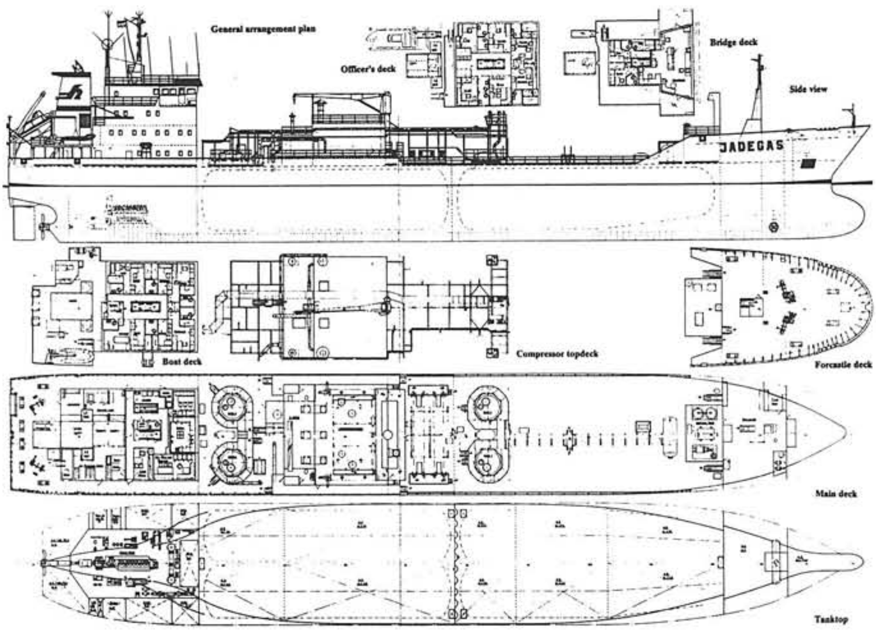
Principal particulars

Length, oa	161.36	m	Deadweight	17,000	t
Length, bp	153.00	m	Main propulsion	MAN B&W 7L20/27	
Breadth	23.00	m	Output	6,600	kW
Depth	11.70	m	Speed (90% MCR)	15.7	kn
Draught	8.60	m	Cargo capacity	20,340	m^3
			Range	8,000	nm

Source: HSB International May 1993

Figure 8: Chemical tanker *Rheinstern*

JADEGAS



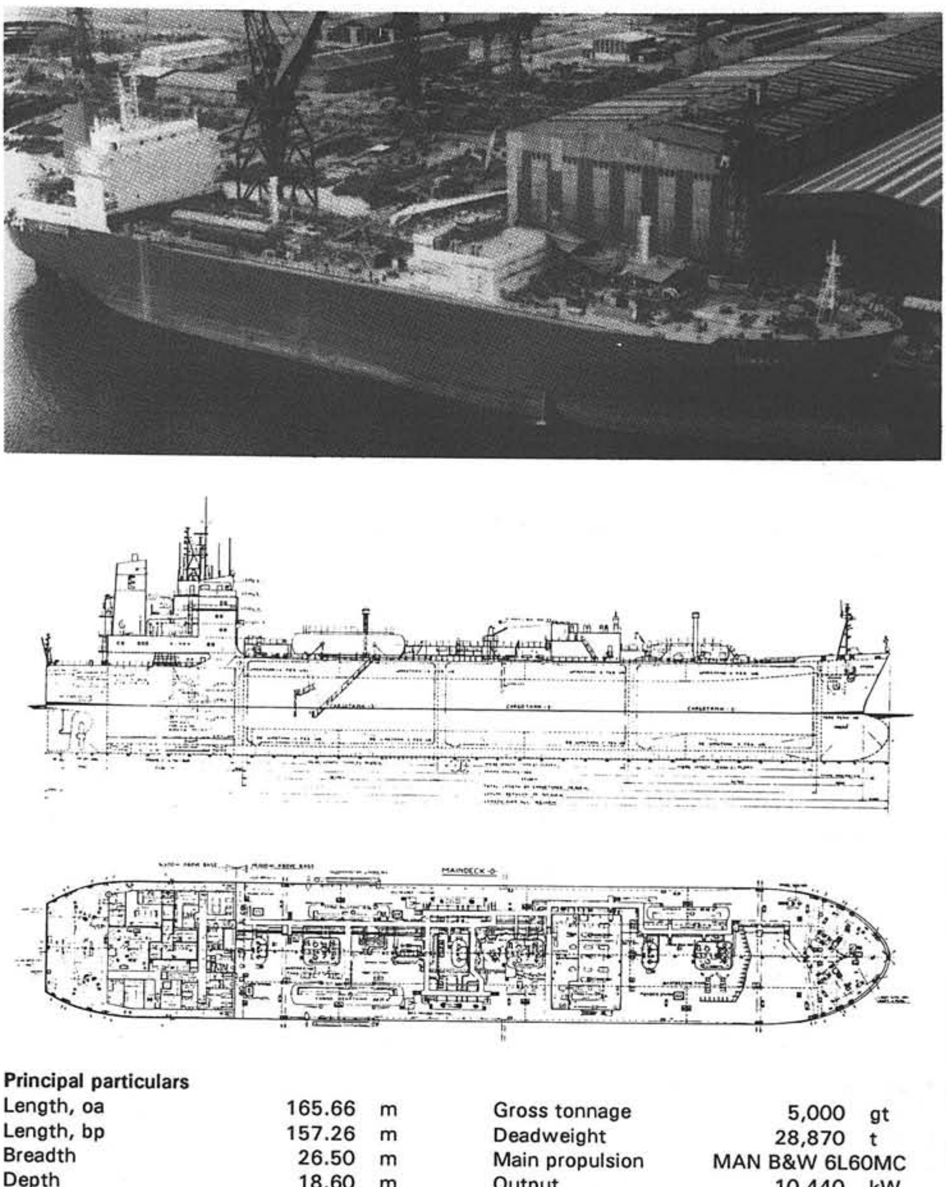
Principal particulars

Length, oa	113.00	m	Deadweight	5,945	t
Length, bp	105.30	m	Main propulsion	MaK 9M453C	
Breadth	15.90	m	Output	3,300	kW
Depth	9.70	m	Speed (LPG service)	14.00	kn
Draught (VCM, max)	7.00	m	Cargo capacity	5,200	m^3
Gross tonnage	5,000	gt			

Source: Hansa 1993 nr. 1

Figure 9: Gas tanker *Jadegas*

SOMBEKE



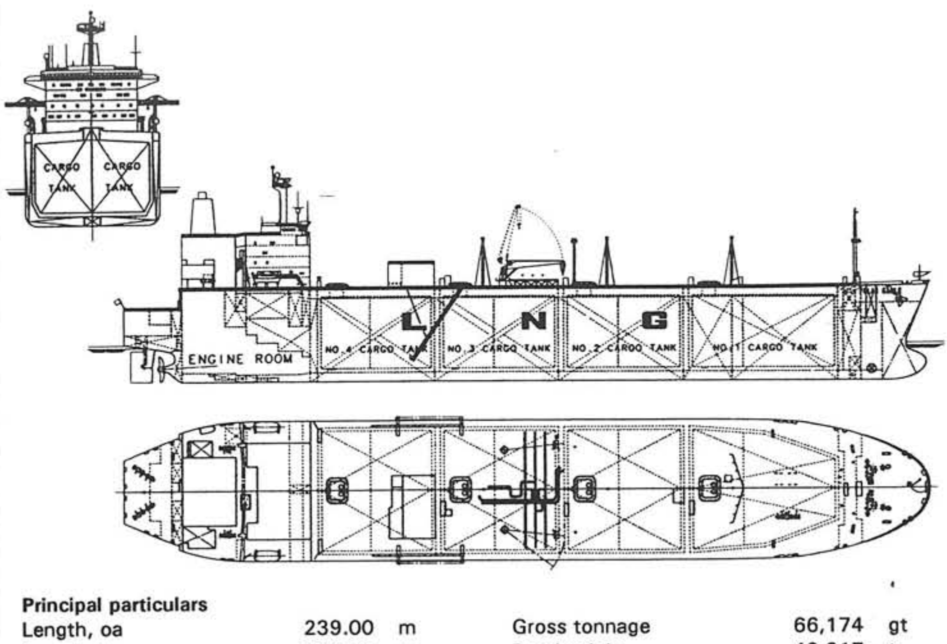
Principal particulars

Length, oa	165.66	m	Gross tonnage	5,000	gt
Length, bp	157.26	m	Deadweight	28,870	t
Breadth	26.50	m	Main propulsion	MAN B&W 6L60MC	
Depth	18.60	m	Output	10,440	kW
Draught (VCM, max)	11.88	m	Cargo capacity	33,619	m^3

Source: HSB International 91-11

Figure 10: Large LPG Carrier *Sombeke*

POLAR EAGLE



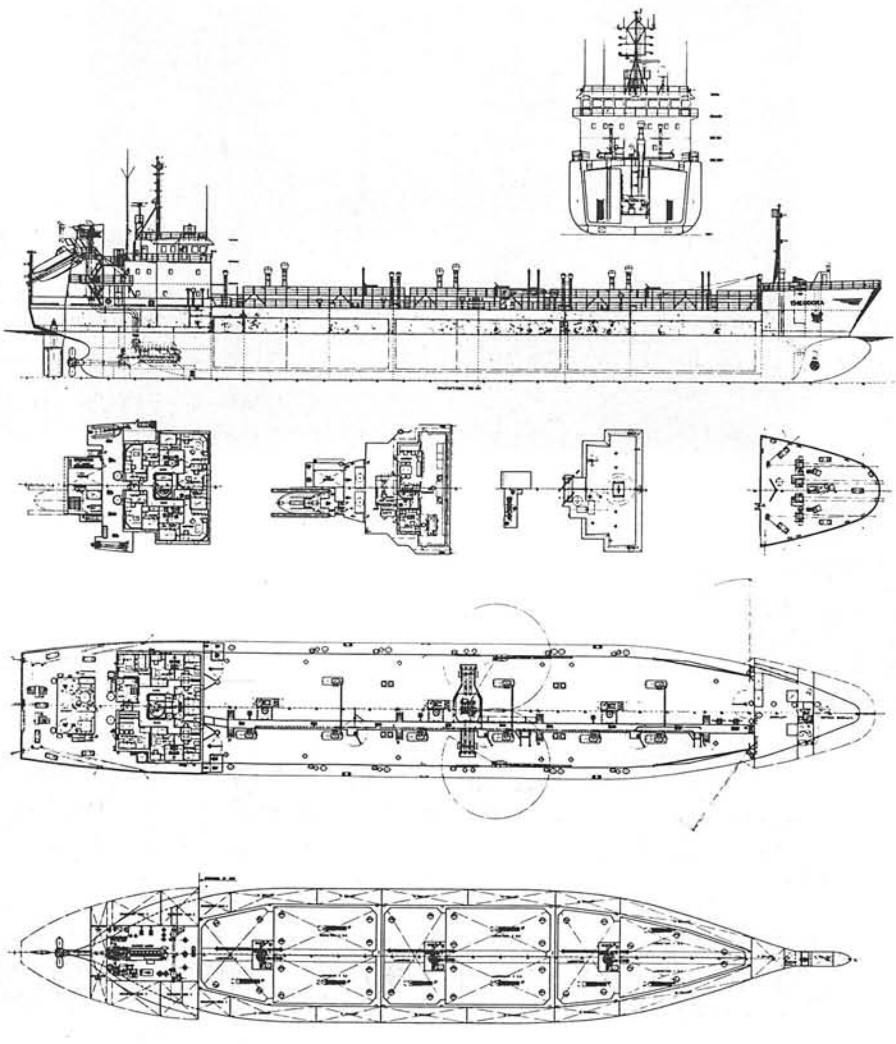
Principal particulars

Length, oa	239.00	m	Gross tonnage	66,174	gt
Length, bp	226.00	m	Deadweight	48,817	t
Breadth	40.00	m	Main engine output (MCR)	21,000	PS
Depth	26.80	m	Speed	18.5	kn
Draught (VCM, max)	10.10	m	Cargo capacity	89,880	m^3

Source: Shipbuilding and Marine Engineering in Japan 1995

Figure 11: LNG Carrier *Polar Eagle*

THEODORA



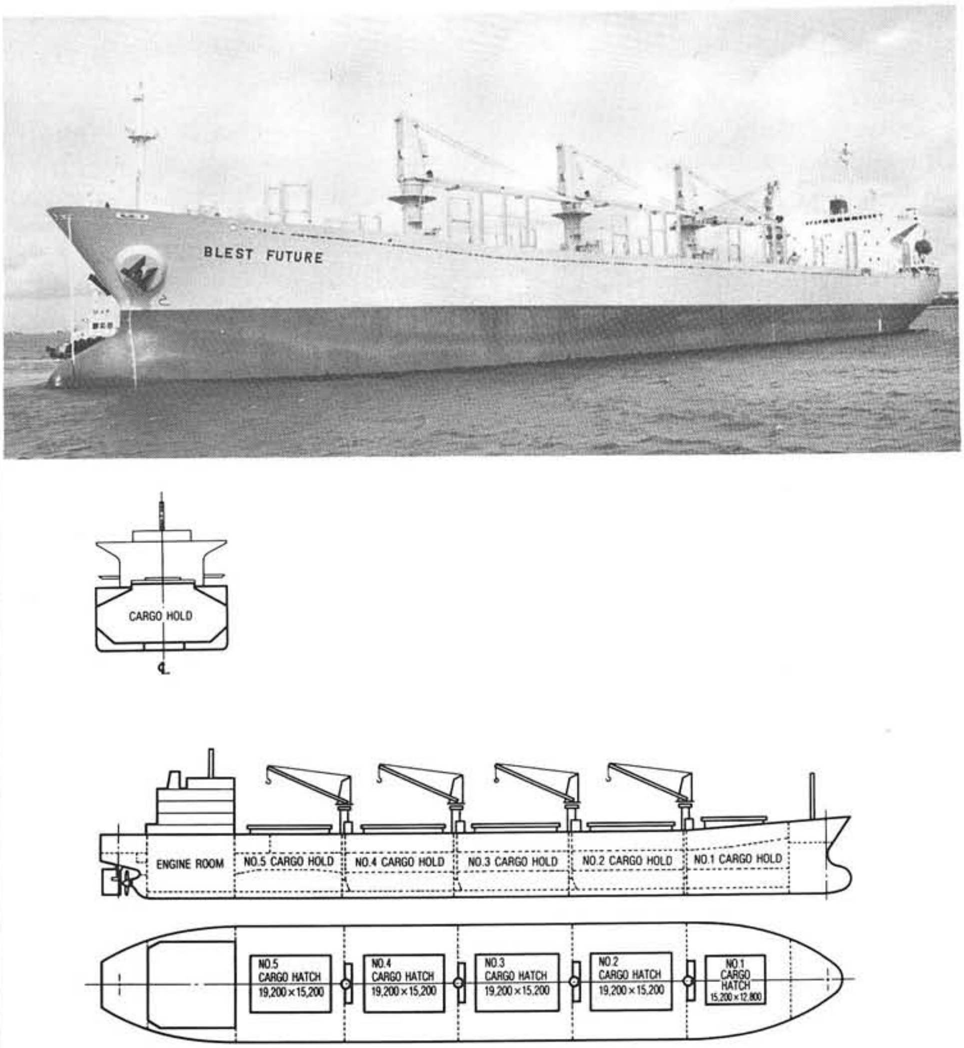
Principal particulars

Length, oa	110.60 m	Gross tonnage	4,000 gt
Length, bp	103.00 m	Deadweight	5,200 t
Breadth	17.00 m	Main propulsion	SWD 8R32E
Depth	9.36 m	Output	3,000 kW
Draught	7.00 m	Cargo capacity	5,245 m^3

Source: HSB International April 1991

Figure 12: Bitumen/pitch tanker *Theodora*

FUTURA



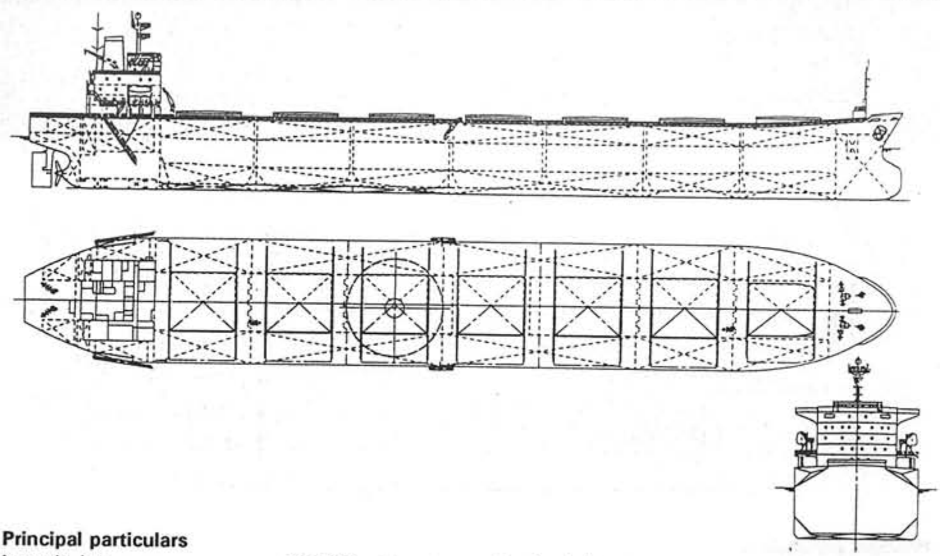
Principal particulars

Length, oa	180.80	m	Deadweight	33,433	t
Length, bp	171.00	m	Main propulsion	DU-Sulzer 6RTA52	
Breadth	30.50	m	Output (MCR)	7,900	PS
Depth	15.30	m	Cargo capacity	46,112	m^3
Draught, design	9.75	m			

Source: Shipbuilding and Marine Engineering in Japan 1995

Figure 13: Handysize bulk carrier *Futura*

ROYAL PILOT



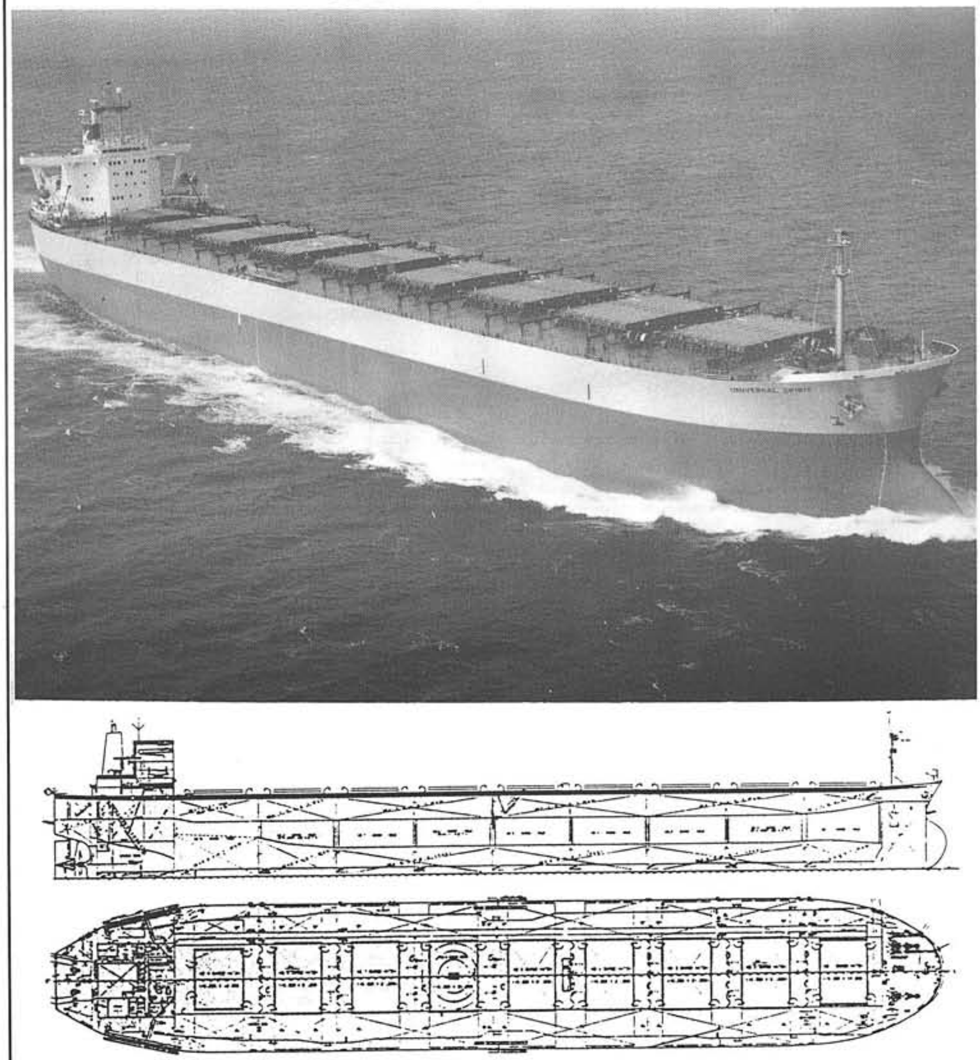
Principal particulars

Length, bp	217.00	m	Deadweight	70165	t
Breadth	30.50	m	Main propulsion	DU-Sulzer 6RTA62	
Depth	18.30	m	Output (MCR)	10,500	PS
Draught, design	13.27	m	Service speed	14.00	kn
Gross tonnage	36,559	gt	Cargo capacity	81,839	m^3

Source: Shipbuilding and Marine Engineering in Japan 1995

Figure 14: Panamax bulk carrier *Royal Pilot*

UNIVERSAL SPIRIT



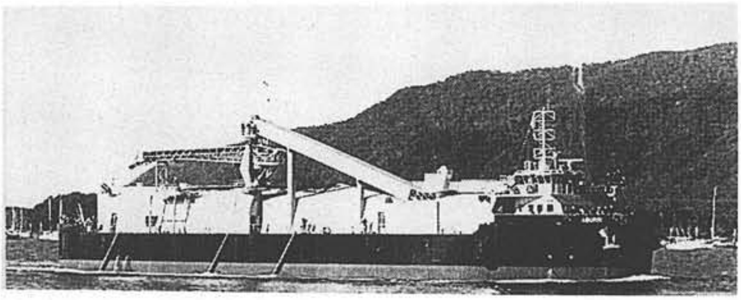
Principal particulars

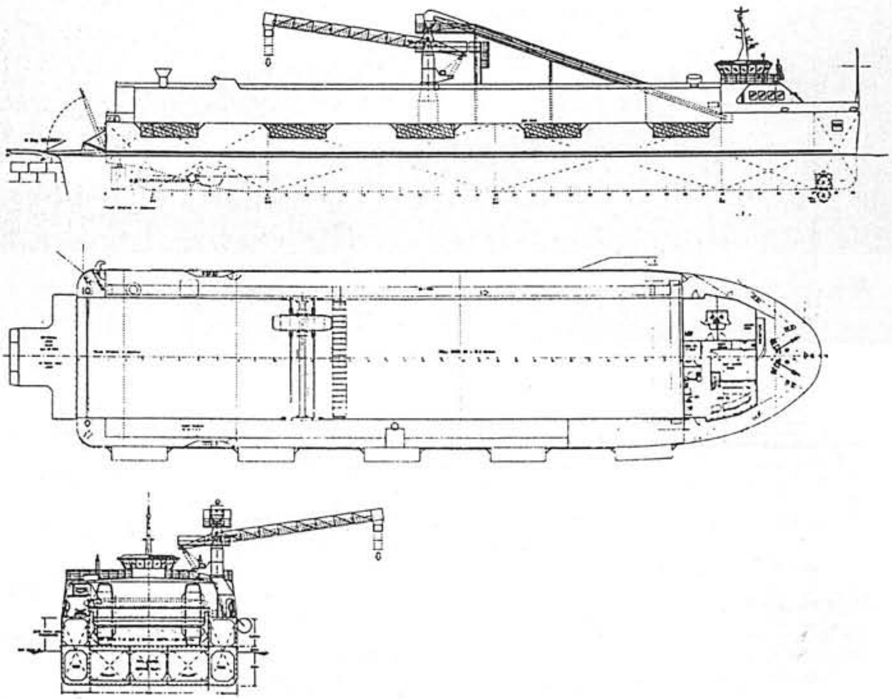
Length, oa	273.00	m	Gross tonnage	77,503	gt
Length, bp	260.00	m	Deadweight	150,966	t
Breadth	43.00	m	Main propulsion	MAN B&W 6S70MC	
Depth	23.90	m	Output (MCR)	17,760	PS
Draught, design	17.40	m	Cargo capacity	167,883	m^3

Source: Shipbuilding and Marine Engineering in Japan 1995

Figure 15: Capesize bulk carrier *Universal spirit*

ABURRI





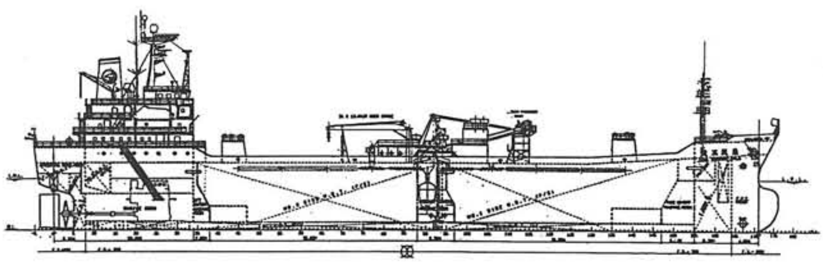
Principal particulars

Length, bp	79.50 m		Main propulsion	2 * Caterpillar 3512
Breadth	18.50 m		Output	671 kW
Draught	3.50 m		Service speed	10.00 kn
Gross tonnage	1,200 gt		Range	4,000 nm
Deadweight	3,150 t			

Source: Work boat world, September 1995

Figure 16: Self-discharging ore-carrier *Aburri*

ASIA CEMENT NO. 5



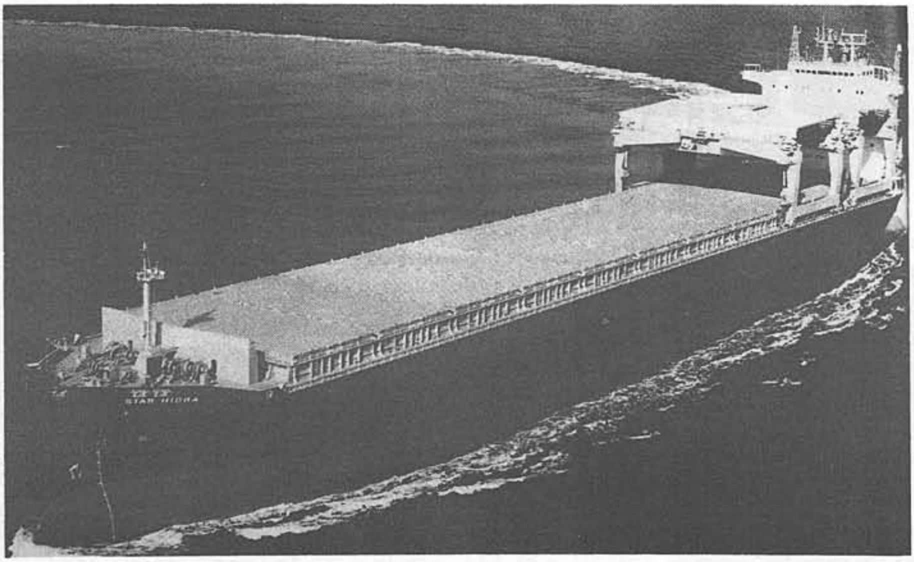
Principal particulars

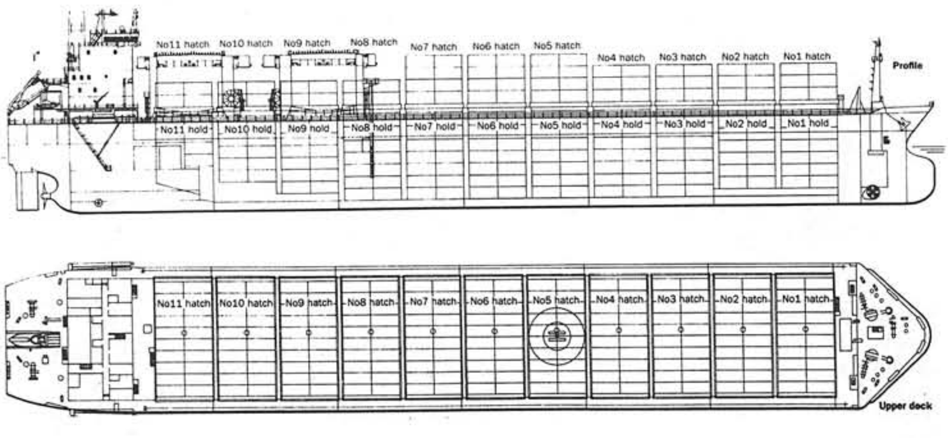
Length, oa	125.53	m	Gross tonnage	7,608	gt
Length, bp	119.00	m	Deadweight	12,340	t
Breadth	20.20	m	Main propulsion	B&W 6L42MC	
Depth	11.10	m	Output (MCR)	5,800	PS
Draught	8.58	m	Trial speed	16.84	kn

Source: Shipbuilding and Marine Engineering in Japan 1995

Figure 17: Cement carrier *Asia Cement No. 5*

STAR HIDRA





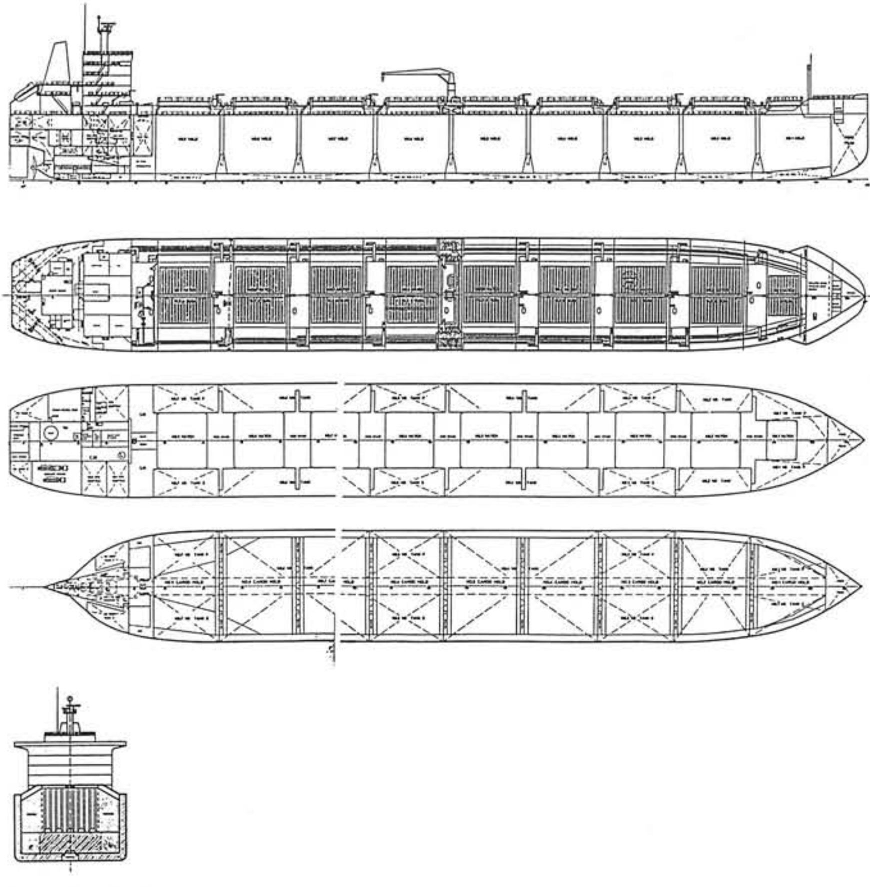
Principal particulars

Length, oa	199.90	m	Deadweight	45,000	t
Length, bp	190.00	m	Main propulsion	MAN B&W 6S60MC	
Breadth	31.00	m	Output (MCR)	11,470	kW
Depth	19.00	m	Service speed	16.00	kn
Draught	12.00	m			

Source: The Motor Ship, April 1995

Figure 18: Open hatch forest products carrier *Star Hidra*

SIBOHELLE



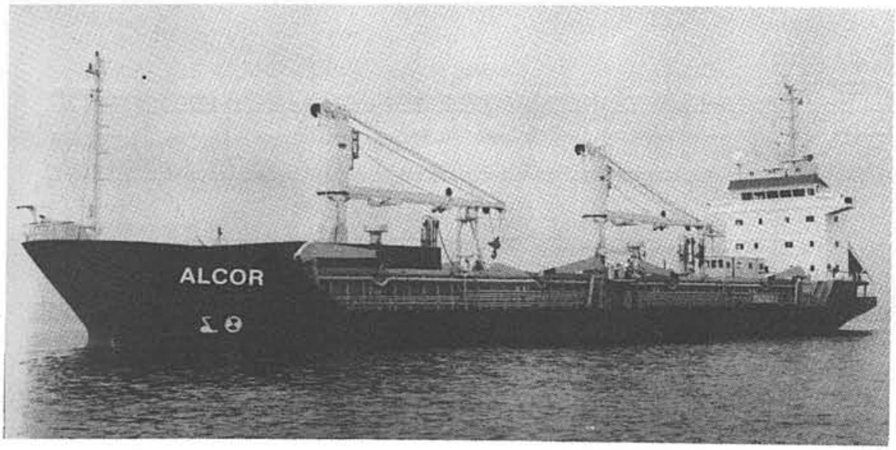
Principal particulars

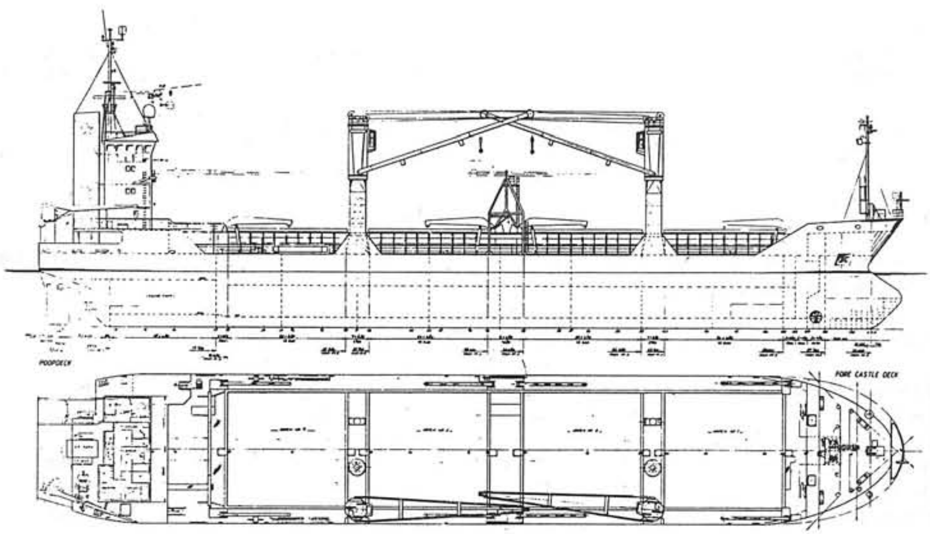
Length, oa	246.88	m	Gross tonnage	45,593	gt
Length, bp	242.88	m	Deadweight	66,715	t
Breadth	32.24	m	Main propulsion	MAN B&W 5 S60MC	
Depth	19.00	m	Output (MCR)	9,340	kW
Draught	12.50	m	Speed (77.5% MCR)	14.00	kn

Source: Significant Ships of 1993

Figure 19: Ore-Bulk-Oil carrier (OBO) *Sibohelle*

ALCOR





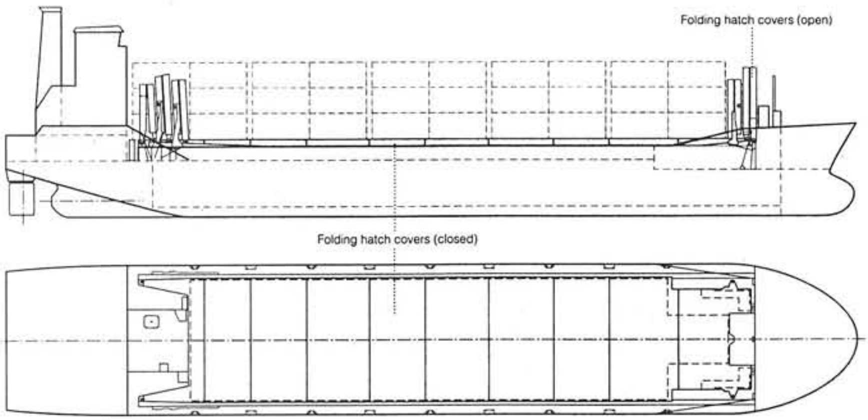
Principal particulars

Length, oa	99.80	m	Deadweight	6,000	t
Length, bp	93.00	m	Main propulsion	Bergen Diesel BRM 8	
Breadth	17.00	m	Output (MCR)	3,235	kW
Depth	8.50	m	Service speed	12.0	kn
Draught	6.53	m			

Source: HSB International, 10-1991

Figure 20: COB carrier *Alcor*

MUUGA



Principal particulars

Length, oa	90.67	m	Deadweight	3,284	t
Length, bp	84.95	m	Main propulsion	Wärtsila 8R32E	
Breadth	15.80	m	Output (MCR)	3,280	kW
Depth	5.80	m	Trial speed	14.4	kn
Draught	4.63	m	Container capacity (TEU)	266	
Gross tonnage	2,568	grt			

Source: HSB International July/August 1995

Figure 21: Feeder container ship *MUUGA*

NANTAI VENUS

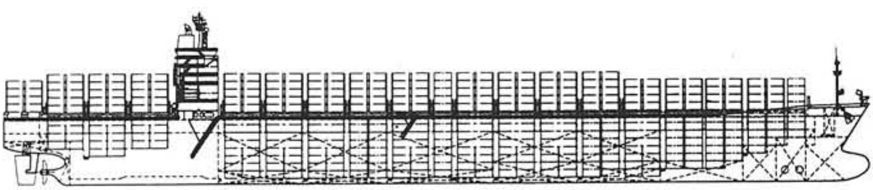
Principal particulars

Length, oa	182.89	m	Deadweight	24,046	t
Length, bp	172.00	m	Main propulsion	B&W 6S60MC	
Breadth	27.60	m	Output (MCR)	16,680	PS
Depth	14.00	m	Trial speed	21.82	kn
Draught	10.10	m	Container capacity (TEU)	1,391	
Gross tonnage	15,749	gt			

Source: Shipbuilding and Marine Engineering in Japan 1995

Figure 22: Container ship *Nantai Venus*

NYK ALTAIR



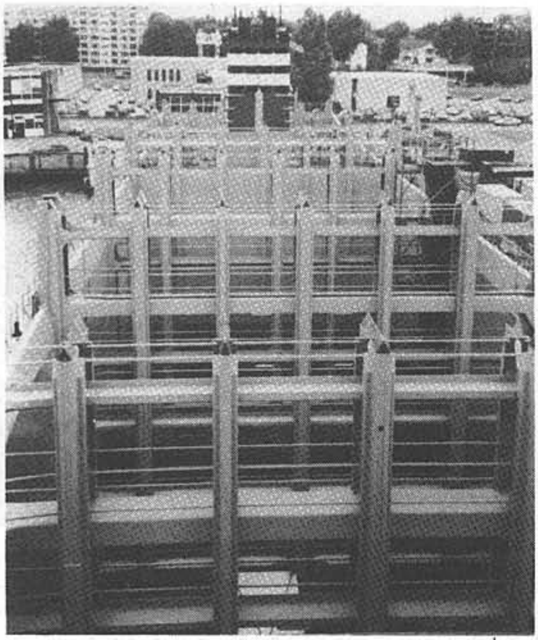
Principal particulars

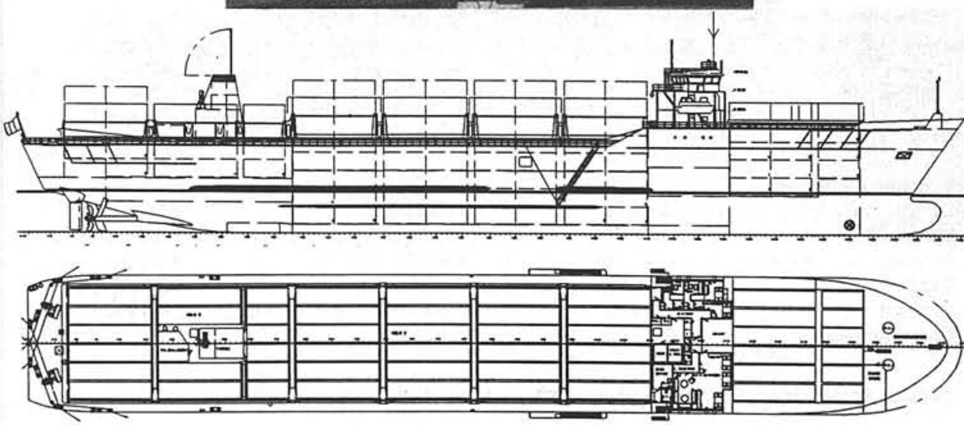
Length, oa	299.95	m	Deadweight	63,163	t
Length, bp	283.00	m	Main propulsion	DU-Sulzer 12RTA84C	
Breadth	37.10	m	Output (MCR)	43,620	kW
Depth	21.80	m	Trial speed	27.06	kn
Draught	13.00	m	Container capacity (TEU)	4,743	
Gross tonnage	60,117	t			

Source: Shipbuilding and Marine Engineering in Japan 1995

Figure 23: Post Panamax container ship *Nyk Altair*

REESTBORG





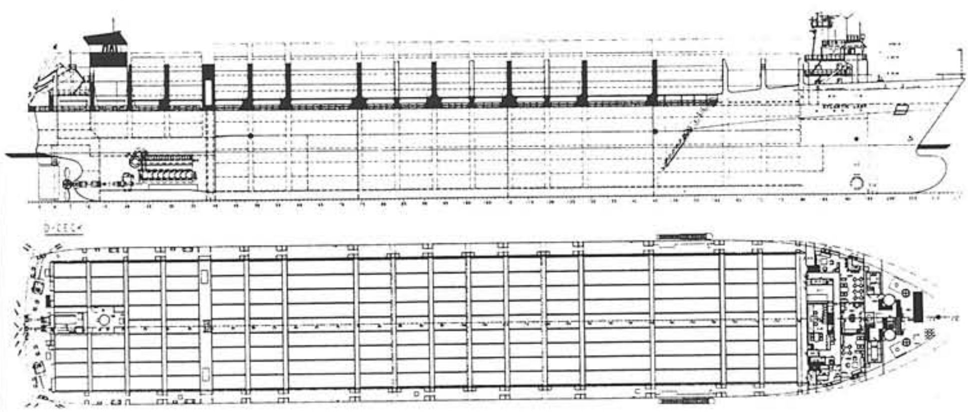
Principal particulars

Length, oa	139.95 m		Deadweight	7,285	t
Length, bp	123.55 m		Main propulsion	Ulstein Bergen BRM-8	
Breadth	20.00 m		Output (MCR)	3,530	kW
Depth	12.60 m		Speed	17.50	kn
Draught	6.30 m		Container capacity (TEU)	588	

Source: HSB International, September 1994

Figure 24: Small open hatch container ship *Reestborg*

EUROPEAN EXPRESS



Principal particulars

Length, oa	173.62	m	Deadweight	20,380 t
Length, bp	160.00	m	Main propulsion	Stork Wärtsilä 8TM20
Breadth	28.80	m	Output (MCR)	9,830 kW
Depth	16.80	m	Container capacity (TEU)	1,472
Draught	8.00	m		

Source: HSB International, July/August 1993

Figure 25: Open hatch container ship *European Express*

NEDLLOYD HONGKONG

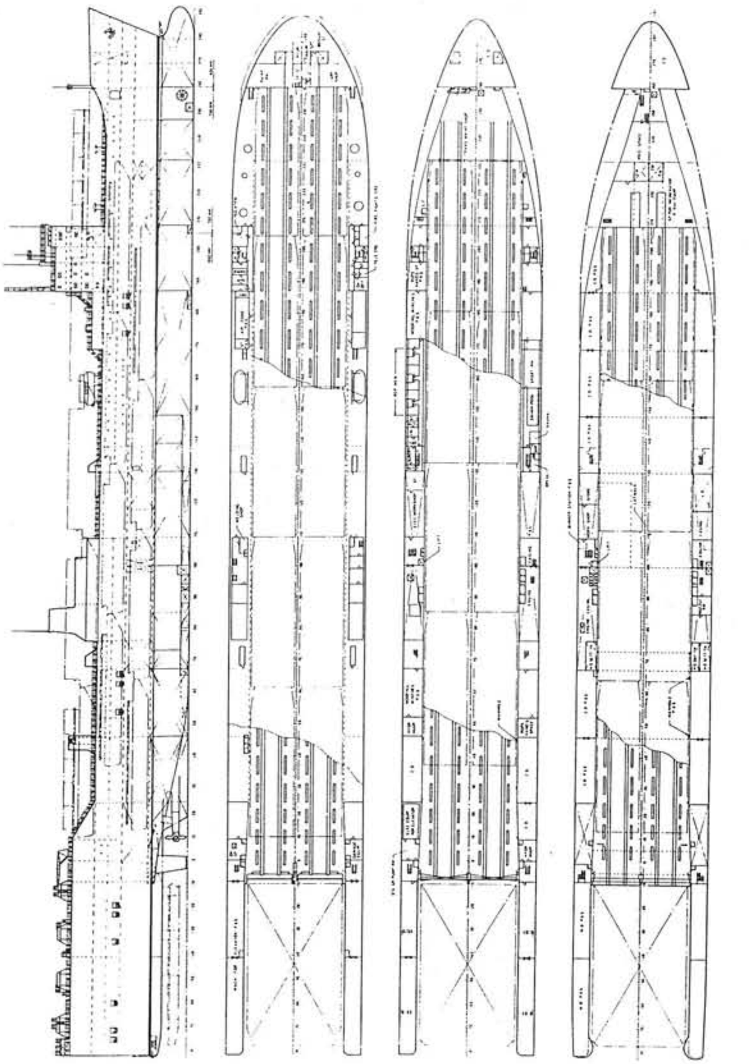
Principal particulars

Length, oa	279.12	m	Deadweight	51,151	t
Length, bp	265.00	m	Main propulsion	DU-Sulzer 12RTA84C	
Breadth	37.75	m	Output (MCR)	41,260	kW
Depth	23.25	m	Trial speed	25.82	kn
Draught	12.50	m	Container capacity (TEU)	4,112	
Gross tonnage	56,248	t			

Source: Shipbuilding and Marine Engineering in Japan 1995

Figure 26: Post Panamax open hatch container ship *NedLloyd Hongkong*

YULIUS FUCHIK

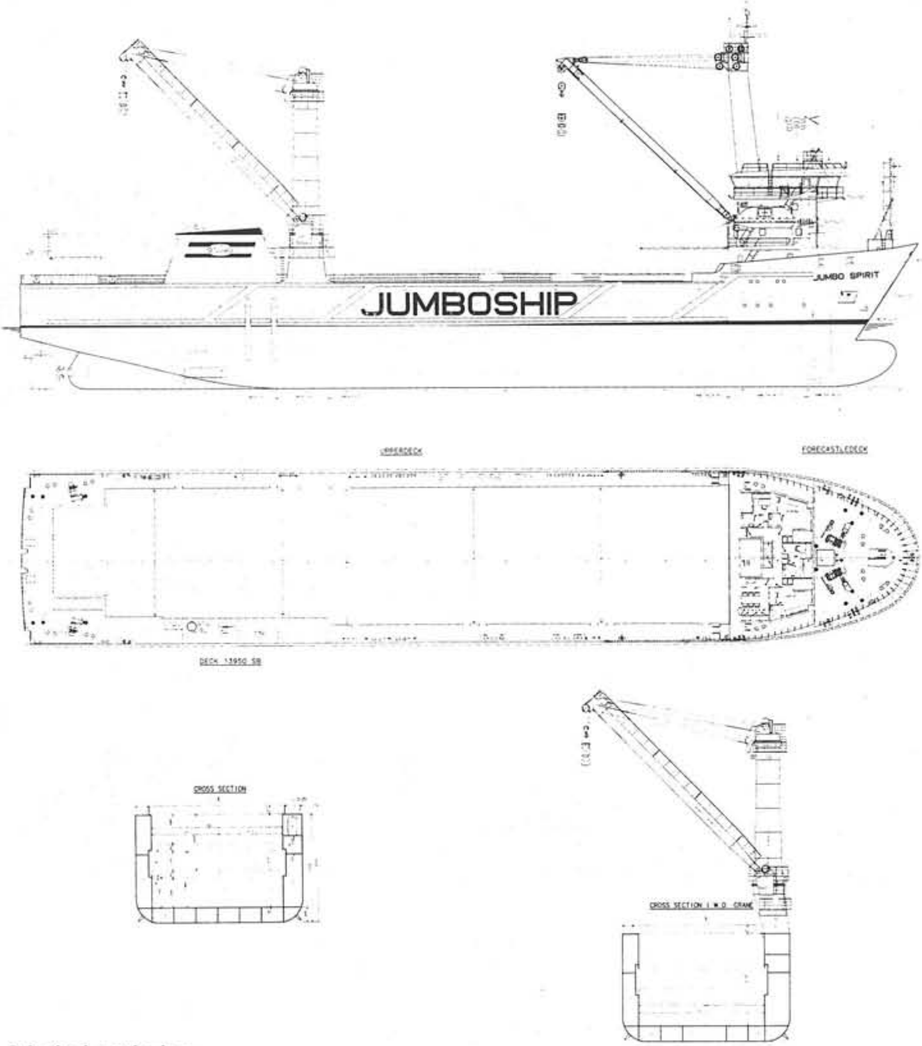


Principal particulars

Length, oa	226.44	m	Deadweight	37,850	t
Length, bp	222.81	m	Output	26,470	kW
Breadth	35.00	m	Speed	16.5	kn
Depth	22.95	m	Range	12,000	nm
Draught	11.00	m			

Figure 27: Barge carrier *Yulius Fuchik*

JUMBO SPIRIT



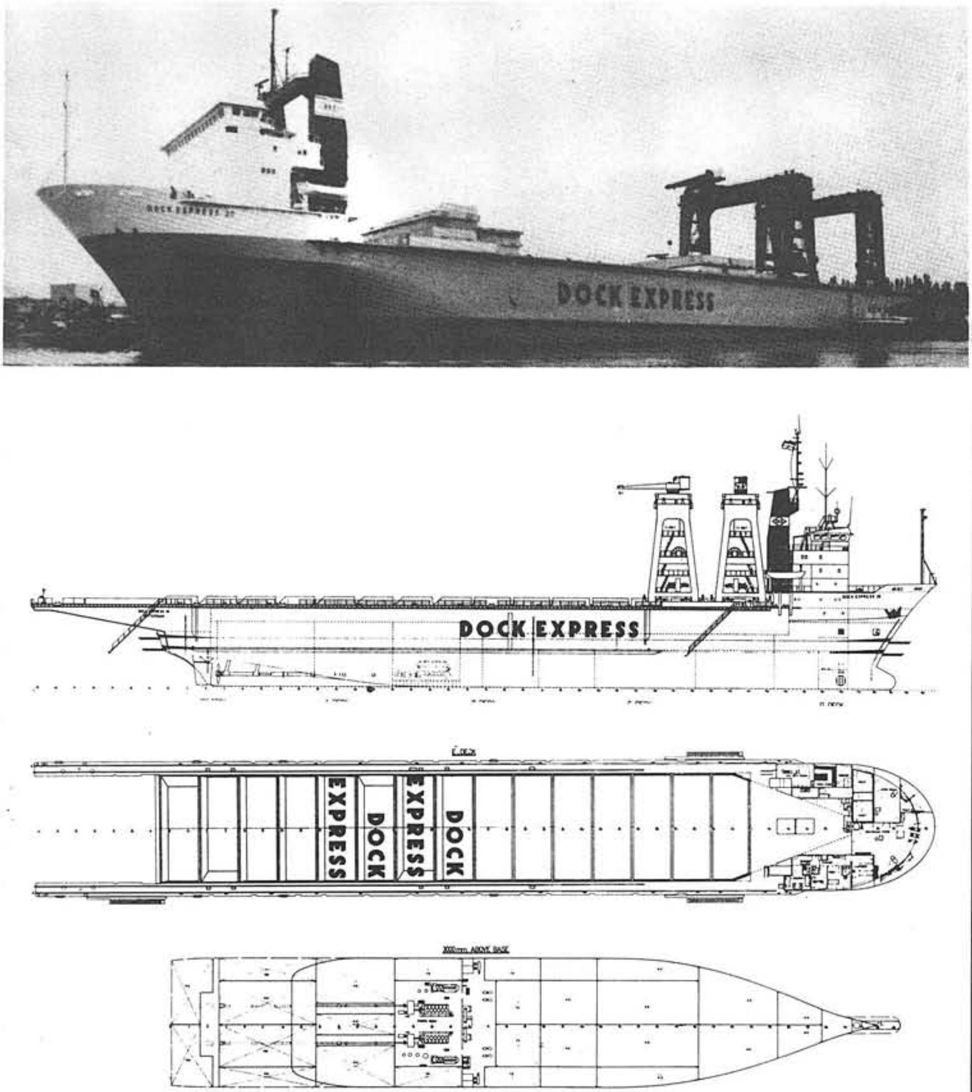
Principal particulars

Length, oa	95.60	m	Deadweight	5,200	t
Length, bp	87.55	m	Main propulsion	MaK 6M32	
Breadth	17.75	m	Output (MCR)	2,640	kW
Depth	11.32	m	Speed	18.5	kn
Draught	6.80	m	Hold capacity	7,280	m^3
Gross tonnage	4,300	gt			

Source: HSB International, April 1995

Figure 28: Heavy lift carrier *Jumbo Spirit*

DOCK EXPRESS 20



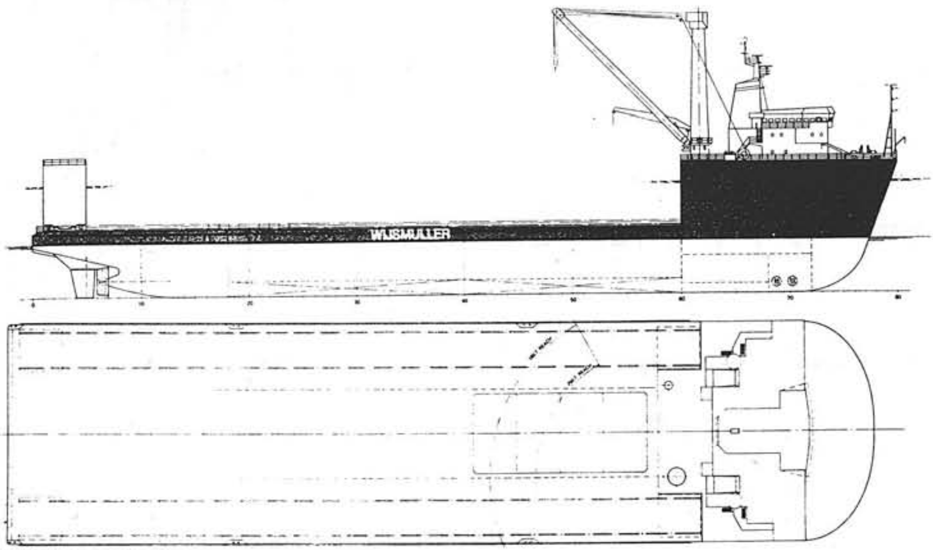
Principal particulars

Length, oa	169.52 m		Draught	6.50 m
Length, bp	126.50 m		Deadweight	9,700 t
Breadth	24.20 m		Main propulsion	Stork-Werkspoor 6TM410
Depth	15.00 m		Output (MCR)	6,250 kW

Source: Holland Shipbuilding, June 1983

Figure 29: Heavy lift carrier *Dock Express 20*

MIGHTY SERVANT 1



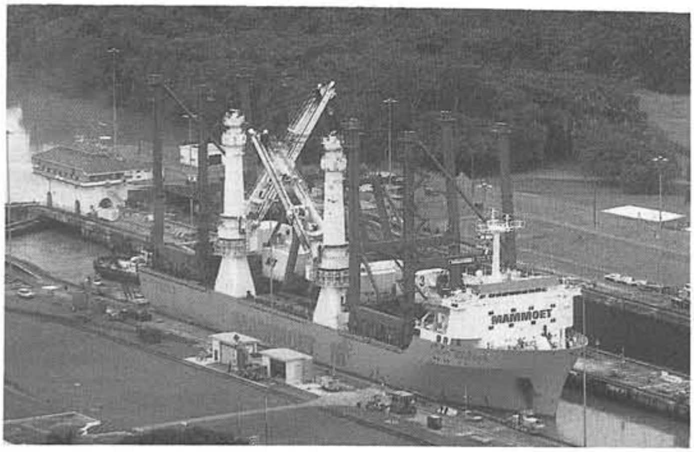
Principal particulars

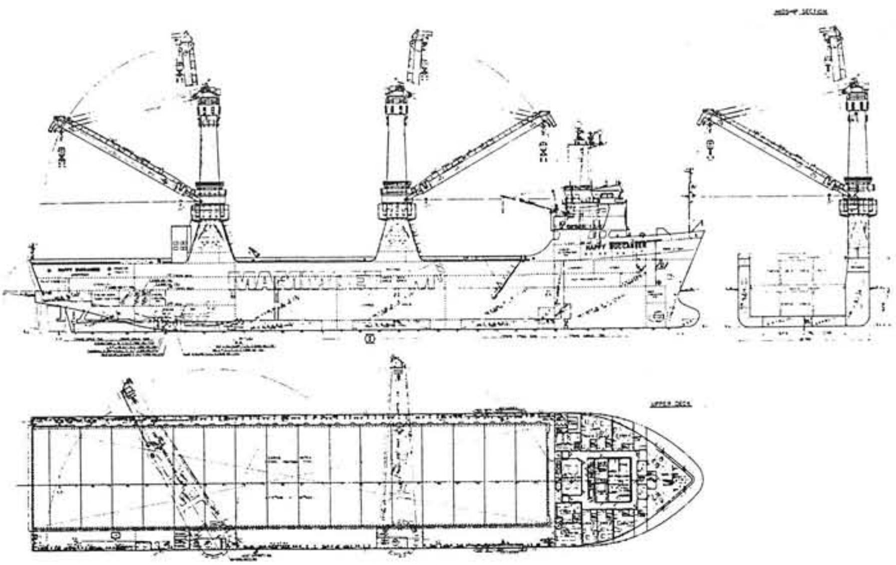
Length, oa	160.00	m	Gross tonnage	21,200	grt
Length, bp	144.70	m	Deadweight	23,800	t
Breadth	40.00	m	Main propulsion	2 * SWD 12TM410	
Depth	12.00	m	Output (MCR)	13,520	kW
Draught	9.50	m	Speed	14.7	kn

Source: Schip & Werf, nr 1 1983/The Motor Ship, Januari 1984

Figure 30: Heavy lift carrier *Mighty Servant 1*

HAPPY BUCCANEER





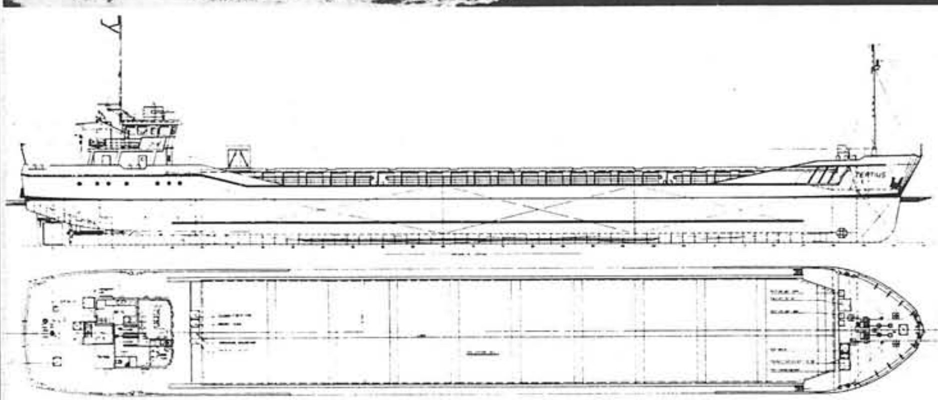
Principal particulars

Length, oa	145.70 m	Gross tonnage	16,341 gt
Length, bp	134.00 m	Deadweight	13,740 t
Breadth	28.30 m	Main propulsion	Sulzer 6ZAL40
Depth	14.80 m	Output	7,675 kW
Draught	8.20 m	Speed	15.5 kn

Source: Marine Industry, 10 - 1984

Figure 31: Heavy lift carrier *Happy Buccaneer*

TERTIUS



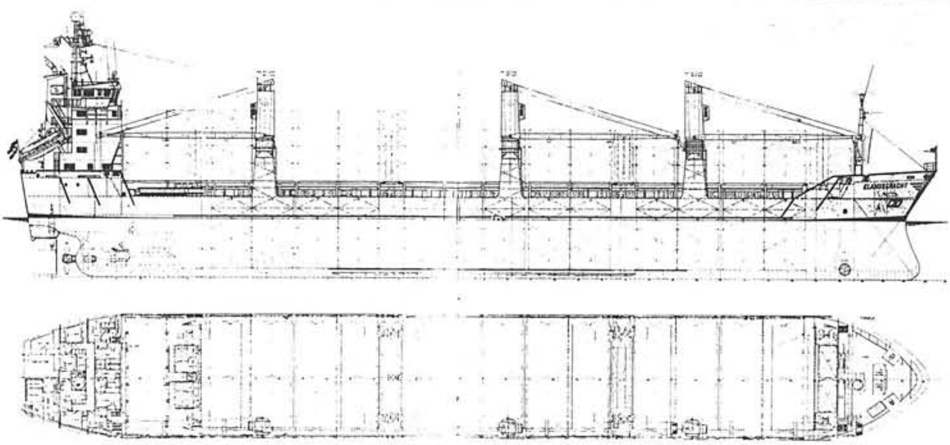
Principal particulars

Length, oa	89.99	m	Gross tonnage	1,999	t
Length, bp	84.99	m	Deadweight	3,270	t
Breadth	12.50	m	Main propulsion	MaK 8M20	
Depth	6.00	m	Output	750	kW
Draught	4.65	m	Trial speed	11.0	kn

Source: HSB International, April 1995

Figure 32: Multi-purpose ship *Tertius*

ERASMUSGRACHT



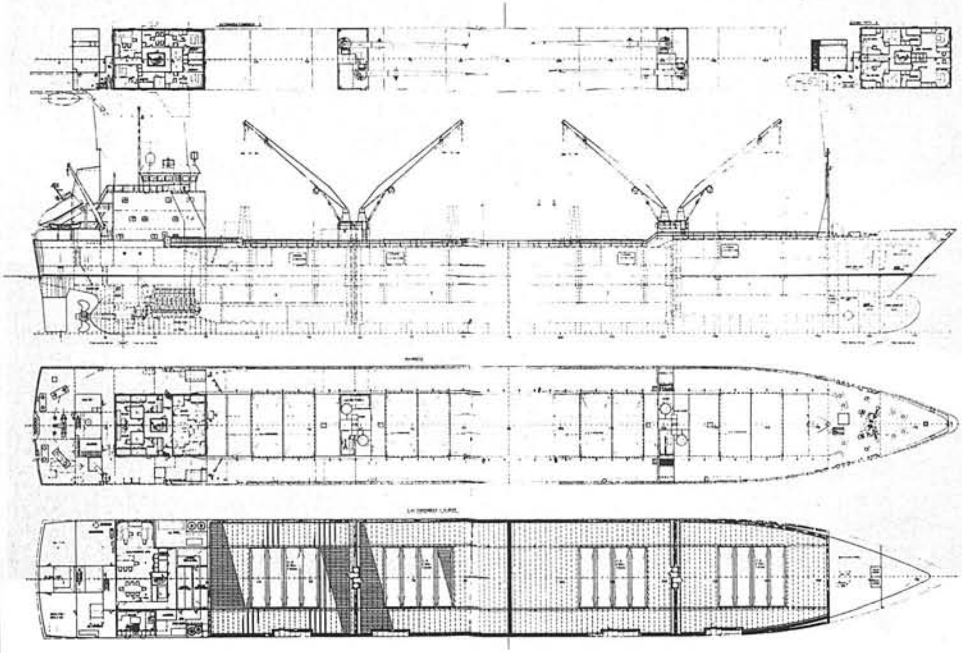
Principal particulars

Length, oa	136.34	m	Deadweight	12,750	t
Length, bp	127.14	m	Main propulsion	Wärtsila Diesel 6R46	
Breadth	18.90	m	Output	5,430	kW
Depth	11.65	m	Cargo capacity	15,771	m^3
Draught	8.51	m			

Source: Schip en Werf de Zee, December 1994

Figure 33: Multi-purpose ship *Erasmusgracht*

COOL EXPRESS



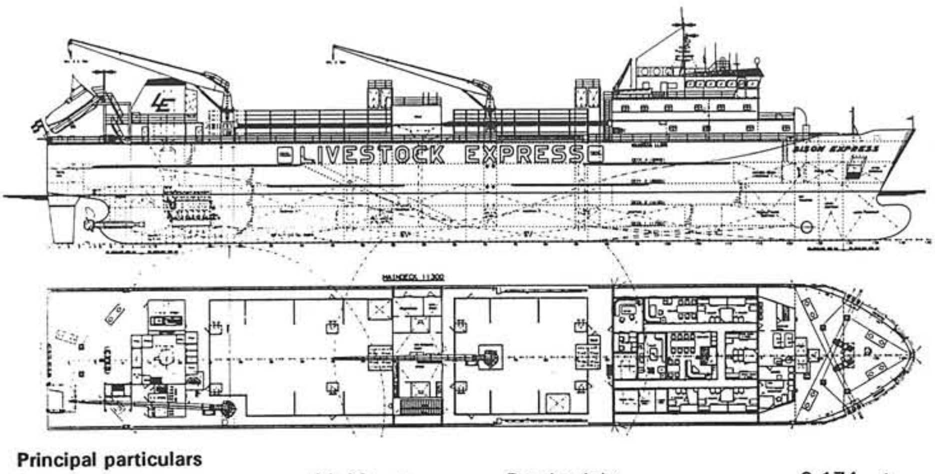
Principal particulars

Length, oa	126.29	m	Draught	8.00	m
Length, bp	116.25	m	Deadweight	7,455	t
Breadth	15.85	m	Service speed (T = 5.96)	18	kn
Depth	11.90	m	Cargo capacity	33,663	m^3

Source: Schip en Werf de Zee 10-1994

Figure 34: Reefer ship *Cool Express*

BISON EXPRESS



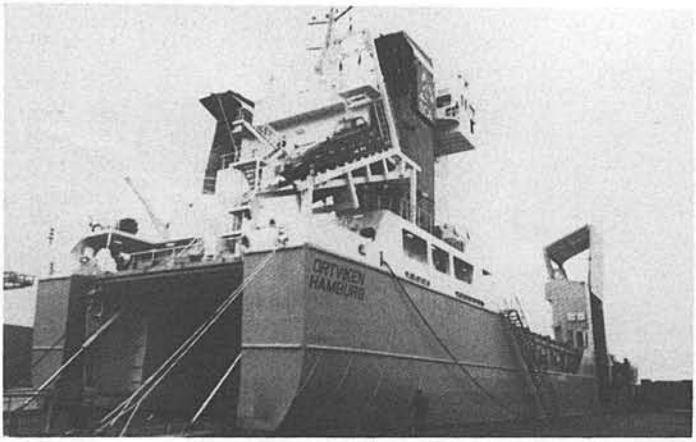
Principal particulars

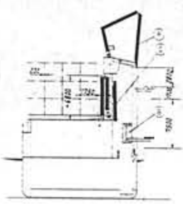
Length, oa	99.68	m	Deadweight	3,174	t
Length, bp	93.19	m	Main propulsion	MaK 6M5552C	
Breadth	15.85	m	Output (MCR)	4,050	kW
Depth	11.30	m	Trial speed	16	kn
Draught	5.64	m	Cargo capacity (no. of cattle)	1,700	

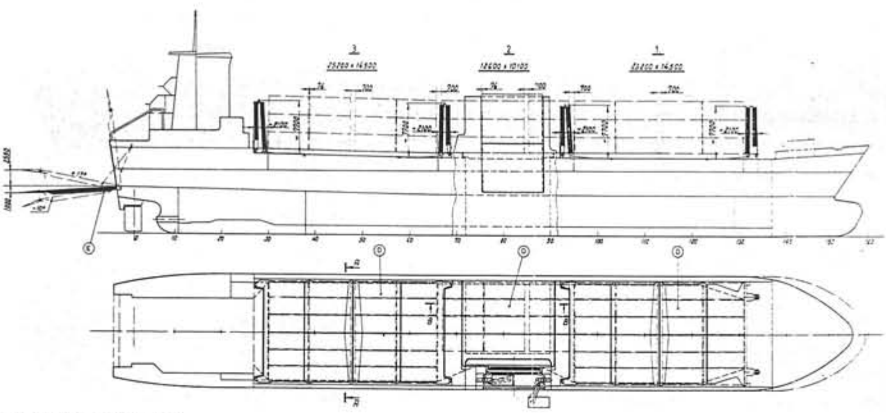
Source: HSB International, October 1995/Schip & Werf de Zee, September 1995

Figure 35: Livestock carrier *Bison Express*

ORTVIKEN







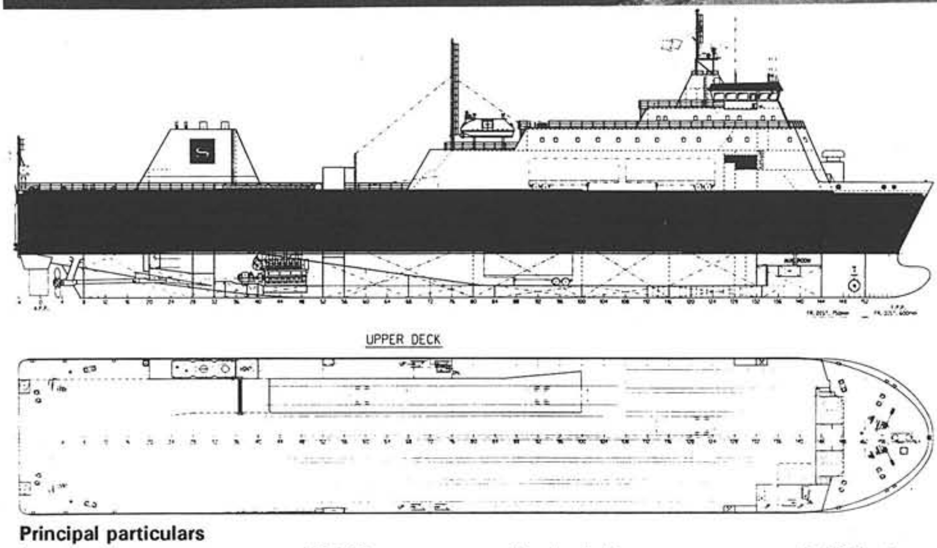
Principal particulars

Length, oa	114.00	m	Gross tonnage	5,800	grt
Length, bp	104.00	m	Deadweight	4,300	t
Breadth	17.00	m	Main propulsion	Deutz-MWM SBV8M640	
Depth	6.20	m	Output (MCR)	3,235	kW
Draught	5.91	m	Service speed	15.00	kn

Source: The Naval Architect, June 1991

Figure 36: Ro-ro/lo-lo forest products carrier *Ortviken*

ISLAND COMMODORE



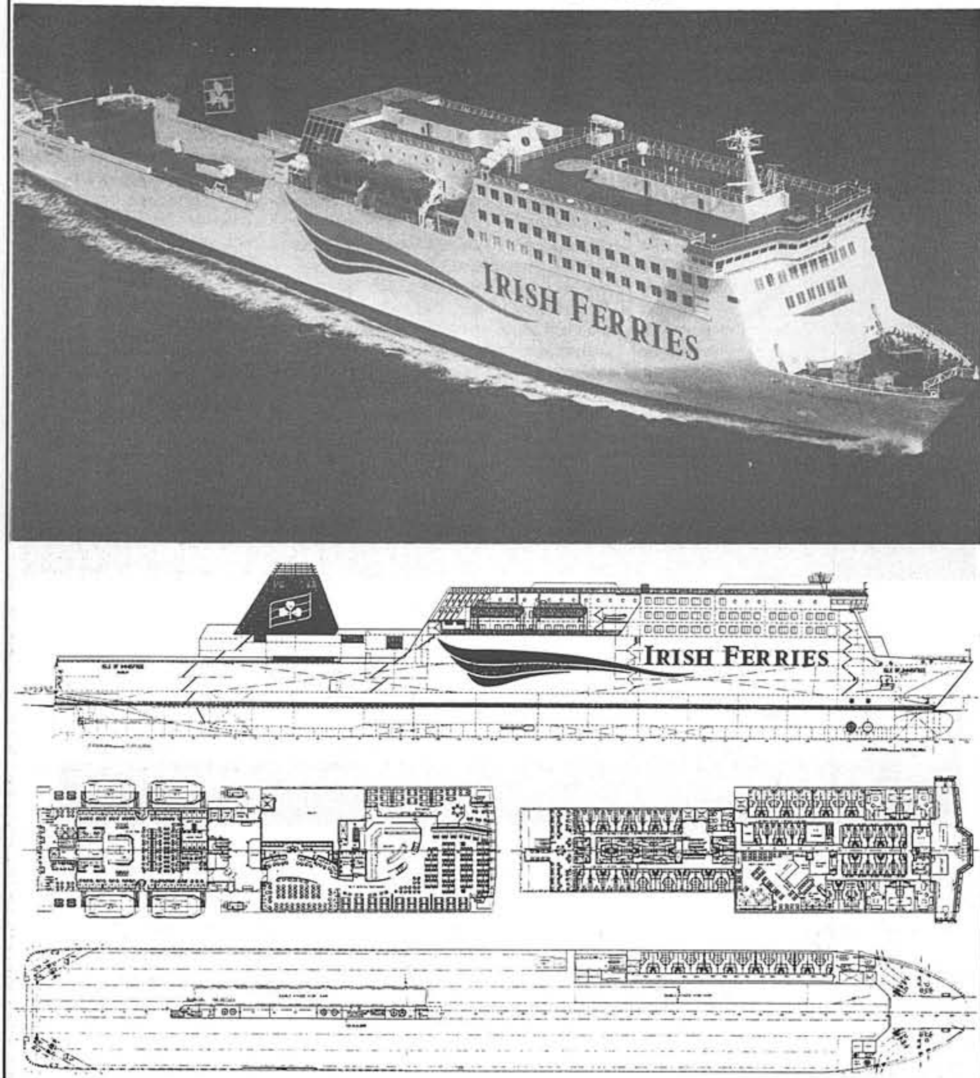
Principal particulars

Length, oa	126.30	m	Deadweight	5,215	t
Length, bp	121.50	m	Main propulsion	2 * MaK 6M552C	
Breadth	118.50	m	Output (MCR)	4,500	kW
Depth	21.00	m	Trial speed	18.9	kn
Draught	6.00	m			

Source: HSB International, May 1995

Figure 37: Cargo ro-ro vessel *Island Commodore*

ISLE OF INNESFREE



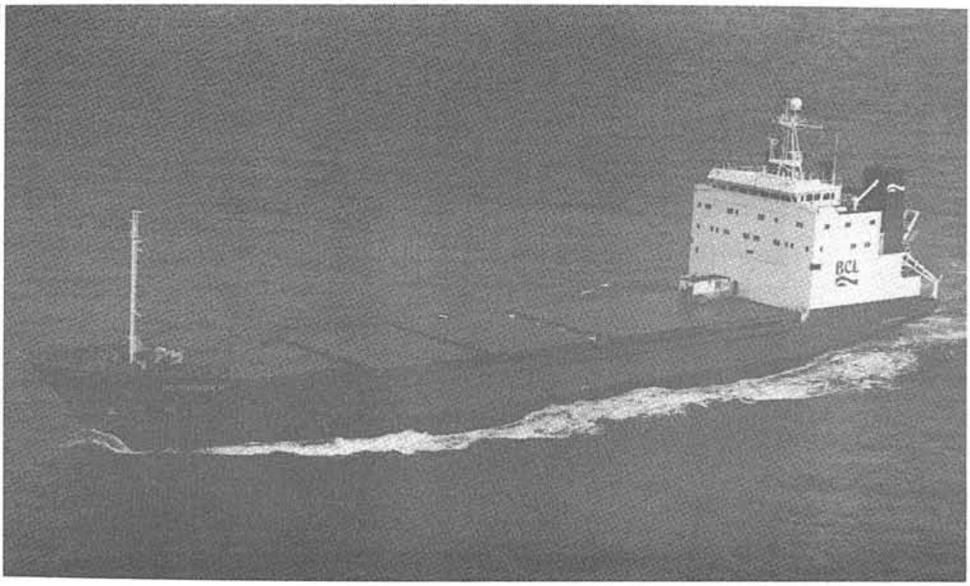
Principal particulars

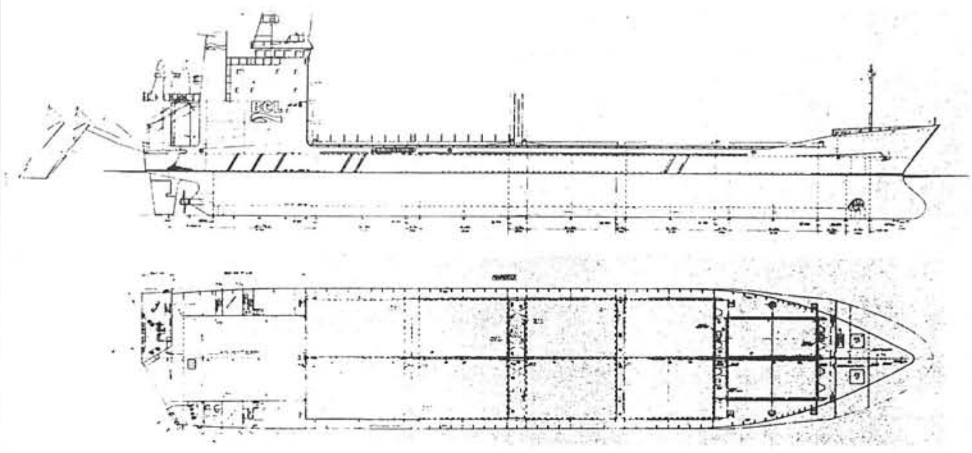
Length, oa	181.60	m	Deadweight	5,285	t
Length, bp	172.30	m	Main propulsion	4 * Sulzer ZAL40S	
Breadth	23.40	m	Output (MCR)	23,040	kW
Depth	8.60	m	Service speed	21.5	kn
Draught (design)	5.60	m			

Source: Schip & Werf de Zee, July/August 1995

Figure 38: Ro-ro passenger/cargo vessel *Isle of Innesfree*

OLEANDER





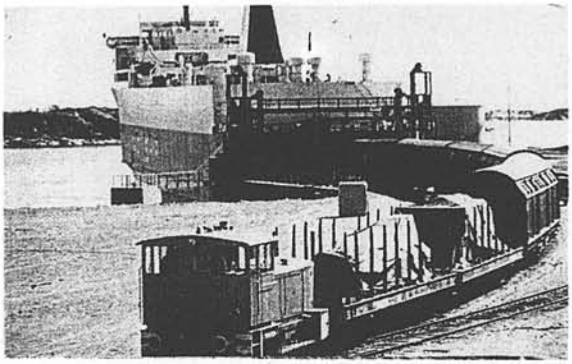
Principal particulars

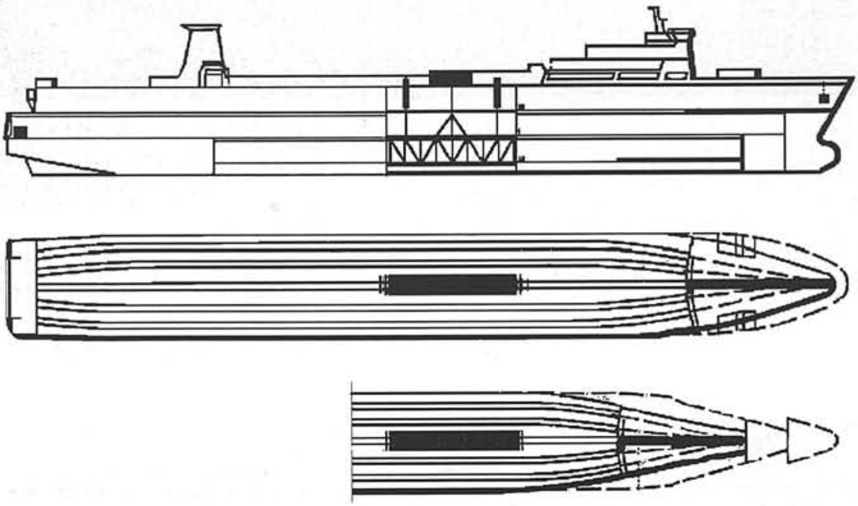
Length, oa	117.50	m	Deadweight	6,250	t
Length, bp	108.00	m	Main propulsion	MaK 8M552	
Breadth	19.80	m	Output (MCR)	4,000	kW
Depth	9.00	m	Trial speed	15.9	kn
Draught (scantling)	5.45	m	Cargo capacity (TEU)	262	
Gross tonnage	<9,000	gt	Range	9,000	nm

Source: HSB International, 8-1990

Figure 39: Ro-ro/container vessel *Oleander*

RAILSHIP II





Principal particulars

Length, oa	186.50	m	Deadweight	9,700	t
Length, bp	174.40	m	Main propulsion	2 *	MaK
Breadth	21.60	m	Output (MCR)	16,000	kW
Depth	18.95	m	Speed	18.5	kn
Draught (scantling)	6.50	m			

Source: HSB International, 8-1990

Figure 40: Rail ferry *Railship II*

ASIAN PROSPERITY

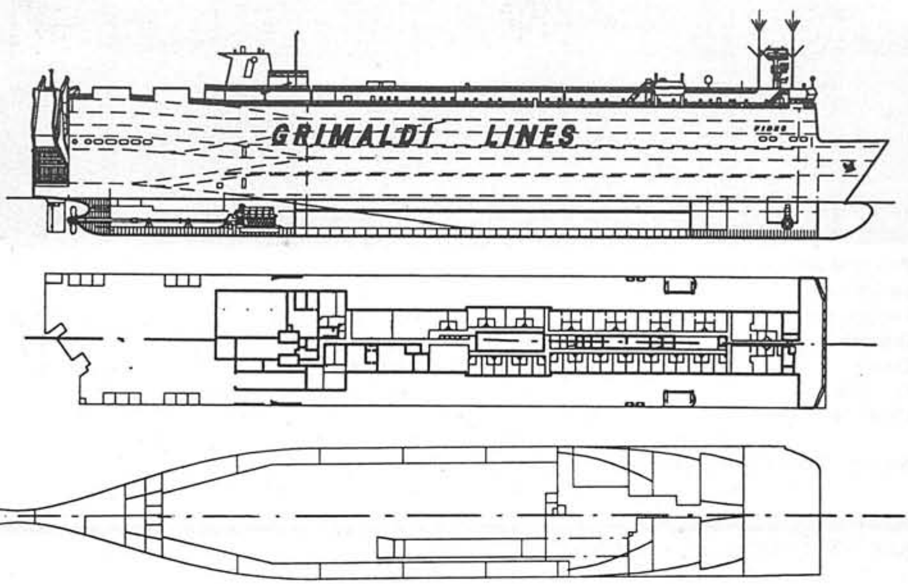
Principal particulars

Length, oa	100.29	m	Deadweight	4,050	t
Length, bp	94.00	m	Main propulsion	Akasaka 8UEC37LA	
Breadth	21.00	m	Output (MCR)	5,600	PS
Depth	10.03	m	Trial speed	16.64	kn
Draught	6.60	m	Cargo capacity (no. of cars)	709	
Gross tonnage	9,535	m			

Source: Shipbuilding and Marine Engineering in Japan 1995

Figure 41: Small car carrier *Asian Prosperity*

FIDES



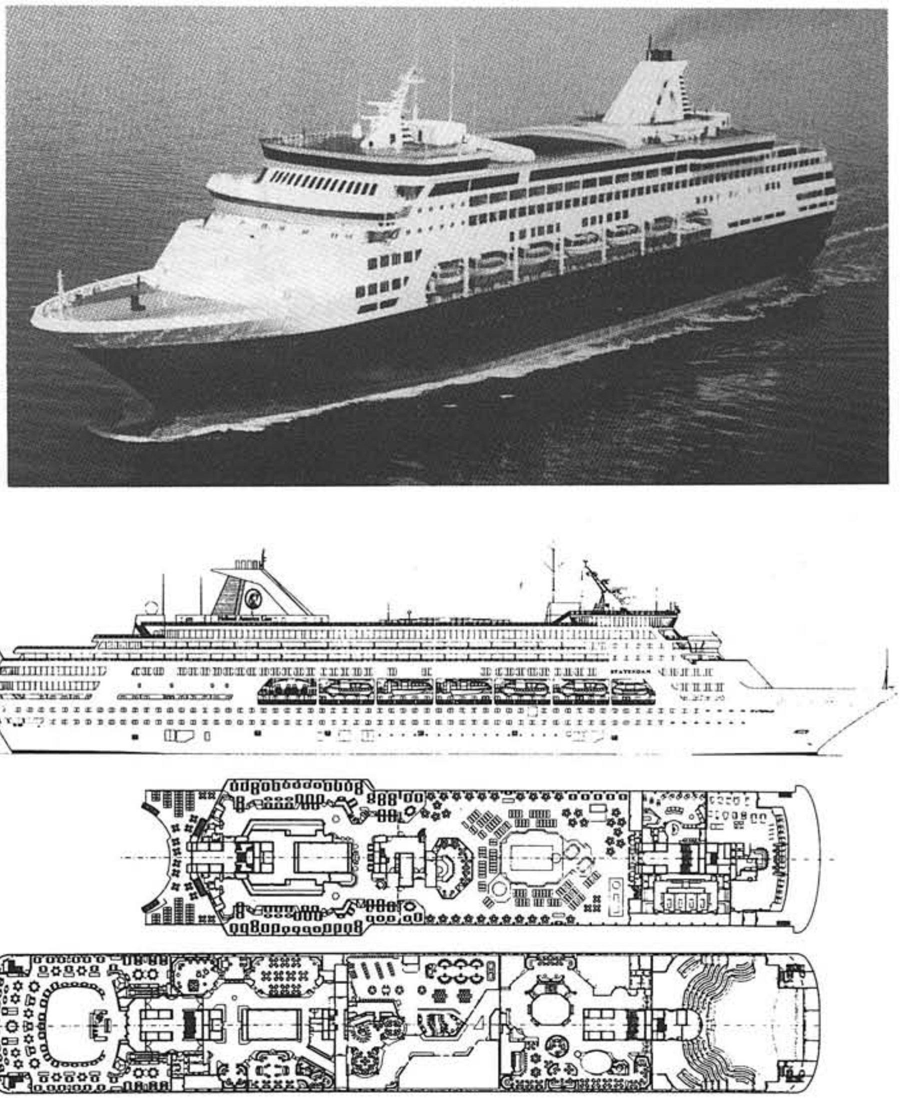
Principal particulars

Length, oa	178.10	m	Deadweight	16,000	t
Length, bp	164.00	m	Main propulsion	2 * Sulzer 8ZA40S	
Breadth	26.80	m	Output (MCR)	11,520	kW
Depth	8.60	m	Speed	19.0	kn
Draught	7.60	m	Cargo capacity (no. of cars)	2,400	

Source: Hansa, 3 - 1993

Figure 42: Large car carrier *Fides*

STATENDAM



Principal particulars

Length, oa	219.30	m	Gross tonnage	54,000	gt
Length, bp	185.00	m	Deadweight	6,600	t
Breadth	30.80	m	Trial speed	22.6	kn
Draught (design)	7.70	m			

Source: HSB International July/August 1993

Figure 43: Cruise vessel *Statendam*

DOGGERSBANK

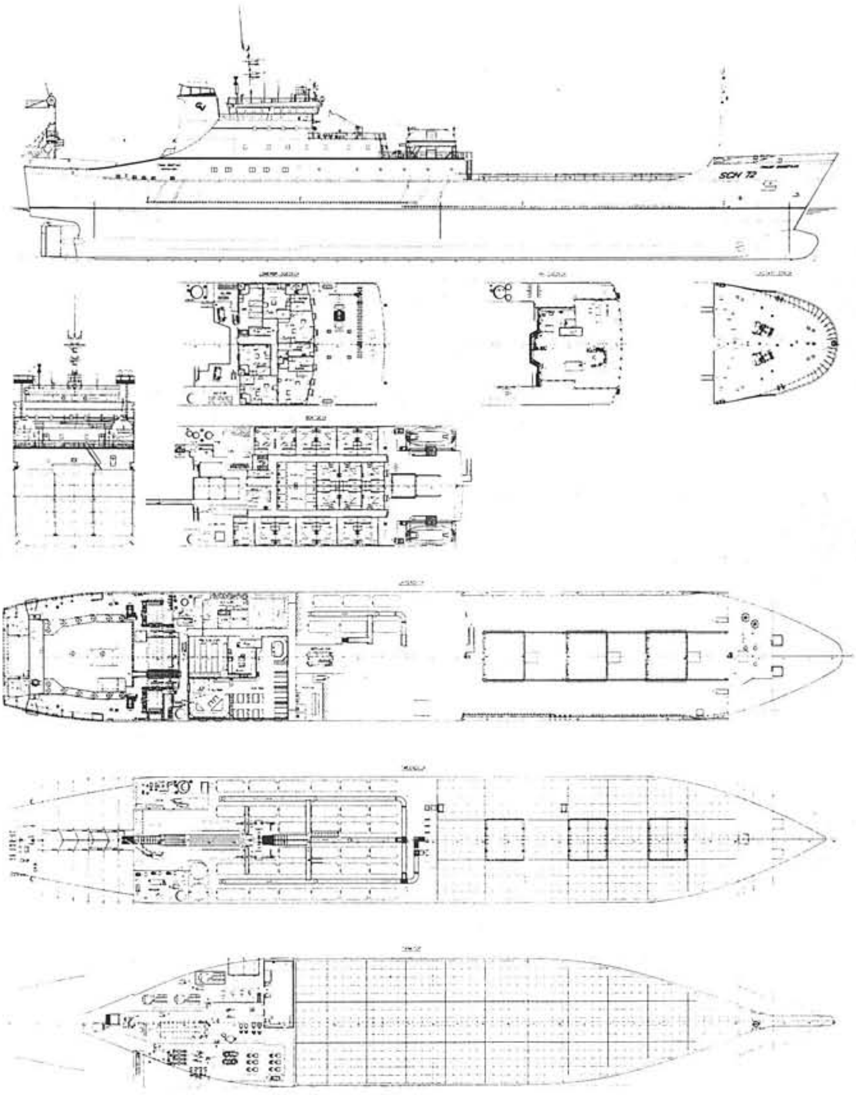
Principal particulars

Length, oa	32.70	m	Deadweight	3,174	t
Breadth	7.50	m	Main propulsion	SWD 6FHD240	
Depth	3.90	m	Output (MCR)	589	kW

Source: HSB International, September 1992

Figure 44: Beam trawler *Doggersbank*

FRANK BONEFAAS



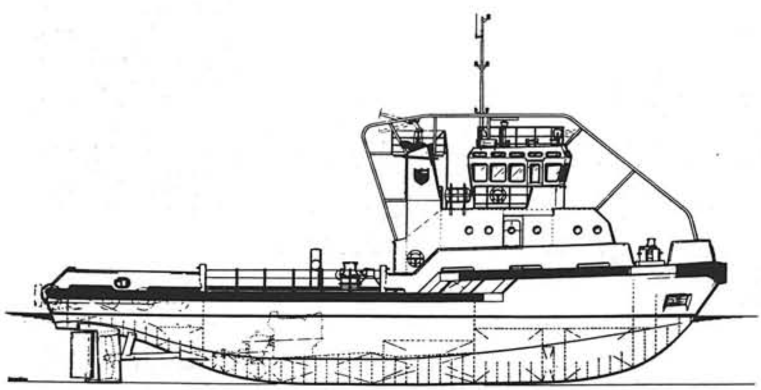
Principal particulars

Length, oa	119.55	m	Draught	6.85	m
Length, bp	112.31	m	Deadweight	6,011	t
Breadth	17.50	m	Main propulsion	Deutz SBV 16M540	
Depth	11.02	m	Output	3,952	kW

Source: Schip & Werf de Zee, 11-1994

Figure 45: Fishing vessel *Frank Bonefaas*

LAMNALCO SABLE



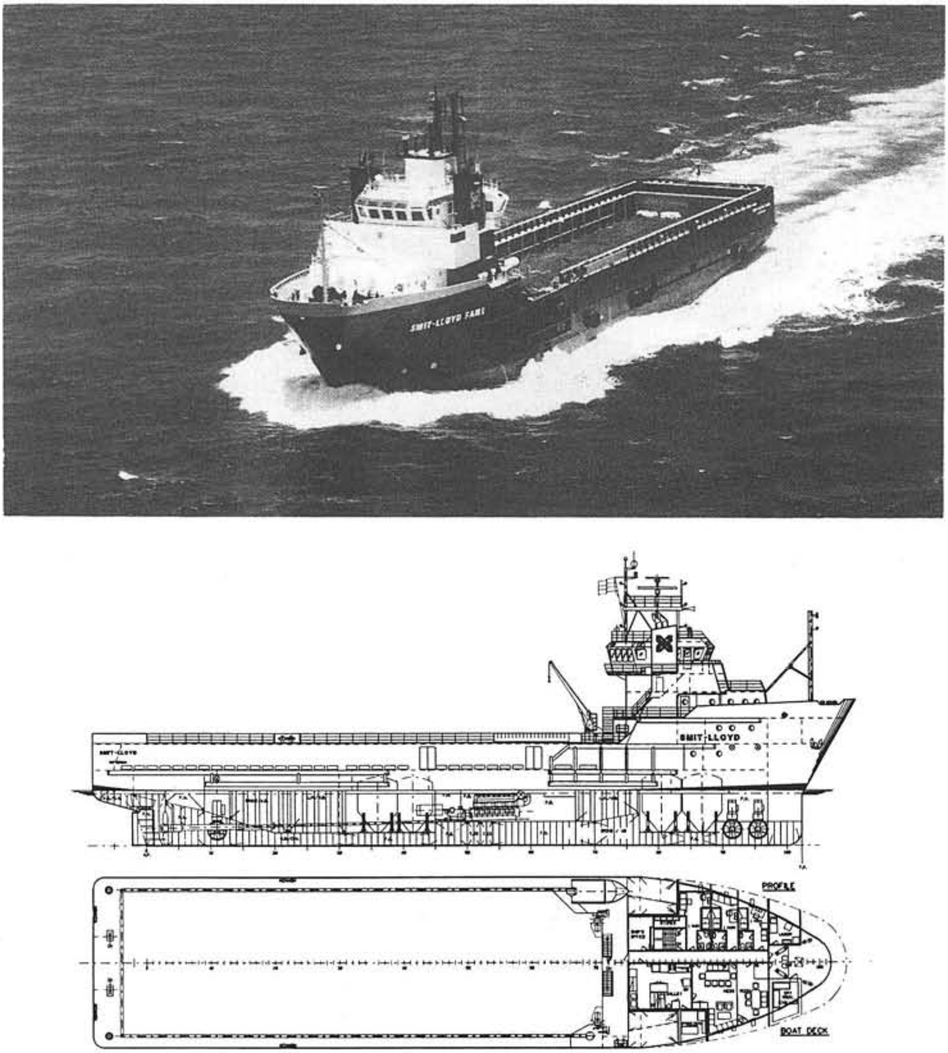
Principal particulars

Length, oa	30.50	m	Displacement	265	t
Breadth	8.42	m	Main propulsion	Caterpillar 3512TA	
Depth	4.05	m	Output	1,730	kW
Draught	3.30	m	Speed	12.9	kn
Gross tonnage	208	gt	Bollard pull	22.3	t

Source: HSB International, november 1992

Figure 46: Offshore supply vessel *Smit Lloyd Fame*

SMIT-LLOYD FAME



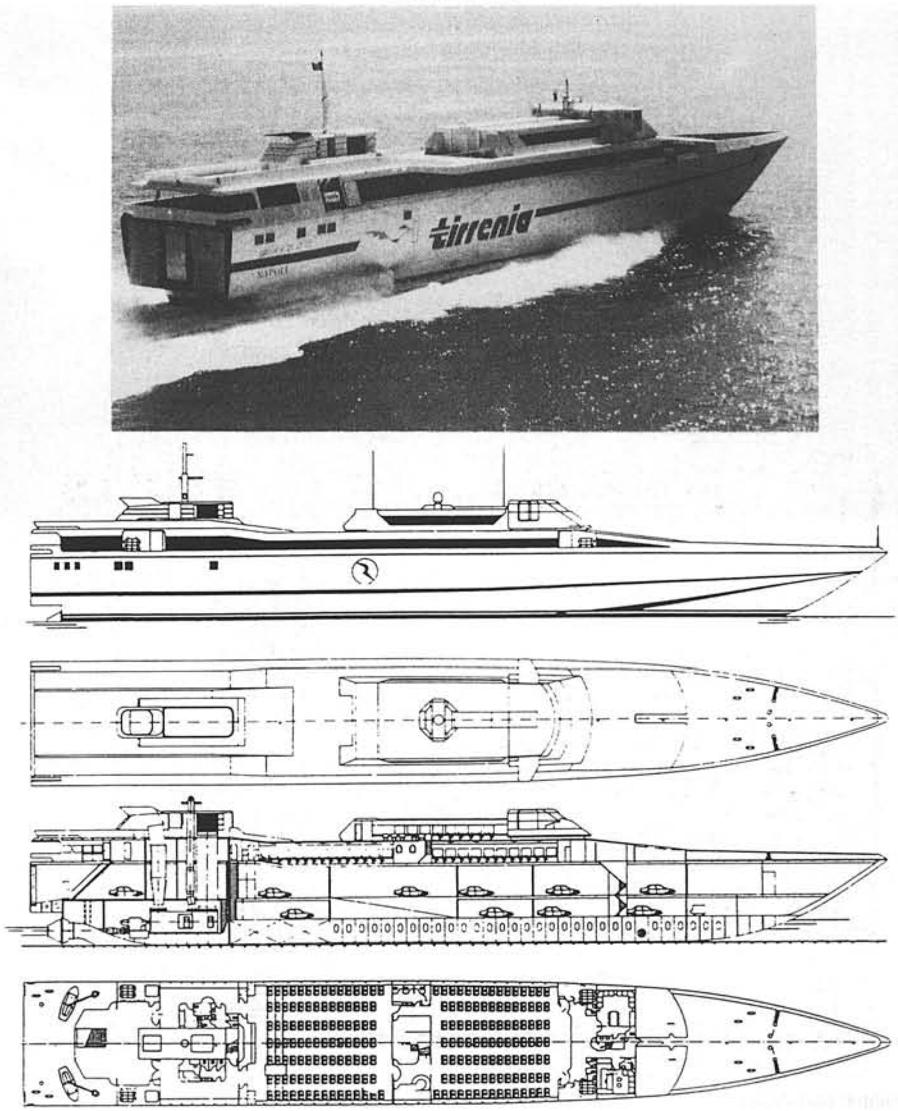
Principal particulars

Length, oa	71.50	m	Gross tonnage	1,995	gt
Length, bp	61.40	m	Deadweight	2,530	t
Breadth	16.30	m	Main propulsion	2 * MAN B&W 8L28/32A	
Depth	7.00	m	Output	4,000	kW
Draught	5.60	m	Trial speed	14.5	kn

Source: Schip & Werf de Zee, mei 1995

Figure 47: Offshore supply vessel *Smit-Lloyd Fame*

GUIZZO



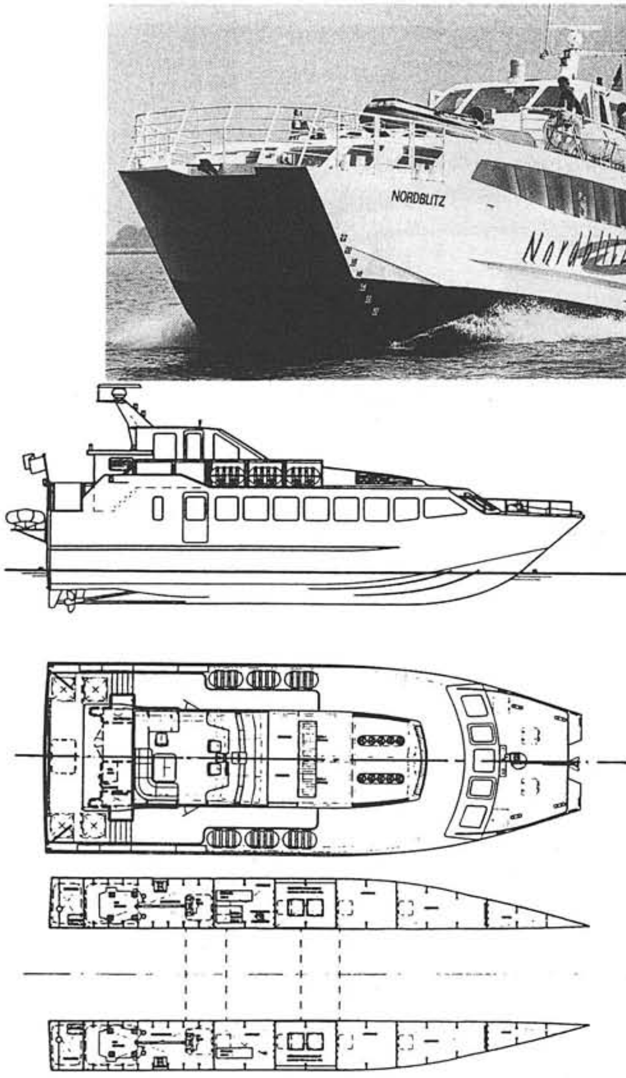
Principal particulars

Length, oa	101.75	m	Draught	2.12	m
Length, bp	85.30	m	Deadweight	1033.5	t
Breadth	14.50	m	Output (MCR)	27,930	kW
Depth	9.50	m	Speed	43	kn

Source: Hansa, 11-1993

Figure 48: Fast mono-hull *Guizzo*

NORDBLITZ



Principal particulars

Length, oa	21.50 m	Displacement	50 t
Length, bp	18.90 m	Main propulsion	2 * MAN diesel
Breadth	7.60 m	Output (MCR)	1,470 kW
Depth	3.10 m	Service speed	36 kn
Draught	1.28 m	Maximum speed	38 kn

Source: Hansa, 10 - 1994

Figure 49: Fast catamaran *Nordblitz*

RADISSON DIAMOND

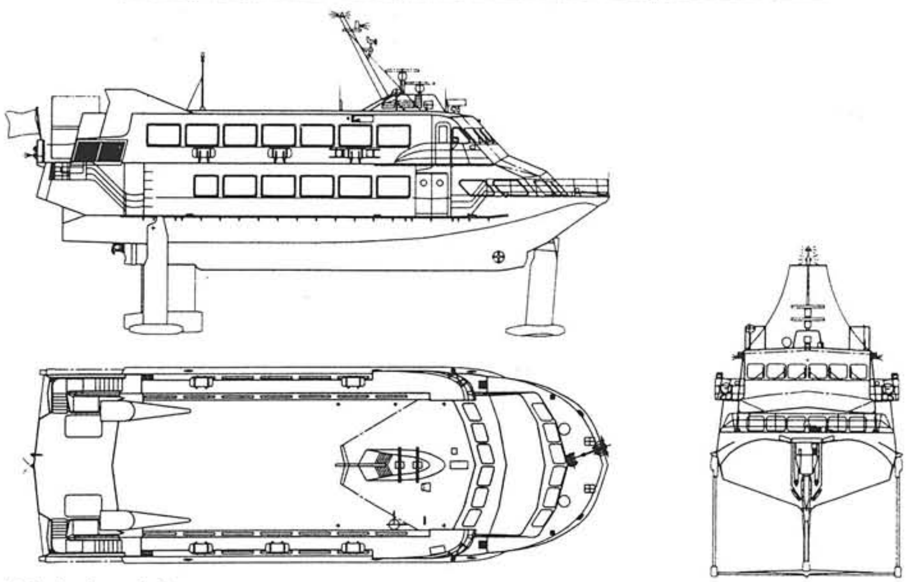
Principal particulars

Length, oa	131.00	m	Displacement	1,300	t
Length, bp	115.80	m	Main propulsion	2 * Wärtsilä Vasa 8R32E	
Breadth	32.00	m		2 * Wärtsilä Vasa 6R32 E	
Depth	15.50	m	Output (trial)	11,400	kW
Draught	8.00	m	Trial speed	14	kn
Gross tonnage	20,400	gt			

Source: The Naval Architect, July/August 1992

Figure 50: SWATH *Radisson Diamond*

EMERALD WING



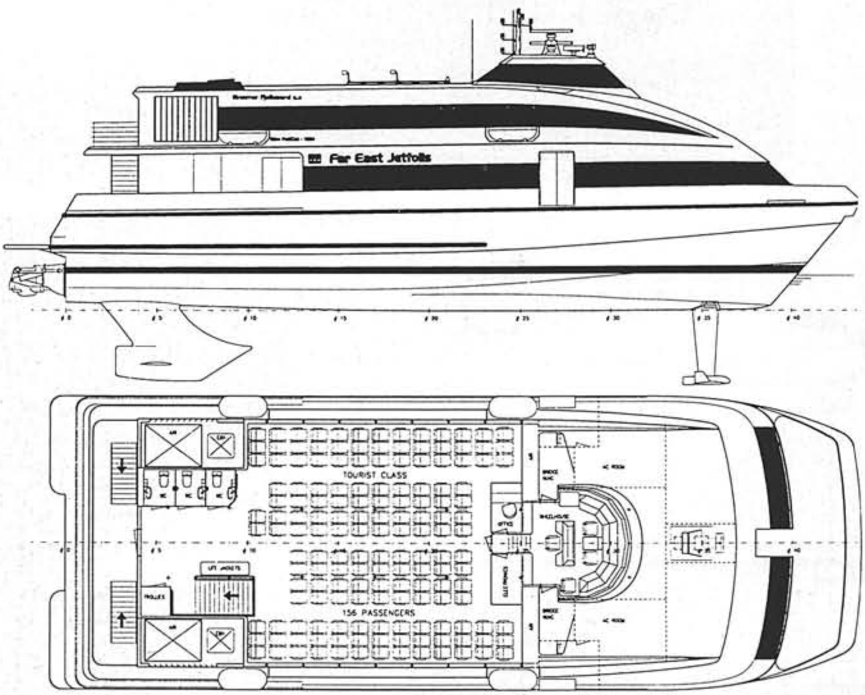
Principal particulars

Length, oa	30.30	m	Draught (including foils)	4.90	m
Length, bp	24.00	m	Main propulsion	2 * gas turbines	
Breadth	8.50	m	Output (MCR)	7,600	PS
Depth	2.60	m	Foilborne speed	45	kn
Draught (excluding foils)	2.20	m			

Source: Shipbuilding and Marine Engineering in Japan 1995

Figure 51: Hydrofoil *Emerald wing*

PENHA



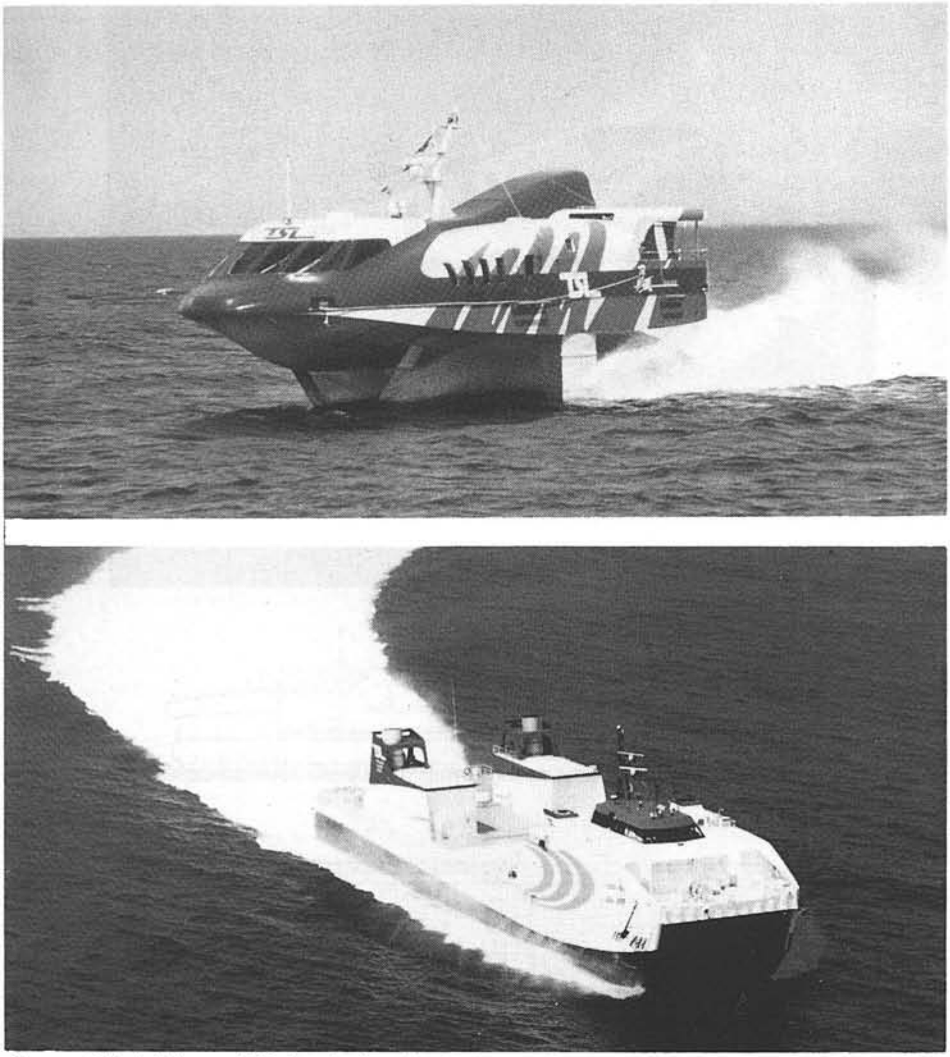
Principal particulars

Length, oa	35.00	m	Main propulsion2 * General Electric LM500		
Breadth	12.00	m	Output (MCR)	8,948	kW
Depth	4.20	m	Service speed	45	kn
Draught (on foil)	2.55	m	Passenger capacity	403	
Draught (off foil)	4.70	m	Range	300	nm
Gross tonnage	450	grt			

Source: Fast Ferry International, July/August 1995

Figure 52: Foil cat *Penha*

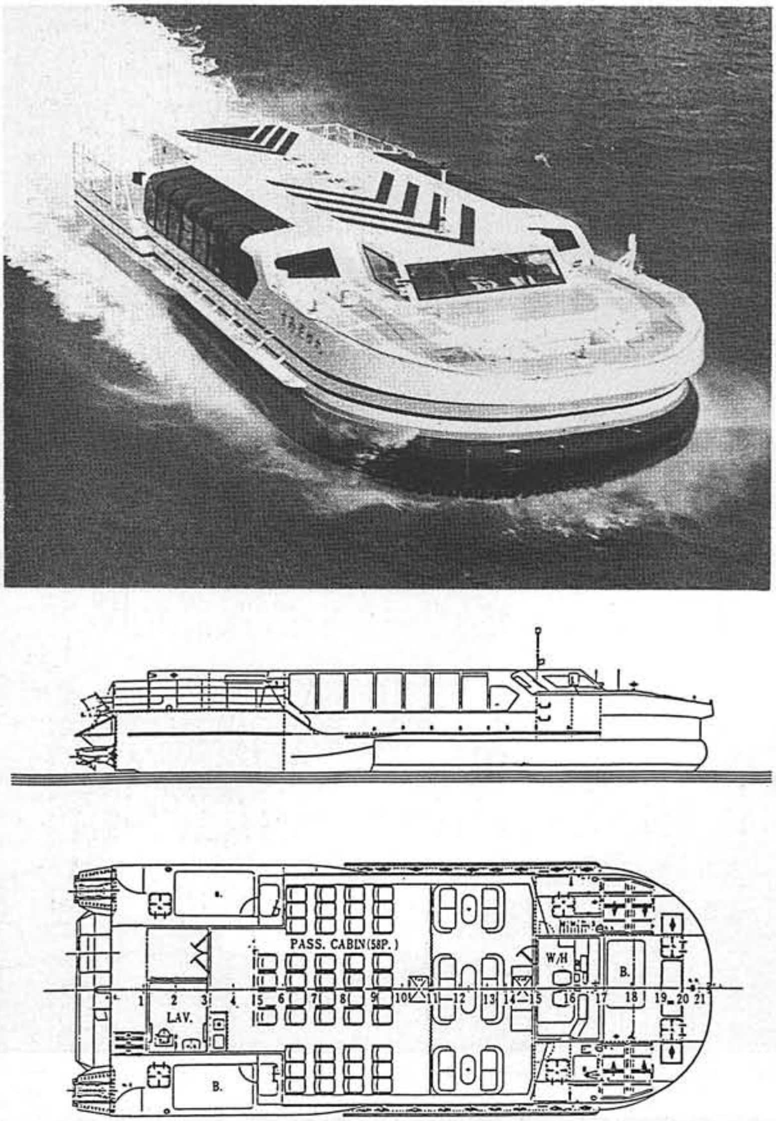
HISHO and HAYATE



Source: Shipbuilding and Marine Engineering in Japan 1995

Figure 53: Techno-Superliners *Hisho* and *Hayate*

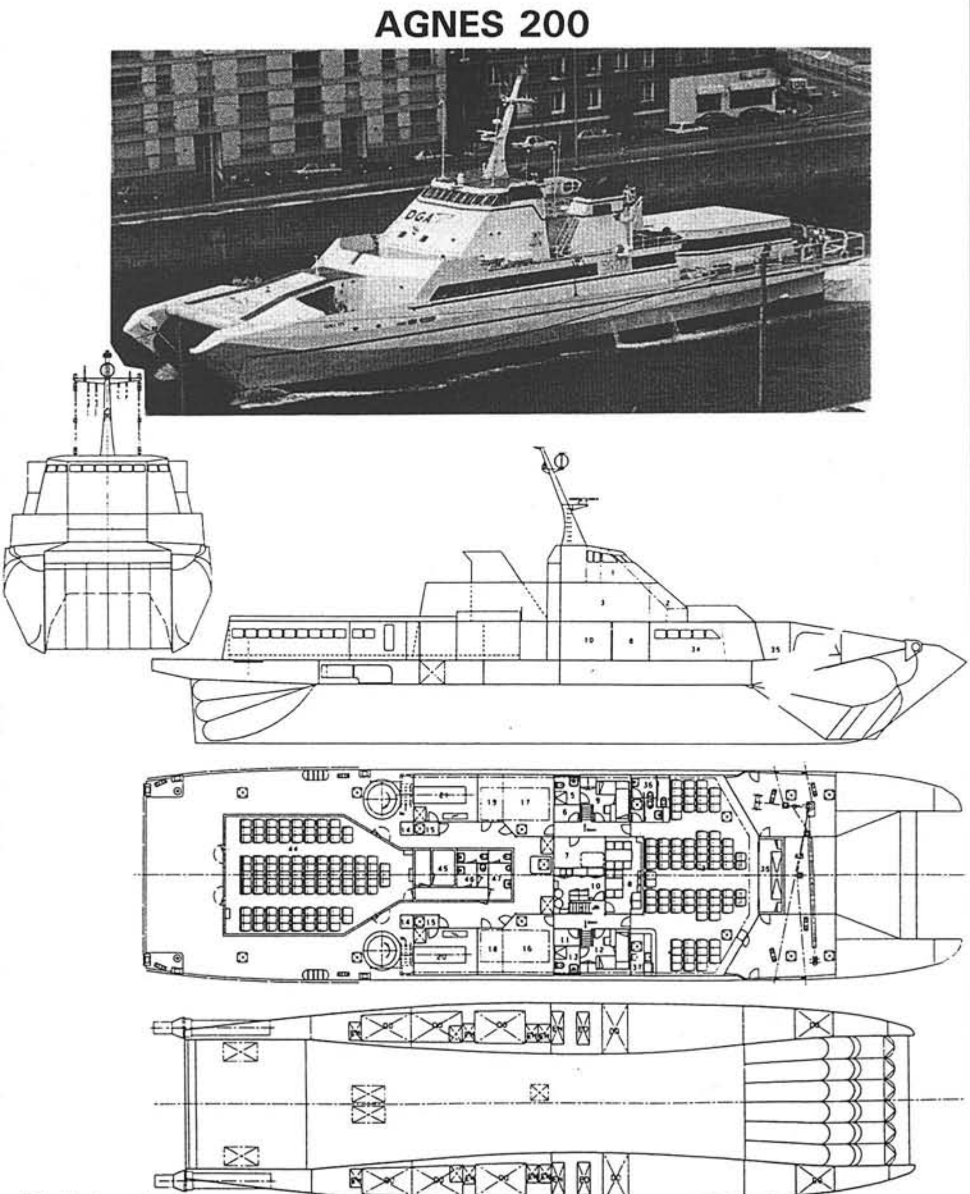
SUMIDAGAWA



Principal particulars

Length, oa	19.95	m	Output (propulsion)	692	kW
Breadth	7.90	m	Output (lift)	272	kW
Depth	3.70	m	Speed	30.4	kn
Draught (off cushion)	1.5	m	Passenger capacity	80	
Draught (on cushion)	0.5	m			

Figure 54: Hovercraft *Sumidagawa*



Principal particulars

Length, oa	51.00	m	Displacement	250	t
Length, bp	45.00	m	Main propulsion	2 * MTU 16V 538TB93	
Breadth	13.00	m	Output (propulsion)	5,966	kW
Draught (on cushion)	2.30	m	Output (lift)	1,492	kW
Draught (off cushion)	1.00	m	Speed (on cushion)	40	kn

Figure 55: SES *Agnes 200*

CHAPTER 3: WORLD FLEETS

The growth of the world fleet as a whole is impressive, as **Figure 1** and **Figure 2** illustrate. **Figure 1** shows the development of the number of ships larger than 100 gt over the period 1921-1994. The fleet increased from 28,433 to 81,084 ships with a corresponding increase in gross tonnage from 58.8 million gt to 482.8 gt, as shown in **Figure 2**.

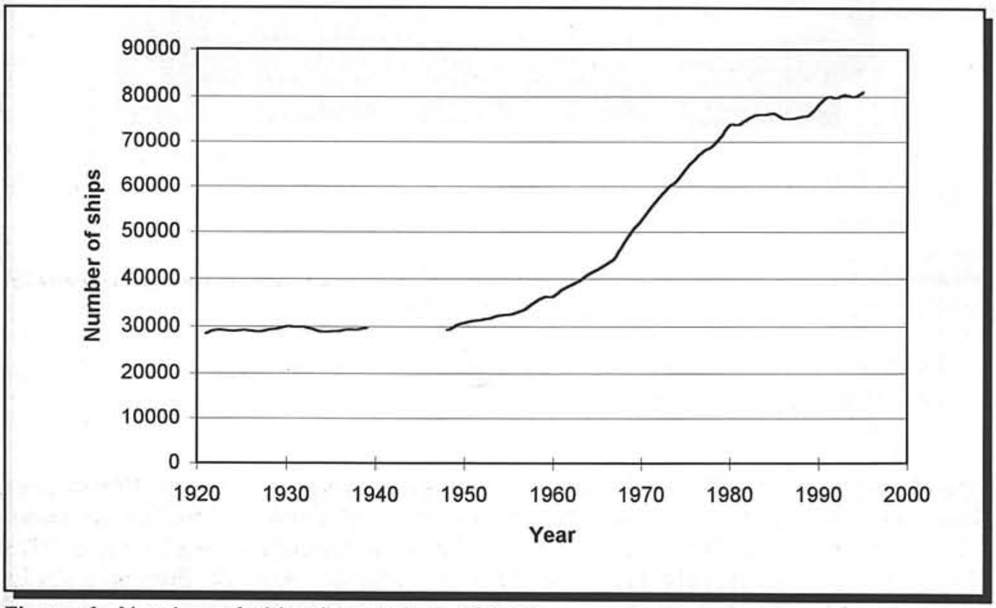


Figure 1: Number of ships larger than 100 gt

The world fleet can be segmented into seventeen main ship categories. These are:

1. Oil tankers;
2. Chemical tankers;
3. Liquid gas tankers;
4. Dry bulk carriers;
5. Ore-bulk-oil combination carriers;
6. General cargo single deck ships;
7. General cargo multi-deck ships;
8. Livestock and car carriers;
9. Reefer ships;
10. Ro-ro cargo ships;
11. Container ships;
12. Cargo passenger and ro-ro passenger ships;
13. Passenger ships;
14. Cruise ships;

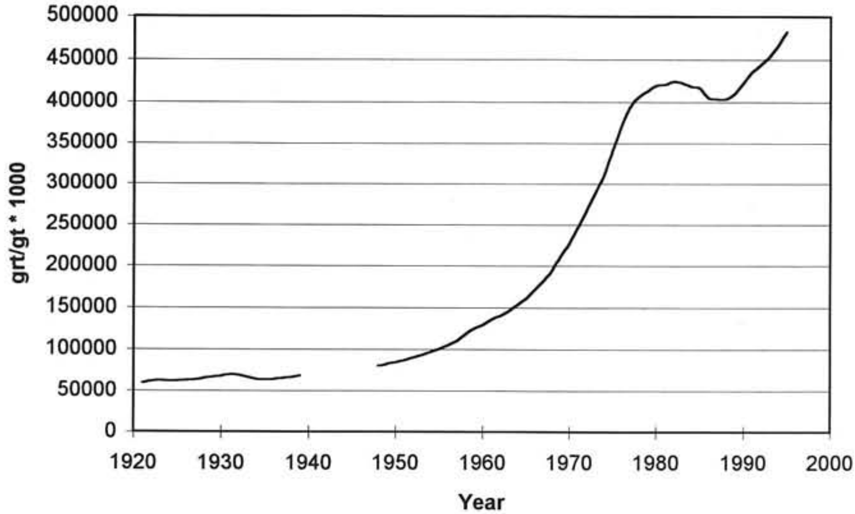


Figure 2: Gross Tonnage of the world fleet

15. Trawlers, fishing vessels, fish factory ships, fish carriers;
16. Offshore service vessels;
17. Research vessels.

The seventeen segments can be classed by their *deadweight* and *age*. Within each deadweight and age class, the total deadweight and average age can be calculated. This provides some clues for the future newbuilding requirements. The following tables and graphs are all based on information from ISL Bremen's *"Shipping Statistics Yearbook 1995"*.
In the graphs and tables, each class is indicated by its upper limit, the lower limit is the upper limit of the previous class minus one.

3.1 Bulk fleet

1. Oil tankers
The table in **Figure 3** shows the subdivision of the world oil tanker fleet, which consists of 6,496 ships, by deadweight category and age group. The graph summarises this information in graphical form.

The oil tanker fleet by the end of 1994 had a total deadweight of 270.9 million tonnes, while the average age of the oil tankers amounted to 16.7 years. The table also illustrates that no Ultra Large Crude Carriers (ULCCs) have been built in recent years. The most popular ship sizes are the Aframax (just below 100,000 dwt), the Suezmax (around 150,000 dwt) and the VLCC (Very Large Crude Carriers, around 250,000 dwt).

Dwt-size	Divison of age (years)						ships >= 300 grt/gt	
class	0-4	5-9	10-14	15-19	20-24	>25	Total	Average age
9999	423	402	538	710	573	1067	3713	18.7
19999	30	40	106	68	70	43	357	15.6
29999	30	50	81	41	99	58	359	16.4
39999	24	48	63	124	115	37	411	16.9
49999	52	54	68	10	5	5	194	9.2
99999	111	117	178	160	92	32	690	12.8
149999	72	49	10	65	81	2	279	12.5
199999	12	4	5	32	3	2	58	13.7
249999	7	20	3	13	33	1	77	15.0
299999	79	31	5	43	105		263	13.0
349999	18	2	2	15	13		50	11.7
399999			1	13	7		21	18.4
449999				14	1		15	18.1
>450000				8	1		9	17.8
Total	858	817	1060	1316	1198	1247	6496	16.7

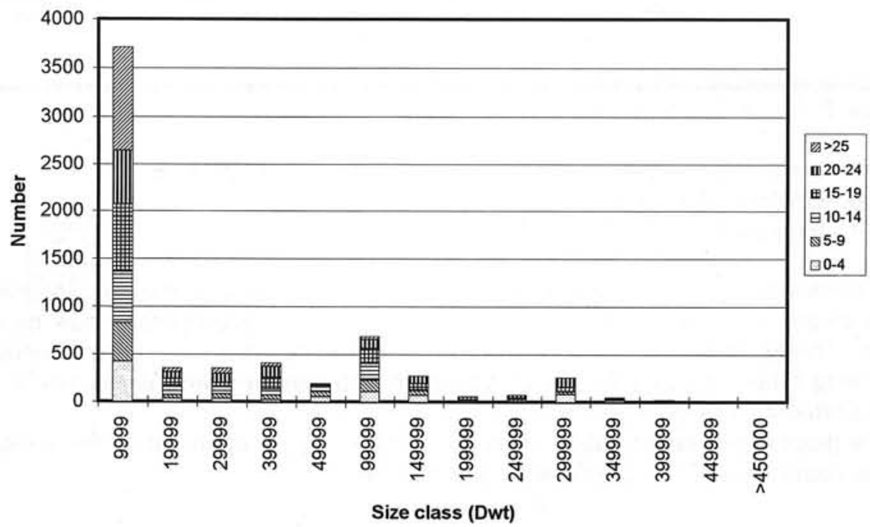


Figure 3: World oil tanker fleet

2. Chemical tankers

The table in **Figure 4** shows the subdivision of the world chemical tanker fleet, which consists of 1,278 ships, by deadweight category and age group. The graph summarises this information in graphical form.

Dwt-size	Divison of age (years)						ships >= 300 grt/gt	
class	0-4	5-9	10-14	15-19	20-24	>25	Total	Average age
4999	212	156	119	138	126	151	902	14.1
7499	12	12	36	14	19	7	100	13.7
9999	34	13	5	8	10	3	73	9.1
14999	14	11	8	7	1		41	7.9
19999	6	5	6	2	2	2	23	11.2
22499		1		1		2	4	18.8
24999		2	12	5	3	4	26	16.3
29999	2	3	8	12	12	4	41	18.2
34999	4		7	14	11	2	38	16.6
39999	5		6	9		1	21	12.0
>40000	5	2	1		1		9	6.3
Total	294	205	208	210	185	176	1278	13.7

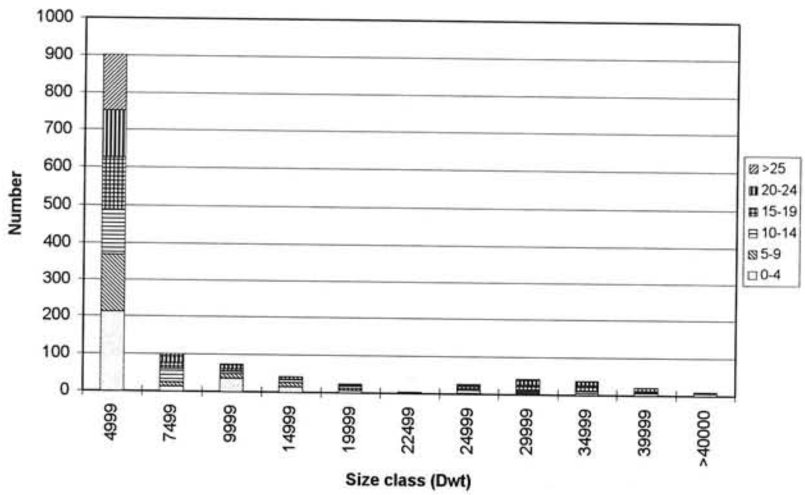


Figure 4: World chemical tanker fleet

The chemical tanker fleet by the end of 1994 had a total deadweight of 7.9 million tonnes, while the average age of the chemical tankers amounted to 13.7 years. Small tankers are the most popular category. Vessels smaller than 5,000 dwt make up almost 70% of the entire chemical tanker fleet.

3. Liquid gas tankers

The table in **Figure 5** shows the subdivision of the world gas tanker fleet, which consists of 918 ships, by *cubic metre* category and age group. The graph summarises this information in graphical form.

The gas tanker fleet by the end of 1994 had a total deadweight of 20,322 m^3, while the average age amounted to 14.5 years. Small ships, between 1,000 and 3,000 dwt, are most popular.

Cu.m.-size	Divison of age (years)						ships >= 300 grt/gt	
class	0-4	5-9	10-14	15-19	20-24	>25	Total	Average age
999		5	11	23	2	42	83	22.0
2999	40	47	49	92	52	52	332	15.6
4999	39	33	23	11	6	12	124	10.3
9999	15	8	35	17	5	6	86	12.9
14999	1	8	5	12	3	5	34	15.9
19999	6	4	8	2		5	25	12.5
29999	7	3	6	3	5	7	31	14.5
39999	5	2	3	3	3	1	17	12.0
49999			1		3	3	7	22.6
74999	4	1	5	15	15	2	42	16.7
99999	24	9	10	24	10		77	11.1
>100000	12	5	16	26	1		60	11.8
Total	153	125	172	228	105	135	918	14.0

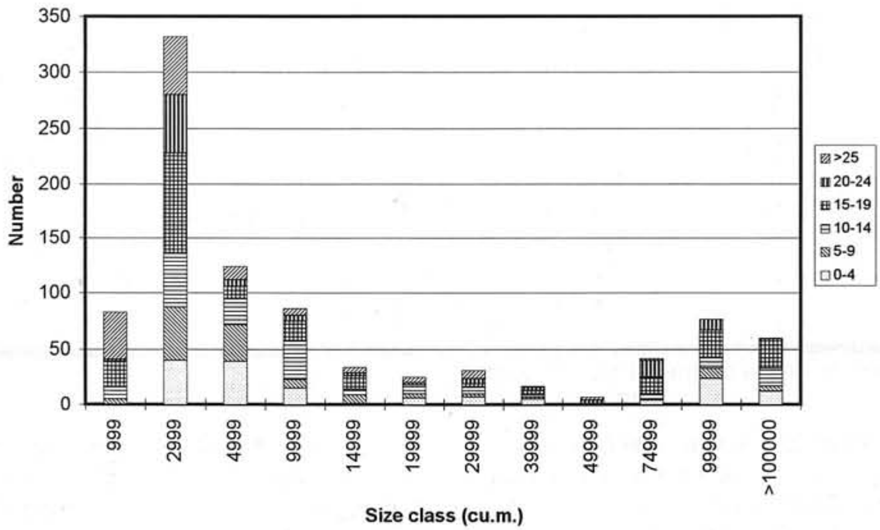


Figure 5: World gas tanker fleet

4. Dry bulk carriers

The table in **Figure 6** shows the subdivision of the world dry bulk carrier fleet, which consists of 5,342 ships, by deadweight category and age group. The graph summarises this information in graphical form.

The dry bulk fleet by the end of 1994 had a total deadweight of 218.9 million tonnes, the average age amounted to 14.1years.

Dwt-size	Divison of age (years)						ships >= 300 grt/gt	
class	0-4	5-9	10-14	15-19	20-24	>25	Total	Average age
9999	111	193	76	96	152	119	747	14.7
14999	11	22	32	57	59	24	205	17.0
19999	12	14	63	187	79	68	423	18.4
24999	32	24	126	133	103	46	464	16.3
29999	40	61	187	213	218	71	790	16.6
34999		24	116	106	133	32	411	17.5
39999	18	46	235	113	55	17	484	13.7
49999	95	114	205	54	33	23	524	10.6
74999	112	142	235	148	148	27	812	12.9
99999	10	3	34	22	13	11	93	15.3
149999	41	33	59	41	42	2	218	12.5
199999	37	49	28	6	8	1	129	8.1
249999	4	19	6		3		32	8.5
>250000	3	3	2		2		10	9.9
Total	526	747	1404	1176	1048	441	5342	14.7

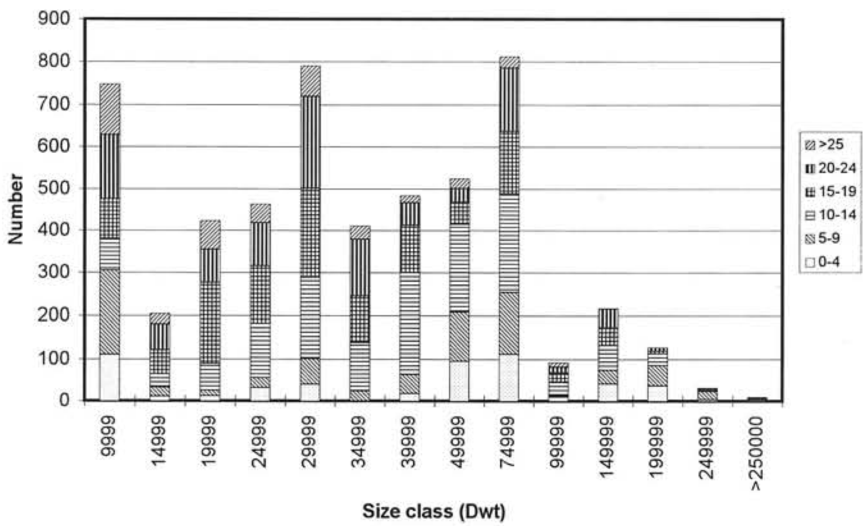


Figure 6: World dry bulk carrier fleet

There are four main sizes: Handysize (25,000 dwt), Handymax (45,000 dwt), Panamax (65,000 dwt) and Capesize (140,000 dwt). This is clearly reflected by the deadweight classes.

5. OBOs

The table in **Figure 7** shows the subdivision of the world ore-bulk-oil carrier fleet, which consists of 339 ships, by deadweight category and age group. The graph summarises this information in graphical form.
The OBO carrier fleet by the end of 1994 had a total deadweight of 26.9 million tonnes, the average age amounted to 14.8 years.

Dwt-size	Divison of age (years)						ships >= 300 grt/gt	
class	0-4	5-9	10-14	15-19	20-24	>25	Total	Average age
49999		9	2	2	1		14	10.3
59999			11	3	1		15	13.5
69999		2	3	4	1		10	13.8
79999	4		27	3	9		43	13.7
89999	5		4	2	4	1	16	12.7
99999	10	2		3	1		16	7.9
124999	2		1	19	21	1	44	18.5
149999	8	2	9	16	9		44	14.1
174999		1		3	14	1	19	20.7
199999					1		1	23.0
249999				2	5		7	20.6
274999					2		2	21.0
>275000		5			3		8	13.1
Total	29	21	57	57	72	3	239	14.8

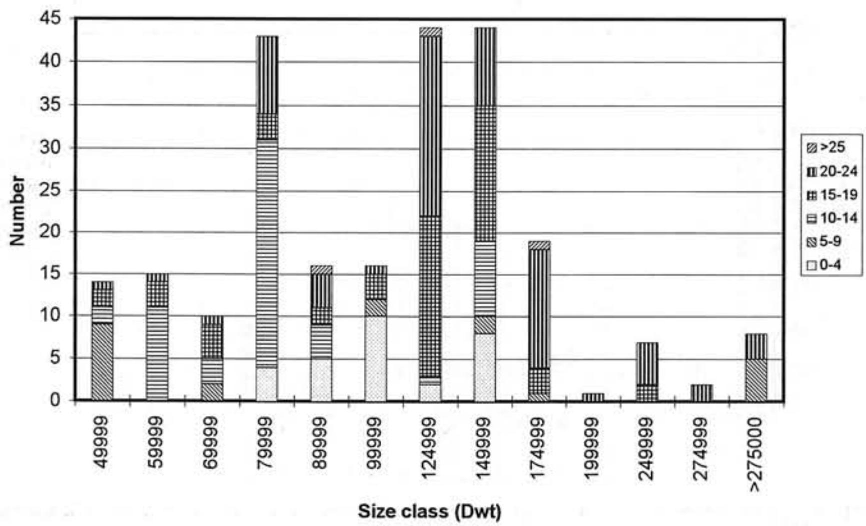


Figure 7: World ore-bulk-oil carrier fleet

The flexibility of the OBO carrier has not been appreciated in the freight markets, and that is the main reason why not many new ships of this relatively expensive bulk carrier type, have been built in recent years.

3.2 General cargo fleet

6. General cargo - single deck

The table in **Figure 8** shows the subdivision of the world single deck general cargo fleet, which consists of 7,802 ships, by deadweight category and age group. The graph summarises this information in graphical form.

Dwt-size	Divison of age (years)						ships >= 300 grt/gt	
class	0-4	5-9	10-14	15-19	20-24	>25	Total	Average age
2499	382	447	563	532	391	1654	3969	22.7
4999	296	209	282	321	321	449	1878	16.5
7499	124	110	229	199	204	197	1063	16.1
9999	39	26	51	81	93	24	314	15.7
12499	4	4	16	38	63	12	137	18.5
14999	9	20	9	8	4	2	52	10.7
19999	10	28	9	33	13	14	107	14.5
24999	12	13	27	50	7	1	110	13.2
29999	1	8	16	11	14		50	14.6
34999		9	9	3	4		25	12.4
39999		5	15	11	11		42	15.2
>40000	10	13	17	15			55	10.5
Total	887	892	1243	1302	1125	2353	7802	19.4

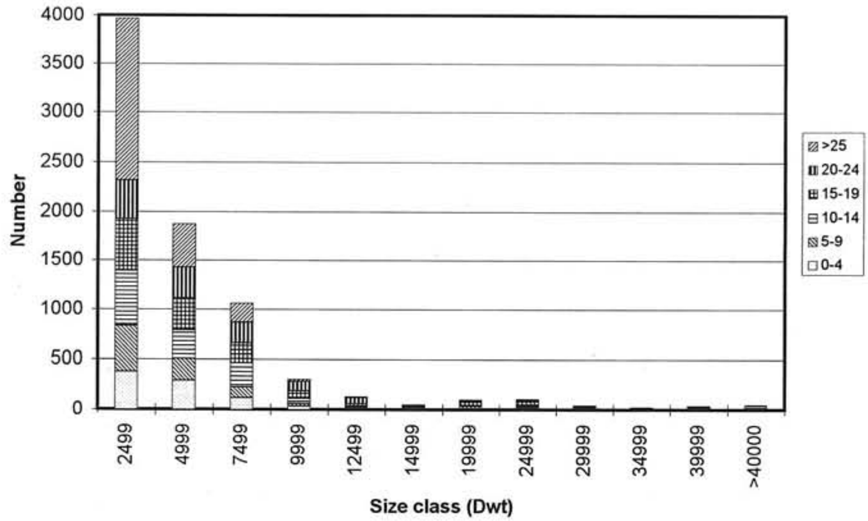


Figure 8: World single deck general cargo fleet

The single deck general cargo fleet by the end of 1994 had a total deadweight of 33.2 million tonnes, the average age amounted to 19.4 years. The number of newly built single deck general cargo ships slowly decreases, which explains the - high average age of the ships. About thirty per cent of the ships is older than 25 years.

7. General cargo - multi-deck

The table in **Figure 9** shows the subdivision of the world multi-deck general cargo fleet, which consists of 5,977 ships, by deadweight category and age group. The graph summarises this information in graphical form.

Dwt-size	Divison of age (years)						ships >= 300 grt/gt	
class	0-4	5-9	10-14	15-19	20-24	>25	Total	Average age
2499	57	129	240	350	261	885	1922	23.4
4999	61	82	268	255	204	263	1133	18.1
7499	19	45	142	116	102	89	513	17.4
9999	21	45	78	115	89	67	415	17.5
12499	7	10	14	72	74	110	287	24.3
14999	2	16	71	154	165	183	591	20.9
19999	12	37	147	375	220	78	869	17.6
14999	8	11	34	142	25	9	229	16.1
29999			7	6	1	1	15	16.1
34999							0	0
39999			1				1	11.0
>40000			2				2	10.7
Total	187	375	1004	1585	1141	1685	5977	20.1

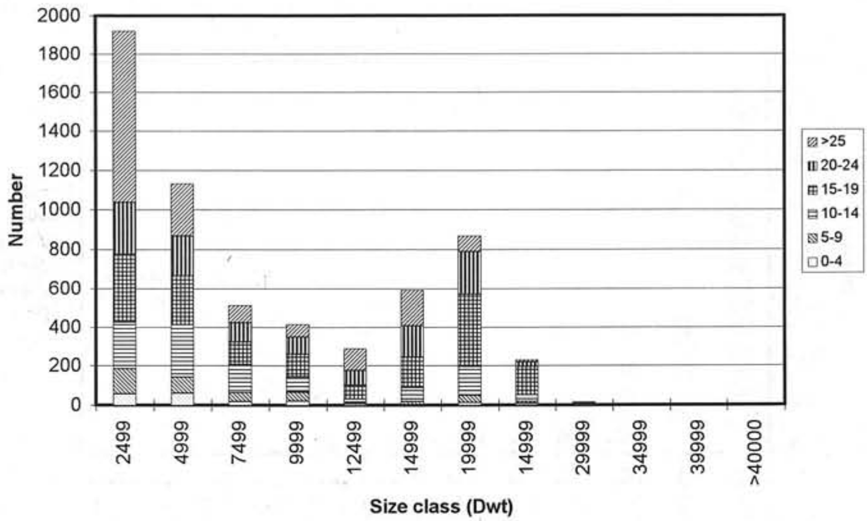


Figure 9: World multi-deck general cargo fleet

The multi-deck general cargo fleet by the end of 1994 had a total deadweight of 44.9 million tonnes, the average age amounted to 20.1 years. The past 10 years the number of newly built ships has decreased even more than the number of single deck general cargo ships.

3.3 Special fleet

8. Livestock and car carriers

The table in **Figure 10** shows the subdivision of the world livestock and car carrier fleet, which consists of 920 ships, by deadweight category and age group. The graph summarises this information in graphical form.

Dwt-size	Divison of age (years)						ships >= 300 grt/gt	
class	0-4	5-9	10-14	15-19	20-24	>25	Total	Average age
4999	54	76	62	83	56	149	480	17.9
7499	4	4	13	32	3	5	61	15.3
9999	7	10	12	9	6	1	45	12.3
12499	7	5	32	29	1	2	76	13.1
14999	6	29	34	25		3	97	12.0
19999	15	30	39	13	3	3	103	10.9
24999		6	5	1		1	13	11.0
29999	2	1	11			3	17	13.0
34999		1	4		2	1	8	17.3
39999				1		2	3	26.3
44999			2	2	1	2	7	18.6
49999					1		1	22.0
>50000			4		1	4	9	18.8
Total	95	162	218	195	74	176	920	15.5

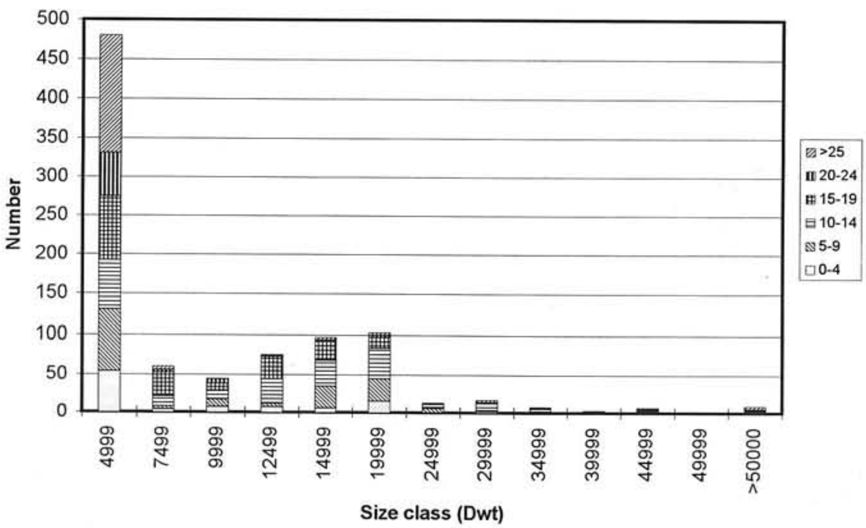


Figure 10: World livestock and car carrier fleet

The livestock and car carrier fleet by the end of 1994 had a total deadweight of 7.6 million tonnes, the average age amounted to 15.5 years. 50 per cent of the fleet consists of small ships, smaller than 2,500 dwt.

9. Reefer ships

The table in **Figure 11** shows the subdivision of the world reefer fleet, which consists of 1,461 ships, by deadweight category and age group. The graph summarises this information in graphical form.

Dwt-size	Divison of age (years)						ships >= 300 grt/gt	
class	0-4	5-9	10-14	15-19	20-24	>25	Total	Average age
2499	8	46	89	87	48	144	422	20.1
4999	12	43	51	63	34	75	278	17.7
7499	57	87	57	23	31	45	300	12.4
9999	29	32	55	57	33	14	220	13.6
12499	38	24	38	28	32	21	181	13.2
14999	17	9	12	2	5		45	8.1
19999	2	2		6	5		15	14.5
>20000							0	
Total	163	243	302	266	188	299	1461	15.8

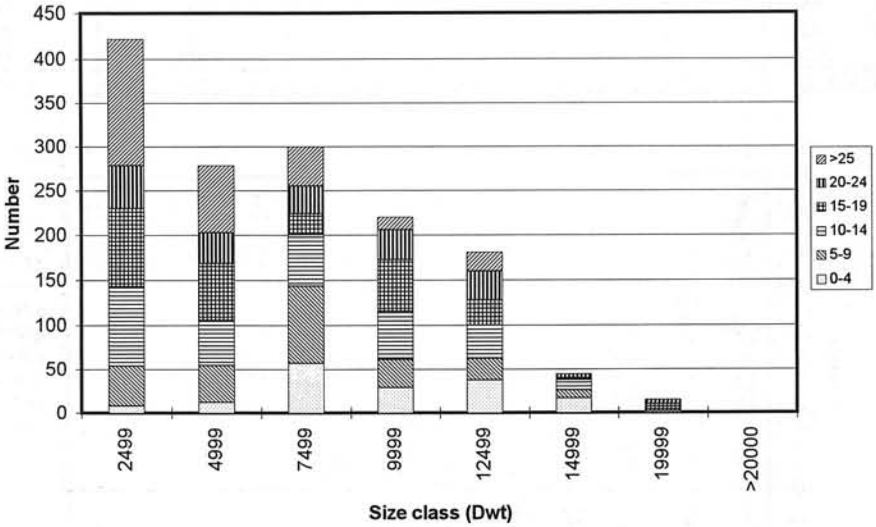


Figure 11: World reefer fleet

The reefer fleet by the end of 1994 had a total deadweight of 8.2 million tonnes, the average age amounted to 15.8 years.

10. Ro-ro cargo ships

The table in **Figure 12** shows the subdivision of the world ro-ro cargo fleet, which consists of 1,016 ships, by deadweight category and age group. The graph summarises this information in graphical form.

Dwt-size	Divison of age (years)						ships >= 300 grt/gt	
class	0-4	5-9	10-14	15-19	20-24	>25	Total	Average age
2499	20	26	67	83	59	92	347	18.9
4999	14	30	51	111	48	29	283	16.5
7499	15	22	36	44	27	4	148	13.9
9999	5	12	17	40	5		79	13.4
12499	3	8	1	19	3		34	13.1
14999	3	5	6	13	2		29	12.5
19999	3	1	7	11	4	1	27	15.0
24999		2	14	21	5		42	15.2
29999		1	1	5			7	14.5
34999	2			9			11	13.8
39999			1	1			2	13.9
>40000			7				7	11.5
Total	65	107	208	357	153	126	1016	16.3

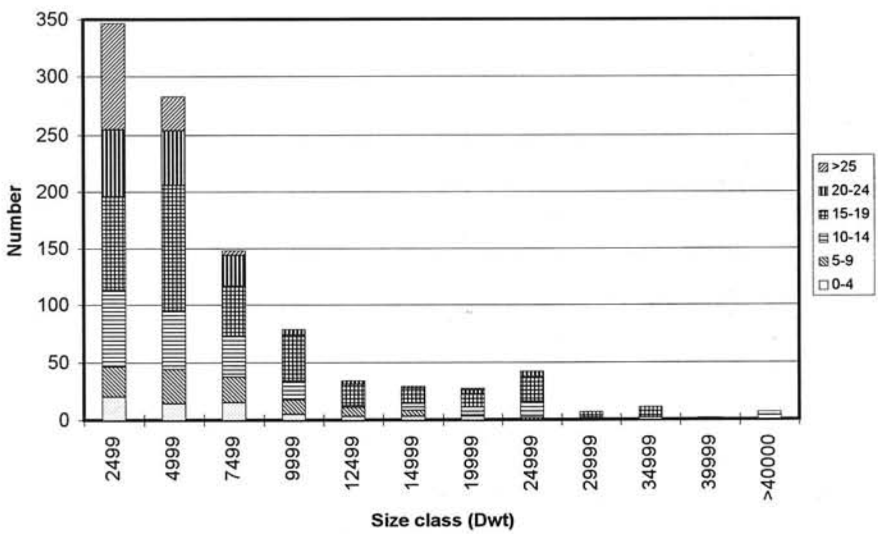


Figure 12: World ro-ro cargo fleet

The ro-ro cargo fleet by the end of 1994 had a total deadweight of 6.1 million tonnes, the average age amounted to 16.3 years.

11. Container ships

The table in **Figure 13** shows the subdivision of the world container ship fleet, which consists of 1,590 ships, by deadweight category and age group. The graph summarises this information in graphical form.

Dwt-size	Divison of age (years)						ships >= 300 grt/gt	
class	0-4	5-9	10-14	15-19	20-24	>25	Total	Average age
9999	73	34	83	89	68	32	379	13.8
14999	55	23	44	24	21	8	175	10.7
19999	23	19	18	55	18	12	145	14.1
24999	82	24	28	54	25	14	227	10.8
29999	17	19	35	23	24	15	133	14.1
34999	19	17	41	23	22	1	123	12.3
39999	11	13	26	19	11		80	12.7
44999	28	58	24	10	1		121	7.9
49999	45	16	2	13	15		91	8.6
59999	27	30	21	3			81	6.5
>60000	26	9					35	3.4
Total	406	262	322	313	205	82	1590	11.8

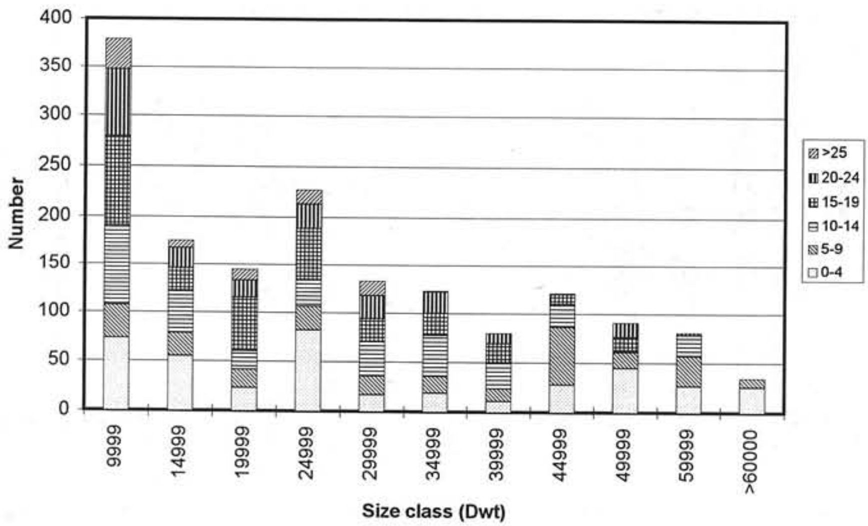


Figure 13: World container ship fleet (I)

The container ship fleet by the end of 1994 had a total capacity of 2.36 million TEU, the average age amounted to 11.8 years. The figures show that the fleet is relatively young and that the average size of the ships is steadily growing, as well as the total fleet size.

Dwt-size	Division of capacity (TEU)										
class	unknown	499	999	1499	1999	2499	2999	3499	3999	>4000	Total
9999	7	311	60		1						379
14999	4	3	127	41							175
19999	4		89	48	4						145
24999	2		19	154	43	8	1				227
29999	3		5	67	54	4					133
34999				10	81	28	4				123
39999				1	20	42	12	4		1	80
44999						9	74	32	5		120
49999						11	47	20	12	1	91
59999						2	2	20	23	32	79
>60000									12	23	35
Total	20	314	300	321	203	104	140	76	52	57	1587

ships >= 300 grt/gt

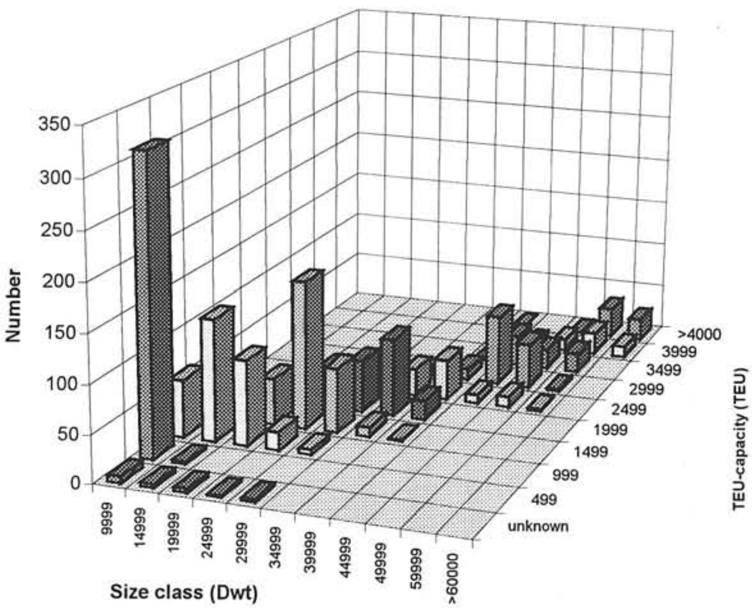


Figure 14: World container ship fleet (II)

Figure 14 shows the relation between the deadweight of container ships and the TEU capacity, by classifying the number of ships in each deadweight and each capacity category. The three-dimensional graph shows the same information in graphical form.

12. Cargo passenger and ro-ro passenger ships

The table in **Figure 15** shows the subdivision of the world cargo passenger and ro-ro passenger fleet, which consists of 2,138 ships, by deadweight category and age group. The graph summarises this information in graphical form.

grt/gt-size	Divison of age (years)						ships >= 300 grt/gt	
class	0-4	5-9	10-14	15-19	20-24	>25	Total	Average age
499	15	36	30	21	56	163	321	25.1
999	27	55	56	78	81	143	440	20.2
1499	13	36	26	35	34	63	207	19.8
1999	5	17	14	16	24	36	112	20.5
2999	19	34	17	21	29	67	187	19.5
4999	24	39	13	27	52	92	247	19.9
9999	16	29	34	39	102	81	301	20.2
14999	33	21	23	29	55	25	186	16.2
19999	8	7	9	10	6	3	43	13.9
24999	10	9	5	8	3	7	42	13.5
29999	5	4	3	3	2	1	18	11.6
34999	3	12	3	2			20	8.0
>35000	4	7	2			1	14	8.0
Total	182	306	235	289	444	682	2138	19.9

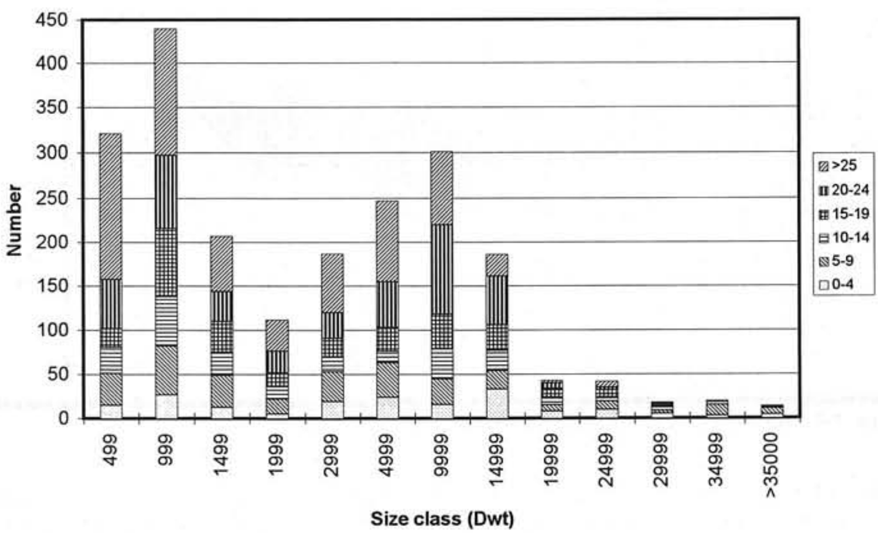


Figure 15: World cargo passenger and ro-ro passenger fleet

The cargo passenger and ro-ro fleet by the end of 1994 had a total deadweight of 10.2 million tonnes, the average age amounted to 19.9 years. More than 25% of the fleet consists of ships older than 25 years.

13. Passenger ships

The table in **Figure 16** shows the subdivision of the world passenger ships fleet, which consists of 1,073 ships, by deadweight category and age group. The graph summarises this information in graphical form.

grt/gt-size	Divison of age (years)						ships >= 300 grt/gt	
class	0-4	5-9	10-14	15-19	20-24	>25	Total	Average age
1999	165	182	71	69	61	239	787	17.2
4999	13	11	7	10	12	40	93	21.7
9999	9	11	2	3	6	32	63	22.0
14999	3	2	4		3	14	26	24.1
19999	3	1	1	2	3	8	18	23.6
24999		4			4	21	29	31.9
29999	2		1		3	4	10	20.2
39999	3	2	6			7	18	18.8
49999	1	6	3			1	11	9.5
59999	5	1					6	3.2
69999	1	2				1	4	9.8
74999	5	2					7	3.7
>75000						1	1	34.0
Total	210	224	95	84	92	368	1073	18.4

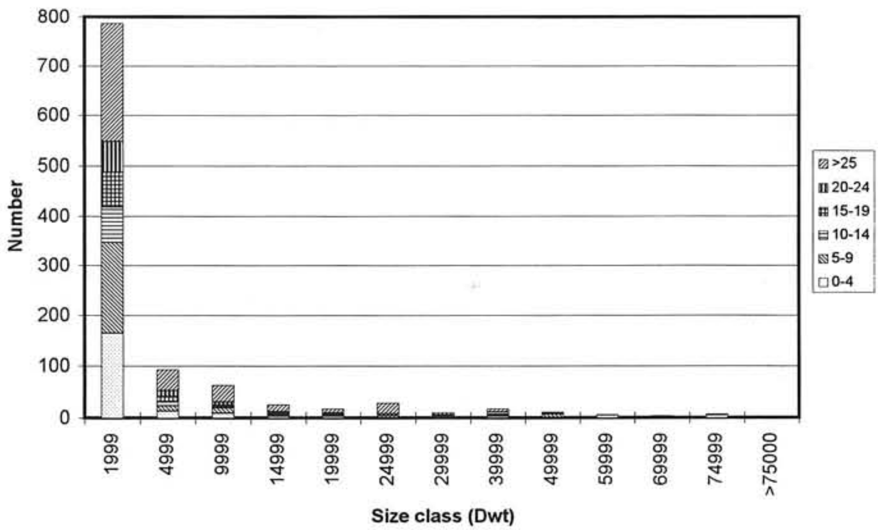


Figure 16: World passenger ship fleet

The passenger ships fleet by the end of 1994 had a total deadweight of 5.1 million tonnes, the average age amounted to 18.4 years. The fleet is relatively old. Most ships are older than 20 (45%) or younger than 10 (38%) years. The ships are small, 74% of the ships are smaller than 2,000 dwt. Almost all ships larger than 40,000 dwt are younger than 10 years.

14. Cruise ships

The tables in **Figure 17** shows the subdivision of the world cruise ship fleet, which consists of 222 ships. The first table shows the subdivision by deadweight, the second table shows the subdivision by age and the third table shows the subdivision by country of registration. The graph shows the subdivision by deadweight in graphical form.

grt/gt-size class	1995
4999	39
9999	36
14999	24
19999	25
29999	42
39999	18
49999	14
59999	7
69999	5
<= 80000	12
Total	222

ships >= 1000 grt/gt

Year of Build class	1995
<1946	2
1950	4
1955	14
1960	20
1965	25
1970	23
1975	26
1980	14
1985	18
1990	39
1995	37
Total	222

ships >= 1000 grt/gt

Flag country	1995
US	42
UK	24
Norway	22
Greece	33
Japan	12
Ukraine	16
Italy	9
Germany	8
Finland	8
Malaysia	3
Other	45
Total	222

ships >= 1000 grt/gt

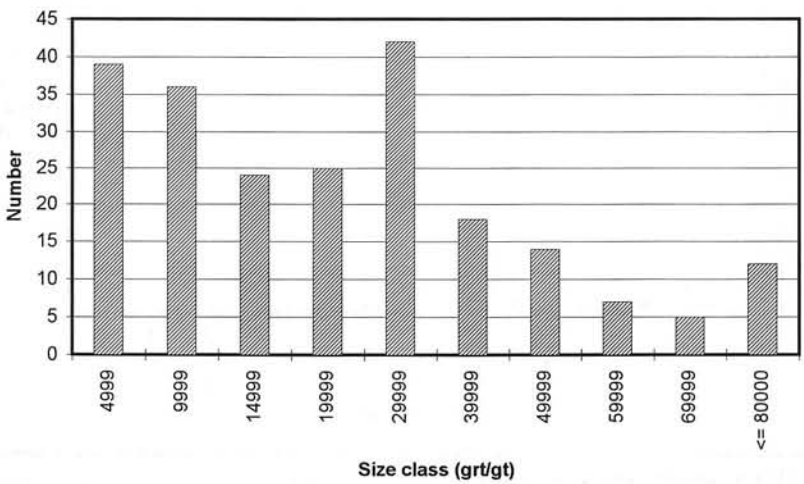


Figure 17: World cruise ship fleet

The cruise ship fleet by the end of 1994 had a total grt/gt size of 5 million. The fleet is relatively old. More than 45 per cent of the fleet is older than 23 years.

15. Fishing vessels

The table in **Figure 18** shows the subdivision of the world fishing vessel fleet, which consists of 23,450 ships, by country for the ten biggest fleets, divided up by *fish catching* and *other fishing*. The graph shows the number of ships for the ten biggest countries.

Flag	Fish catching			Other fishing			ships >= 300 grt/gt	
grt/gt rank	No.	Age		No.	Age		Total	grt/gt-%share
Russia	2272	15		284	15		2556	34.5
US	2851	20		24	34		2875	6.1
Japan	2360	11		120	11		2480	5.5
Ukraine	300	15		29	20		329	4.5
Korea	1113	22		59	15		1172	3.8
Spain	1326	22		2	20		1328	3.6
Norway	509	23		17	32		526	2.1
Panama	609	22		8	23		617	2.1
Lithuania	146	16		6	29		152	2.0
Argentina	358	19		4	23		362	1.5
Other	10865			188			11053	34.7
Total	22709			741			23450	

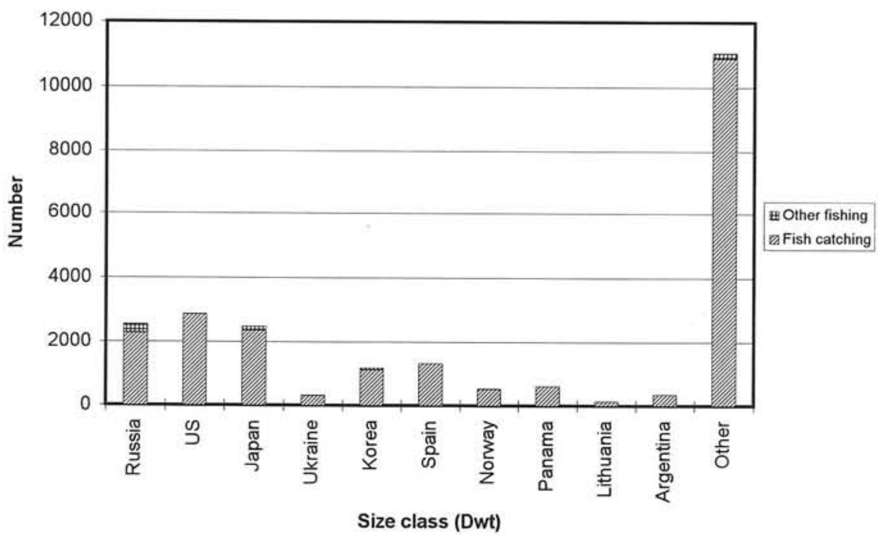


Figure 18: World fishing vessel fleet

The fishery fleet by the end of 1994 had a total grt/gt size of 13.0 million, the average age amounted to respectively 18 and 17 years. The overview shows that a large part of the fishery fleet is concentrated in three countries: Russia, Japan and the United States of America. Together they make up 35% of the number of vessels and 46% of the grt/gt size of the entire world fleet.

16. Offshore service vessels

The table in **Figure 19** shows the subdivision of the world offshore service vessel fleet, which consists of 3,213 ships, by type of vessel and age. The graph summarises this information in graphical form.

Type of vessel	Divison of age (years)				ships >= 100 grt/gt	
	1-5	6-10	11-15	15>	Total	%-share
Anchor handling tug/supply	28	91	470	526	1115	34.7
Anchor handling tug	4	6	44	254	308	9.6
Crew boat	2	17	43	59	121	3.8
Diving support		5	30	54	89	2.8
Gravel/stone discharge		1	1	8	10	0.3
Heavy lift/crane ship		3	5	5	13	0.4
Heavy deck cargo carrier		1	11		12	0.4
Maintenance	3		17	38	58	18.8
Mooring		1	9	2	12	0.4
Multifunctional support	2	3	10	8	23	0.7
Oilwell service	2	5	6	25	38	1.2
Platform supply	19	8	40	45	112	3.5
Pipe layer	1		3	12	16	0.5
Pollution control		1	1	1	3	0.1
ROV/submersible support		1	3	14	18	0.6
Standby/Rescue	9	7	31	172	219	6.8
Supply	9	14	248	365	636	19.8
Survey	16	24	60	153	253	7.9
Utility/workboat	5	7	80	65	157	4.9
Total	100	195	1112	1806	3213	

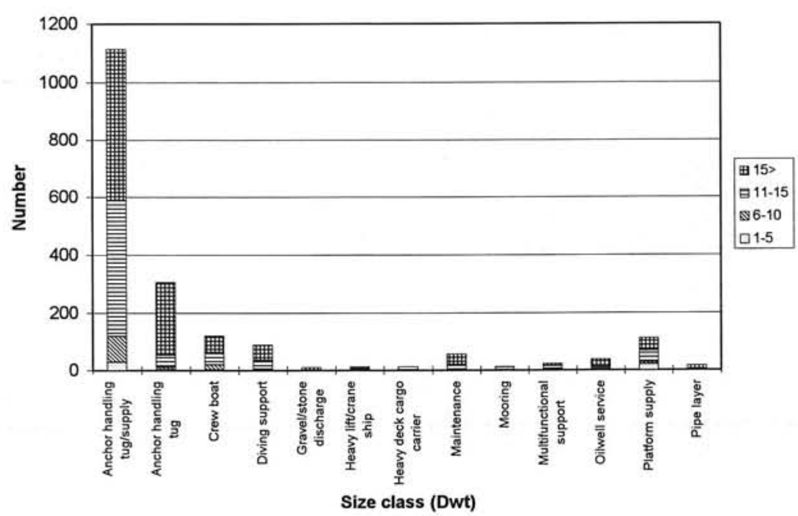


Figure 19: World offshore service vessel fleet

17. Research vessels

The table in **Figure 20** shows the subdivision of the world research vessel fleet, which consists of 1,110 ships, by flag and type. The graph summarises this information in graphical form. This overview shows that the USSR owns, by far, the largest fleet

Flag	Fishing research		Special research		Other research		ships >= 100 grt/gt	
grt/gt rank	No.	grt/gt%	No.	grt/gt%	No.	grt/gt%	Total	grt/gt-%share
Russia	34	29.5	84	26.4	65	24.5	183	26.3
Ukraine	9	8.8	6	0.6	27	22.3	42	9.2
US	9	1.9	73	12.0	37	.8	119	8.9
Panama	6	1.3	54	16.1	12	1.6	72	8.8
Norway	7	2.9	26	9.0	12	6.1	45	7.0
China	3	1.2	23	65	26	5.0	52	5.1
Japan	43	14.3	14	2.5	14	4.2	71	5.0
UK	7	3.4	15	2.9	13	4.0	35	3.4
Germany	11	4.6	19	2.7	16	3.5	46	3.3
Canada	8	2.5	16	2.4	14	1.9	38	2.3
Other	142	26.2	135	18.9	130	23.1	407	20.7
Total	279		465		366		1110	

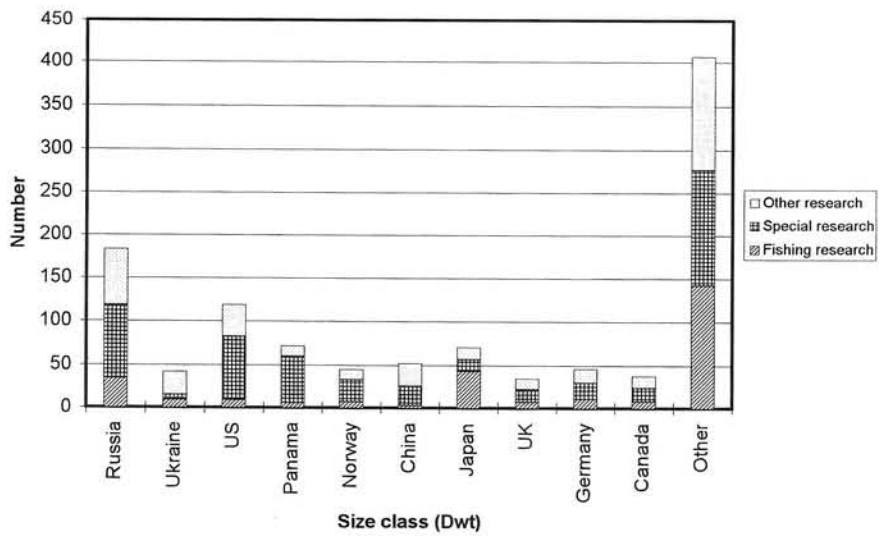


Figure 20: World research vessel fleet

CHAPTER 4: WORLD SHIPBUILDING

4.1 Overview

Shipping and shipbuilding have been very closely related until 1960, when the traditional shipping nations started to lose their market share in the construction of ships, in particular to Japan.
Figure 1 shows the development of the world shipbuilding output over the period 1960-1995. This graph clearly illustrates the phenomenal 'overshoot' in output since the early 1970s. The rise and collapse of the shipbuilding output occurred in between the oil crises of 1973 and 1979. The world output peaked in 1975 with 34 million gt, which fell in 1988 to an all-time low of 10.9 million gt.

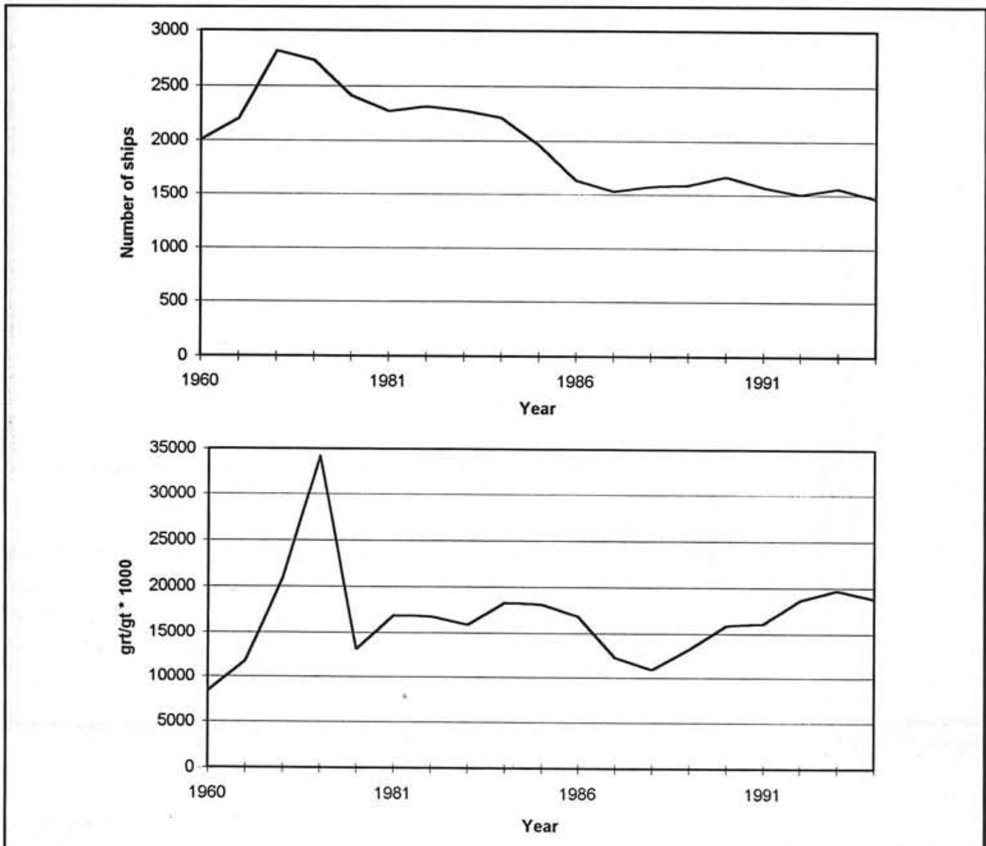


Figure 1: World shipbuilding

In this period the world shipbuilding fortunes have dramatically changed, in particular the complete disappearance of the building of large vessels in Northwestern Europe, and the emergence of South Korea as a contender to the dominant position of Japan. By 1995, the Koreans are on the verge of taking over the leading role of Japan in terms of shipbuilding output. The next decade will show the rapid increase in Chinese shipbuilding output, which in turn will challenge the top-slot positions of Japan and Korea.

Figure 2 shows the development of the output in gt and number of ships of the Dutch and Norwegian shipbuilding sector over the same period. The output in both countries peaked in 1975, after which it decreased dramatically.

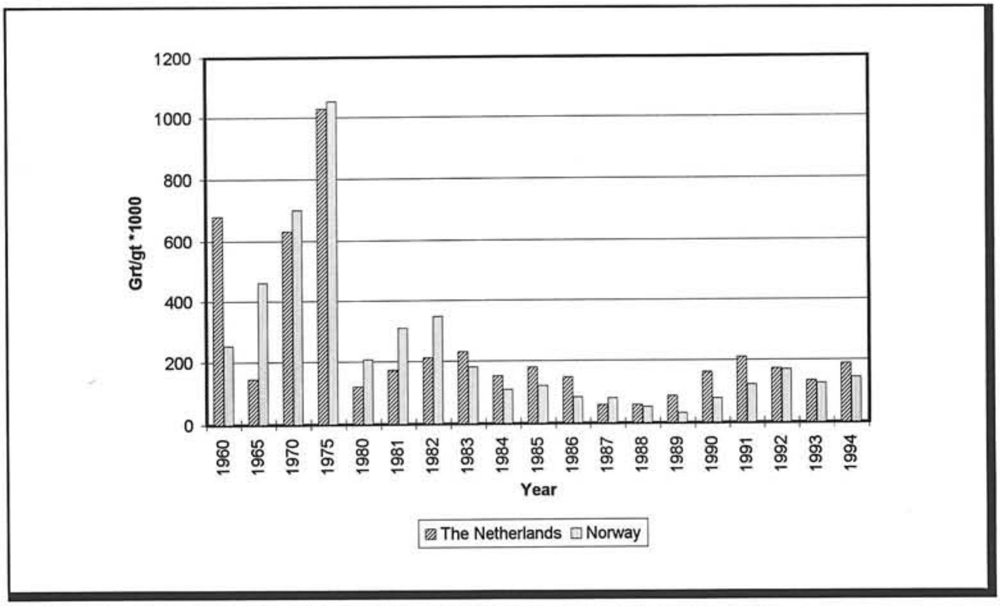


Figure 2: Output of the Dutch and Norwegian shipbuilding sector

Fairplay's *"Newbuilding Review"* contains a summary of all vessels on order by country of build. These statistics are shown for November 1995, in abbreviated form in **Table I** and it shows that Dutch yards have 61 ships on order with an aggregate deadweight of 285,938, while Norwegian yards have 15 ships on order with 273,600 dwt. In deadweight terms, The Netherlands and Norway are ranked number 23 and 24 on the list of the world largest shipbuilding nations. South Korea and Japan take the top positions with respectively 27 million dwt and 24.2 million dwt, of a total world order book of 78.4 million dwt.

The reversal of fortune in shipbuilding is clearly illustrated by **Figure 3** showing a world merchant fleet of 34,743 ships and 662.6 million dwt (1993), segmented by major regions and year of built. This graph shows the dominance of both Europe and North America in the period up to 1970, and later the decline, as well the growth of both Japan and South Korea in more recent decades.

Country	Dry cargo		Container		Tanker		Bulker		Ro-ro		Total	
	No.	Dwt*	No.	Dwt*	No.	Dwt*	No.	Dwt*	No.	Dwt*	No.	Dwt*
S. Korea	12	59	100	3,412	103	12,338	119	10,944	11	260	345	27,014
Japan	94	314	73	2,608	141	9,030	192	12,133	13	159	513	24,245
China	42	612	12	86	26	938	79	2,854	-	-	159	4,490
Poland	10	44	76	1,578	7	180	20	1,161	2	13	115	2,975
Taiwan	2	19	6	136	1	2	19	2,050	-	-	28	2,208
Germany	28	161	83	1,911	4	75	-	-	2	14	117	2,161
Romania	31	117	2	13	19	610	20	1,306	1	1	73	2,109
Ukraine	23	119	-	-	23	878	9	630	2	9	57	1,636
Spain	10	54	12	144	21	935	2	3,256	6	44	51	1,503
Italy	-	-	2	72	16	426	7	5,212	13	214	38	1,233
Denmark	11	65	10	462	11	266	4	298	1	5	37	1,096
Brazil	2	39	7	182	6	226	10	549	1	17	26	1,013
Russia	40	196	-	-	6	61	12	578	1	13	59	849
Croatia	6	128	1	35	12	419	6	253	-	-	25	835
USA	-	-	-	-	9	295	4	105	6	361	19	761
UK	-	-	-	-	7	317	3	331	1	10	11	658
Bulgaria	10	68	-	-	21	94	12	311	-	-	43	473
India	4	9	-	-	3	196	7	228	-	-	14	433
Indonesia	23	166	-	-	10	115	4	127	-	-	37	409
Turkey	21	179	7	66	2	3	2	150	1	4	33	402
Singapore	-	-	4	45	23	174	5	118	-	-	32	336
Finland	-	-	-	-	4	274	1	13	-	-	5	287
Netherlands	26	109	13	76	14	45	3	32	5	24	61	286
Norway	-	-	-	-	8	216	-	-	7	58	15	274
France	-	-	-	-	5	237	-	-	-	-	5	237
Argentina	-	-	-	-	5	114	-	-	-	-	5	114
Yugoslavia	16	82	-	-	-	-	-	-	-	-	16	82
Slovakia	17	65	-	-	-	-	-	-	-	-	17	64
Portugal	1	5	2	10	4	23	1	9	-	-	8	46
Malaysia	-	-	2	12	2	13	1	16	-	-	5	41
Sweden	-	-	-	-	-	-	1	24	1	6	2	30
Egypt	3	18	-	-	-	-	1	7	-	-	4	24
Iran	1	3	-	-	3	8	-	-	-	-	4	11
Philippines	-	-	-	-	2	10	-	-	-	-	2	10
Belgium	-	-	-	-	1	10	-	-	-	-	1	10

*) tonnes * 1,000

Source: Fairplay 16th November 1995

Table I: Newbuildings

The rise and decline of the shipbuilding sector in The Netherlands and in other European countries such as UK and Sweden is well documented in the doctorate thesis of C. de Voogd. The study spells out the dramatic and often painful process of restructuring, and compares the shipbuilding sector in this respect with other industrial sectors, such as coal mining. The redundant coal mining industry and its labour force in the southern part of The Netherlands were successfully transformed into new economic activities, is more than one can say about the restructuring of the shipbuilding sector.

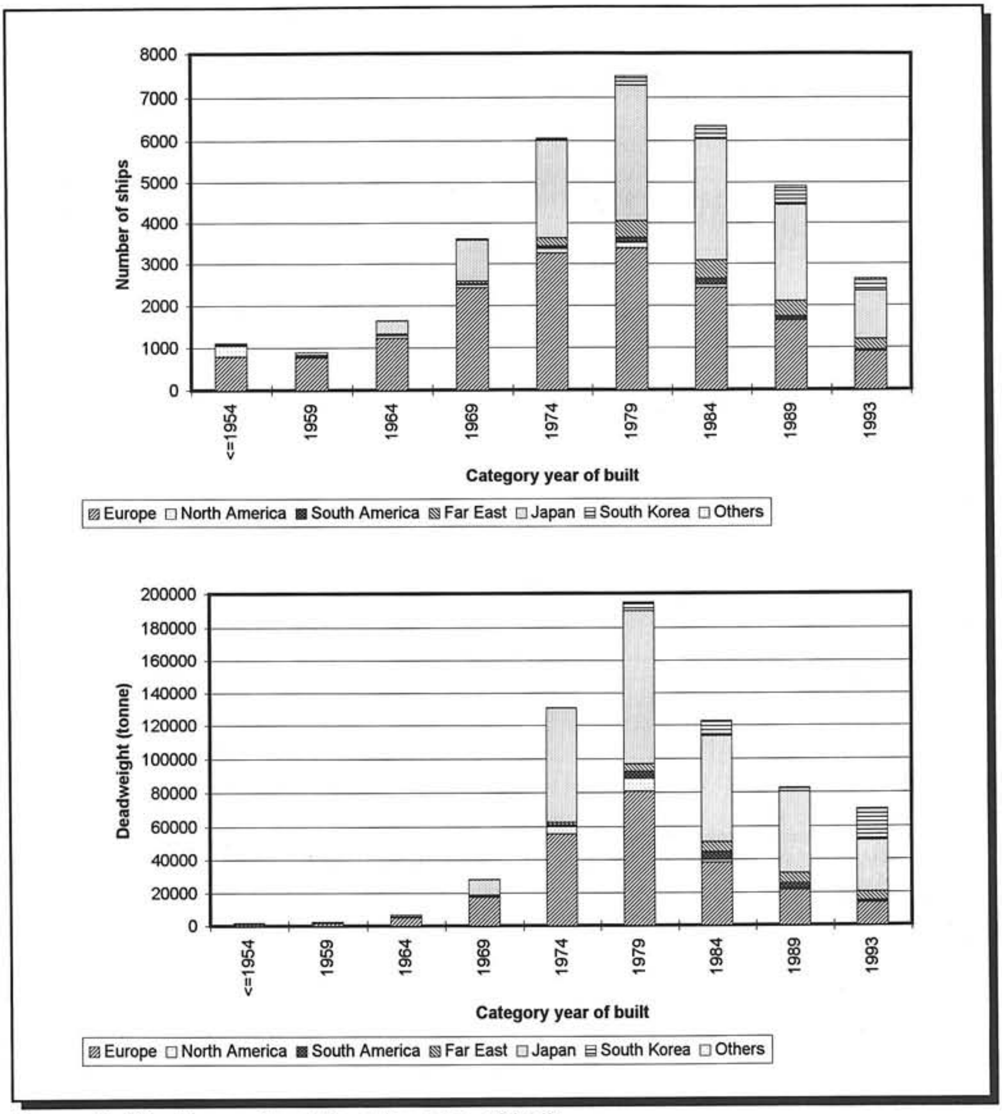


Figure 3: World merchant fleet by area of built

The decline in shipbuilding output and increase in productivity are reflected in the development of the work force in shipbuilding and ship repair in Western Europe (**Figure 4**). From an all-time high of more than 460,000 in 1975, the labour force declined to 144,000 in 1992.
A similar pattern of contraction can be found in Japan, and to a lesser extent in South Korea. China is the only major shipbuilding nation that has developed an increase in labour force since 1975. This is illustrated in **Table II**.

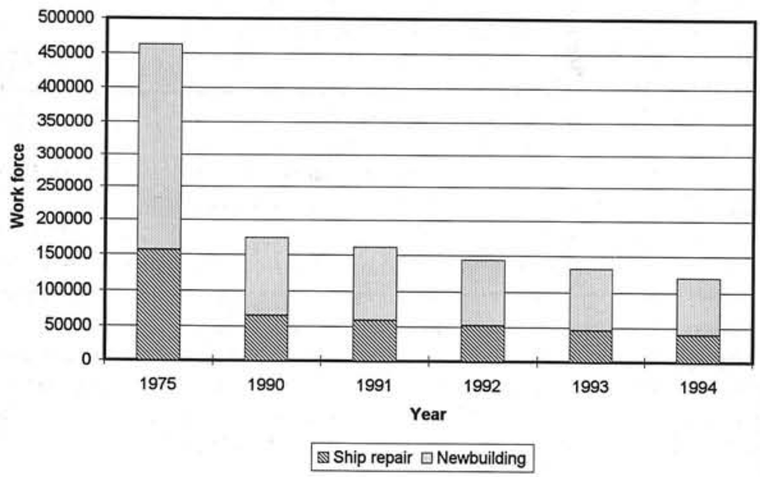


Figure 4: Work force in Western European shipbuilding industry

Year	Japan (SAJ member firms)	South Korea (KSA member firms)	Western Europe (AWES member firms)	China (7 dockyards)	Total
1975	160.5	11.0	350.0	40.0	561.5
1980	74.5	35.0	230.0	47.0	386.5
1985	73.0	51.0	165.0	55.0	344.0
1989	35.1	35.5	116.5	57.5	244.6
1990	35.4	38.9			
1992	40.6	36.2	115.5	56.0	248.3
1994	40.2	38.7			

Unit: 1,000 persons

Table II: Shipbuilding sector's employees of major shipbuilding companies

Many industry observers predict a similar fate for the Japanese shipyards in the face of the Korean and Chinese competition. However, the Japanese have reduced their work force through shipyard closures and a phenomenal investment in productivity enhancement equipment and software.

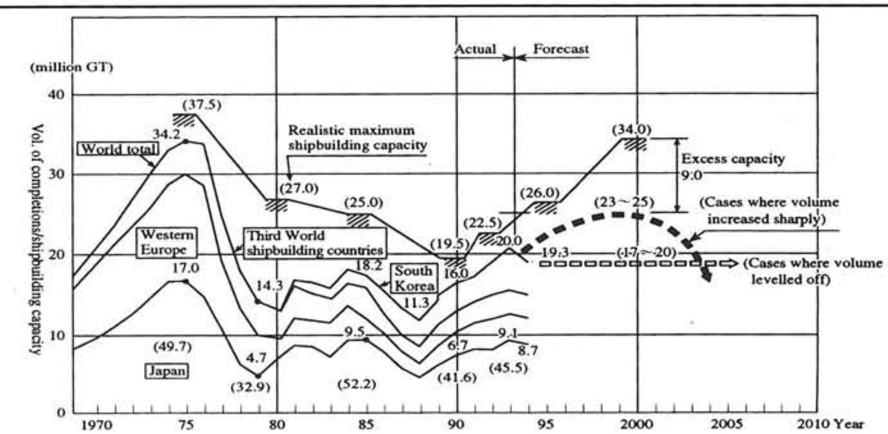
The Japanese Maritime Research Institute (JAMRI) regularly publishes in-depth studies on world shipbuilding with respect to the changing competitive positions, refered to earlier. In their study *"Trends of World Shipping and Shipbuilding in 1994 and Prospects for 1995"*, a number of tables illustrate the changing competitive position of world shipbuilding over the period 1988-1994.

Table III shows the newbuilding completions by country. If these figures are compared with the ships on order (**Table I**), than the rise of South Korea becomes even more visible, as this country has become the largest shipbuilder in terms of order book, however not yet in terms of completions.

Table IV shows the distribution of the newbuilding by major ship types over the same period. In deadweight terms, oil tankers, dry bulk carriers and container ships made up the largest segments. In number of ships, the general cargo ships and fishing vessels are also relevant.

The relationship between shipbuilding output and capacity is shown in **Figure 5**. Based on the existing expansion plans of shipyards, especially in Korea (Halla), the projected shipbuilding capacity will increase sharply in the years to come. As a consequence, it is likely that a large overcapacity is in the making and in conjunction, a new shipbuilding crisis. **Table V** shows the extent of the capacity plans from Japan, Korea, Western Europe and other countries.

The newbuilding capacity will by the year 2000 be back at the historic level of 1975, which at that time marked the collapse of the world shipbuilding industry. What will happen in the meantime? Will it again become a survival of the fittest? Much will depend on the competitive position of the shipyards.



Notes: 1. Merchant ships of 100 GT and above.
2. Figures in ( ) represent % share against the world total. Third World shipbuilding countries' figures up to 1979 include South Korea.
3. Realistic maximum shipbuilding capacity values in and after 1995 were calculated by taking into account South Koreas's and China's shipbuilding capacity expansions plans, manpower increases and productivity improvement.

Sources: Lloyd's calassification society for volume of construction; JAMRI report for shipbuilding capacity; JAMRI for forecast.

Figure 5: Trends of newbuilding construction

Country\year	1988	1989	1990	1991	1992	1993	1994 (est.)
Japan	**4,023**	**5,609**	**6,661**	**7,348**	**7,633**	**9,086**	**8,700***
South Korea	**3,178**	**3,516**	**3,441**	**3,733**	**4,513**	**4,467**	**4,800***
AWES contries	**2,011**	**2,473**	**2,939**	**3,061**	**3,149**	**3,816**	**3,250***
Belgium	55	40	59	11	111	3	
Denmark	324	399	408	490	378	960	520
France	78	165	63	110	132	41	160
Germany	812	752	874	821	874	963	975
Greece	7	6	19	9	0	1	
Italy	161	343	392	508	388	469	620
Netherlands	69	98	185	220	162	152	190
UK	52	117	127	108	228	229	160
Finland	169	234	256	149	197	182	120
Norway	57	48	88	132	179	161	170
Sweden	29	17	27	41	20	1	
Spain	156	234	367	440	382	556	240
Portugal	12	20	74	22	98	98	90
Other countries	**2,100**	**2,905**	**2,954**	**2,714**	**3,304**	**2,656**	**2,550***
China	220	401	402	499	581	476	520
Taiwan	502	406	669	515	698	590	500
Brazil	42	167	255	251	267	315	220
USA	18	17	22	36	66	14	
Former USSR	414	391	415	254	279	285	
Poland	289	205	139	183	347	331	660
Yugoslavia	270	503	462	357	9	2	
Rumania	132	335	181	198	187	120	
Others	313	480	409	421	421	523	
Total	**11,312**	**14,503**	**15,995**	**16,856**	**18,599**	**20,025**	**19,300***

Unit: 1,000 gt

*) Appoximated values

Table III: Newbuilding completions

Ship type/year	1988	1989	1990	1991	1992	1993	1994
Oil tanker	3,567	5,220	4,434	6,773	8,780	9,921	5,600
Chemical tanker	563	245	547	473	509	362	
Combination carrier	243	196	-	616	854	242	120
Bulk carrier	2,127	4,092	5,588	3,203	2,573	4,018	5,500
Container ship	1,474	1,267	1,627	1,956	2,044	2,150	2,300
General cargo ship	815	862	1,026	1,313	1,813	543	
Reefer	281	293	408	320	349	386	
Ro-ro	1301	797	569	600	900	870	
Liquefied gas carrier	28	504	661	729	646	787	600
Passenger ship	188	197	413	364	341	359	
Fishing vessel	474	432	402	289	223	180	
Others	251	248	320	221	197	206	
Total	**11,312**	**14,503**	**15,995**	**16,865**	**18,559**	**20,025**	

Unit: 1,000 gt

Ship type/year	1988	1989	1990	1991	1992	1993
Oil tanker	160	172	145	171	221	273
Chemical tanker	75	77	100	116	95	95
Combination carrier	3	6	0	8	5	5
Bulk carrier	114	126	172	126	113	113
Container ship	40	44	68	78	94	94
General cargo ship	299	324	355	388	232	232
Reefer	49	50	58	49	45	45
Ro-ro	101	110	93	72	72	72
Liquefied gas carrier	9	33	47	55	33	33
Passenger ship	105	107	118	96	81	81
Fishing vessel	802	742	632	486	323	232
Others	337	349	285	274	230	230
Total	**2,094**	**2,140**	**2,073**	**1,919**	**1,833**	**1,505**

Unit: Number of ships

Table IV: Distribution of newbuildings by ship type

Area/year	1975	1980	1985	1990	1995 (est.)	2000- (forecast)
Japan	18.0 (48%)	11.5 (43%)	11.0 (44%)	7.0 (36.%)	10.0 (39)	12.0 (35%)
South Korea	1.0 (3%)	1.5 (5%)	3.0 (12%)	4.0 (20.5%)	6.5 (25%)	9.0 (26%)
Western Europe	14.0 (37%)	10.0 (37%)	4.5 (23%)	4.5 (23%)	5.0 (19%)	7.0 (21%)
Others	4.5 (12%)	4.0 (15%)	4.0 (16%)	40 (20.5%)	4.5 (17%)	6.0 (18.%)
Total	37.5	27.0	25.0	19.5	26.0	34.0

Unit: million gt

Table V: World's newbuilding capacity (realistic maximum shipbuilding capacity)

4.2 Competitive position of shipyards

What factors determine the competitive position of shipyards? **Figure 6** provides some of the answers for the relative positions of Japan and South Korea. The figure shows the cost difference between the two countries for the major inputs, such as steel, engines, labour and other. According to this graph, the Korean yards have a cost advantage of 8%.

Table VI shows a cost comparison made by JAMRI (in: *"Recent changes in the South Korean Shipbuilding industry and its future prospects"*, August 1994) for the Japanese, Korean and Chinese yards. This table clearly demonstrates the cost advantage of Korea and China over Japan.
How can the Japanese yards compete in the future? The answer is rather straightforward in the absence of subsidies: By increasing productivity. **Table VII** compares some important aspects of productivity for Japanese, Korean and Chinese yards.

This table reveals the structural differences between the competitive advantages of each nation. Given these fundamental differences, one should not count the Japanese yards out, in the battle for market share in world shipbuilding. Some of the major yards are determined to stay in the race by investing heavily in new plant and equipment.

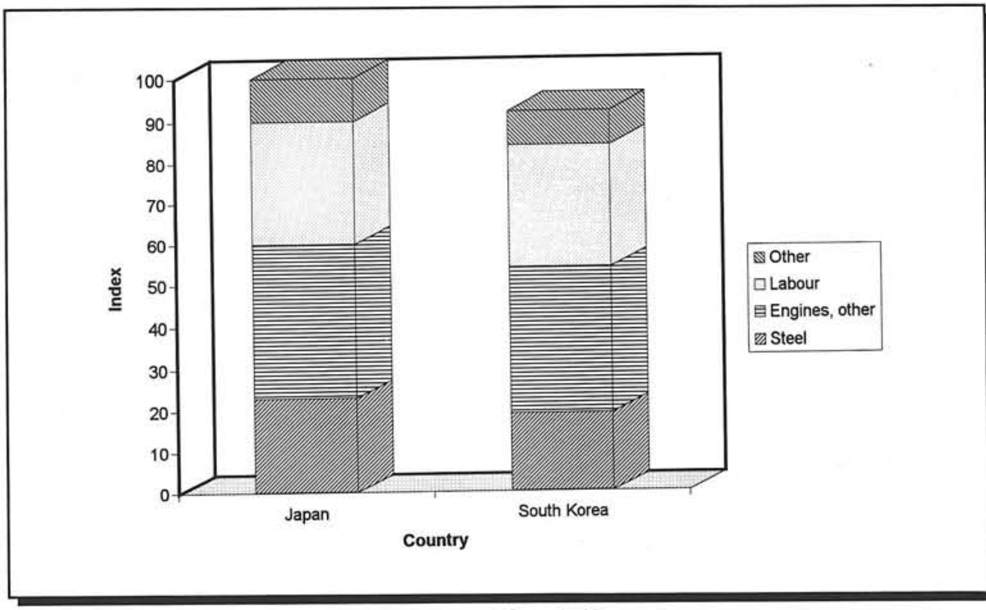


Figure 6: Shipbuilding costs in Japan and South Korea

Division	Items	Japan	South Korea	China
Building costs	a. Material costs (%)	65	66	66
	- Steel materials	*25*	*23*	*24*
	- Main engine	*9*	*10*	*10*
	- Other	*31*	*33*	*32*
	b. Manpower costs (%)	25	27	28
	c. Other expenses (%)	10	6	6
	Exchange rate in US$	110 Yen	800 Won	5.7 Yuan
	Building costs index	100	80	85
	Import dependence for materials	5-15%	30-40%	60-70%
	Steel materials costs (index)	100	80	85
Wages	a. Real term wage 1990 (Yen)	400,000	220-150,000	12,000
	- Same 1993	430,000	290-200,000	17,000
	b. Hourly wages (US$)	15	7-4	0.55
	c. Wage hike per year	2-3%	12-15%	10-15%
	d. Material cost increase per year	1-2%	7-8%	
Ship prices (VLCC)*	1983	100	90	
	1990	100	95-105	
	1992	100	90-95	80-90
	1993	100	80-85	93

*) Index: Japan = 100

Table VI: Comparison of Japanese, Chinese and South Korean shipbuilding

Division	Item	Japan	South Korea	Remarks
Productivity	a. Man hours (10,000)			
	- 280,000 dwt VLCC	38-45	70-80	Single hull
	- 280,000 dwt DH VLCC	55-65	85-95	Double hull
	- 150,000 dwt tanker	30	64	Single hull
	b. Hours worked (hrs/m)	175	230	
	c. Productivity (Japan = 1.0)	1.0	0.7-0.3	Hull 2/3-1/3
	- Growth rate hereafter	3-5%	8-10%	Outfit 1/3-1/4
Automation/ computerisation	a. Automation rate (%)			Robots are not being utilised in South Korea's shipbuilding
	- Welding	80-90	50	
	- Cutting	90	20	
	- Painting	20	5	
	b. Computerisation design (%)	80	35	
Technical competence	a. Design techniques	100	80-85	
	b. management techniques	100	75	
Labour force	a. Shipbuilding sector	41,000	36,250	
	b. Average age (year)	42	35	

Table VII: Productivity of South Korean shipbuilding industry compared with Japan

How do the European yards fare at the competitive level? In a study by KPMG Peat Marwick for the Commission of the European Communities in 1992, the competitiveness of European yards is considered in more detail. The consultant found that the European shipbuilding industry is very fragmented, which is illustrated by the small share of major shipbuilding groupings. This is in contrast to the Japanese and Korean groupings, which are often part of a conglomerate including shipowners, charterers, ship suppliers, financiers, trading houses and shipbuilders. KPMG made the distinction between smaller yards and main international yards in Europe, which have different profiles.

Smaller yards typically:

- Build for EU based owners and cite other EU builders as the main competition;
- Mainly build dry cargo ships, small tankers, fishing and service vessels;
- Have low overhead operations with limited management resources.

Main international yards typically:

- Target a wider base of owners and compete more directly with Japanese, Korean and Finnish shipbuilders;
- Mainly build container ships, tankers, bulk carriers, passenger vessels, reefers and dredgers;
- Have more resources in non-direct production activities.

Table VIII shows a comparison of the EU yard average performance indicator, with the figure 100 representing the average for all international yards. The overview results show significantly more use of best practice in Japanese yards compared to the EU average group, with the exception of the design/technical area. Korean yards were broadly similar to the EU average group but with particular strength in marketing and weakness in purchasing. There are also significant differences in the best practices across European yards.

	EU average group	Japan	South Korea
Strategy/management	98	116	98
Marketing	89	109	128
Purchasing	96	118	84
Human resources	108	115	115
Design/Technical	97	97	92
Planning	84	113	84
Production	100	107	109
Over-all	96	111	104

Table VIII: Use of technology

4.3 The Dutch shipyards

The Dutch yards are among the yards with the highest productivity in Europe, as the study *"Concurrentiepositie Nederlandse Scheepsbouw 1984-1992"* illustrates. In order to compare the productivity of shipyards, a new measure was developed in the 1970s called the compensated gross tonnes (cgt). This indicator adjusts the different ship types to a common denominator in terms of required labour input. It will be self-evident that the man-hour requirement of ten ships of 2,500 dwt will be higher than of one ship of 25,000 dwt. The background of the cgt development can be found in *"Tonnen-arbeid"*, *"Schip & Werf"* no. 14, 1983, by ir. Saurwalt.

The world shipbuilding output in 1992 amounted to 12.1 million cgt, and the share of the European shipbuilders (AWES) was 3 million cgt. The Dutch yards produced in 1992 400,000 cgt, which is the result of a relatively high complexity factor attached to the ships built. This complexity factor is based on the ratio cgt/gt, the compensated gross tonnes divided by the gross tonnage. **Table IX** shows the development of the complexity ratio for the various AWES countries over the period 1989-1992. In 1992 the Dutch and Norwegian yards built ships with the highest complexity, respectively 1.80 and 1.67.
The Dutch yards work with many subcontractors, which results in a relatively high labour productivity at the yards itself. The productivity was in 1991 81 cgt per man year, which is the highest of the AWES countries (average 35 cgt), almost

the same as the Japanese productivity, which in that year was 82 cgt/man year. **Table X** shows the growth of the labour productivity over the years 1985-1991.

	1989	1990	1991	1992
Belgium	1.30	1.20	2.72	1.11
Denmark	0.66	0.68	0.70	0.64
France	1.31	1.84	1.62	1.61
Germany	1.18	1.27	1.14	1.03
United Kingdom	1.18	1.56	0.91	0.84
Italy	0.88	0.85	0.85	0.82
The Netherlands	2.02	1.86	1.82	1.80
Portugal	1.91	0.93	2.22	0.60
Spain	1.38	1.04	0.94	0.78
Finland	1.70	1.63	1.54	1.16
Norway	2.66	2.22	1.69	1.67
Sweden	2.73	5.09	5.97	1.39
AWES	1.21	1.21	1.10	1.01

Source: AWES

Table IX: Complexity of ships delivered (cgt/gt)

	1985	1988	1989	1990	1991	Average growth
Belgium	35	23	27	21	29	-2.9
Denmark	43	33	36	40	43	-0.1
France	20	26	19	32	33	8.2
West Germany	34	34	39	42	45	4.8
United Kingdom	11	13	11	17	25	14.4
Italy	10	21	22	29	31	21.3
The Netherlands	42	51	62	64	81	11.5
Portugal	7	5	10	11	14	12.1
Spain	17	20	23	28	31	10.9
Finland	30	34	44	43	37	3.9
Norway	30	35	36	41	46	7.0
Sweden	34	46	37	33	35	0.5
AWES	24	25	26	32	35	6.7
Japan	69	62	68	77	82	2.9
South Korea	23	26	29	31	35	7.7
Taiwan	30	24	27	27	31	0.4
Poland				6	8	

Source: AWES

Table X: Productivity of the shipyards (cgt/man year)

Productivity should also be related to labour cost, which is also relatively low in The Netherlands. This results in the lowest level of labour cost per cgt: US$ 600-690. **Table XI** shows a comparison for three years (1990-1992) of the labour cost development in a number of countries. The table also shows the number of hours worked per year, which highlights the large discrepancy between the countries in Western Europe and the Far East. The most striking extremes are Portugal (1,415 hours per year) and South Korea (2,360 hours), a difference of 67%.

	Labour costs per man year (1,000 US$)			Hours worked 1990	Costs per hour (US$) 1990
	1990	1991	1992		
Belgium	33.7	35.4	39.5	1,750	19.3
Denmark	34.7	34.9	38.3	1,725	20.2
France	37.4	37.8	41.9	1,755	21.3
West Germany	40.5	41.8	48.4	1,700	23.8
United Kingdom	24.2	25.8	30.5	1,775	13.6
Italy	32.3	34.0	36.5	1,460	22.1
The Netherlands	34.2	34.7	39.0	1,730	19.7
Portugal	13.0	14.8	17.8	1,415	9.2
Spain	28.5	30.3	33.7	1,660	17.2
Finland	42.8	43.4	40.6	1,610	26.5
Norway	34.3	34.8	37.7	1,550	22.2
Sweden	37.5	39.6	42.3	1,670	22.2
AWES	33.4	34.6	38.1		
Japan	38.7	43.5	47.7	1,980	19.6
South Korea	13.0	13.6	14.1	2,360	5.5
Taiwan	15.0	16.8	19.1	2,300	6.5
Poland	2.4	3.8	3.8	1,650	2.3

Table XI: Labour costs

The picture of labour cost becomes even more complex when the exchange rates of the major currencies are considered. The roller coaster development of the US dollar, which is the dominant currency in the shipping world, affects to a large extent the competitive position of the different countries.

Finally, the cost of construction has to be balanced against the revenues of the ship sales. **Table XII** shows the average revenue per compensated gross tonne in US$ in the AWES countries over the years 1988-1990. These revenues surpris-surprise by differering substantially by country. The average AWES figure of US$ 2,867/cgt is high in comparison to the Dutch yards average of US$ 2,075 in 1990.

	1988	1989	1990
Belgium	2,290	2,686	2,897
Denmark	2,830	3,003	3,173
France	2,447	2,493	2,807
West Germany	1,313	1,439	1,793
United Kingdom	1,955	2,129	1,678
Italy	2,997	2,850	2,831
The Netherlands	1,885	1,941	2,075
Portugal	998	985	943
Spain	1,969	2,976	3,910
Finland	2,609	2,720	2,611
Norway	1,700	2,971	3,334
Sweden	2,474	2,529	3,036
AWES	2,074	2,696	2,867

Source: AWES

Table XII: Revenues per cgt in US$

4.4 Shipyards and shipbuilding costs

The world shipyards are segmented by Clarkson Research Studies into three leagues. The Major League consists of 69 yards with a total operational capacity of 9.91 million cgt. The Minor League consists of 102 yards with a total operational capacity of 2.285 million cgt. The Little League consists of 103 yards with a total operational capacity of 0.985 million cgt.
Table XIII, **Table XIV** and **Table XV** show the names and capacities of the major yards in each league. **Figure 7** and **Figure 8** show the location of the major yards in Europe and the Far East.

The relative success of some yards in securing newbuilding orders depends on a number of factors, which all contribute to the single most important factor: Newbuilding costs. These are:

- Simplicity of the design and/or its (easy) manufacturability;
- Labour productivity and level of automation;
- Costs of labour and steel;
- Foreign exchange rates;
- Subsidies.

Figure 9 shows the comparative labour costs in US$/hour in a number of countries for three years: 1980, 1990 and 1994 (source: Ocean Shipping Consultants). This graph shows the phenomenal increase in labour costs in the two major shipbuilding nations Japan and South Korea. The South Korean costs are still the lowest, apart from of course China, which is not shown in the graph.

Shipbuilder/Shipyard			Capacity				
Yard	Owner/city	Country	No. Docks	No. Berths	Length (m)	dwt (tonnes)	cgt (1,000)
Hyundai H.I	Ulsan	S. Korea	7	1	660	1,000	1,364
Daewoo S.B.	Okpo	S. Korea	2		530	1,000	780
Samsung S.B.	Samsung	S. Korea	2		339	310	615
Mitsubishi H.I.	Nagasaki	Japan	5	2	375	545	463
China S.B. Corp.	Kaaohsiung	Taiwan	1		950	1,000	371
Hitachi Zosen	Ariake	Japan	2		503	545	340
Imabari S.B.	Marugame	Japan	2	1	268	155	310
Namura Zosensho	Imari	Japan	1		280	155	274
Mitsui	Chiba	Japan	3		365	435	252
Kawasaki H.I.	Sakaide	Japan	3		390	645	250
Hashihama Zosen	Todotsu	Japan	1	1	271	197	241
Oshima S.B. Co.	Oshima	Japan	1		270	155	235
IHI	Kure	Japan	3		370	547	207
Nippon Kokan Kk	Tsu	Japan	1		373	479	205
Odense Staalsb	Lindo	Denmark	3		415	650	187
Sasebo H.I.	Sasebo	Japan	1	1	375	459	183
Harland & Wolf	Belfast	UK	1		556	1,000	183
Onomichi Dockyd	Onomichi	Japan		1	255	103	179
B & W	Copenhagen	Denmark	1		240	90	178
H.D.W.	Kiel	Germany	4		426	700	177
Tsuneishi Zosen	Numakuma	Japan	1	2	248	122	173
Sumitomo H.I.	Oppama	Japan	1		358	428	161
Sanoyusa Dock	Mizushima	Japan	1		270	155	158
Shin Kurushima	Onshi	Japan	2		260	149	157
Brod. Split	Split	Croatia		4		160	121
Koyo dock Kk	Mihari	Japan	5	1	330	308	102
Stoczz. Szczecin	Szczecin	Poland		5	251	40	89
Hudong Shipyard	Shanghai	China		10	254		61
Constantza S.Y.	Constantza	Romania	2		260	200	61
Kvaerner Masa	Turku	Finland	1		365	400	60
Thyssen Nordsee	Emden	Germany		3	286	125	57
Hanjin H.I.	Busan	S. Korea	4	4	301	150	56
Jos L. Meyer	Papenburg	Germany	1	2	370	155	51
Stocznia Komuny	Gdynia	Poland	2		380	320	46
G. Dimitrov S.Y.	Varna	Bulgaria	2		237	100	44
Kawasaki H.I.	Kobe	Japan	4	2	236	105	40
Mitsubishi H.I.	Kobe	Japan	4	4	290	165	38
Dalian	New Yard	China	2	1	365	280	26
Fincantieri	Genoa	Italy	3		285	140	21
De l'Antlantique	St. Naziare	France	1		900		

Definition of large shipyards: Yards able to produce ships greater than 90,000 dwt or longer than 250 m.

Table XIII: Large shipyards

Shipbuilder/Shipyard			Capacity				
Yard	Owner/city	Country	No. Docks	No. Berths	Length (m)	dwt (tonnes)	cgt (1,000)
Inchon S.B.	Inchon	S. Korea	1	3	220		129
Imabari S.B.	Imabari	Japan	2	1	163	29	79
Saiki H.I.	Saiki	Japan		2	155	14	88
Jiangnan S.Y.	Shanghai	China	3		232		86
Hitachi Zosen	Maizuru	Japan	2	1	238	77	73
I.H.I.	Tokyo	Japan	2	1	172	39	73
Dalian Shipyard	Dalian	China		3	290	80	72
Minami Nippon	Usuki	Japan		1	178	33	68
Danyard A/S	Frederiksh.	Denmark		1	132	10	67
Brod. Uljanik	Pula	Croatia		2	173	80	65
Kvaerner - Govan	Govan	UK		3	275	78	59
Shanghai Shipyard	Shanghai	China		2	255	39	54
Stocznia Gdansk	Gdansk	Poland		6	280	55	51
Meeres - Technik	Wismar	Germany		2		38	51
Fincantieri	Ancona	Italy	1	1	240		49
Hakodate Dock	Hakodate	Japan	2	1	180	44	46
Naikai Shipbuilding	Innoshima	Japan		2	176	34	45
Cochin S.Y. ltd.	Cochin	India	1		255	86	43
J.J. Sietas	Hamburg	Germany	2		250	22	38
Kherson Shipyard	Kherson	Ukraine				39	37
Santierul Naval	Mangalia	Romania	2		200	36	34
Kvaerner Warno.	Floroe	Norway				65	32
Kleven	Warnem.	Germany				35	28
Galatz Shipyard	Galatz	Romania	1	2	235	60	28
Chernomorskiy	Nikolayev	Ukraine				39	26
Ulstein Hatlo	Ulsteinvik	Norway		1	130	20	24
Guangshou S.Y.	Guangshou	China		3	277	40	22
Caneco S.A.	Rio de Jan.	Brazil	3	2	220	80	14
Xingang S.Y.	Tianjin	China	2	2	264	30	14
Cant. Apuania	M. Di. Car.	Italy	3		200	60	12
Ast. Del Nervion	Bilbao	Spain		1	50	15	9
Admiralteiskiy	St. Petersb.	Russia				60	
Seebeckwerft	Bremerh.	Germany	6	1	161	50	
Hindustan S.Y.	Visakhapat.	India	1	2	247	50	
Finnyards	Rauma	Finland		2	200	45	
Mitsubishi H.I.	Shimonos.	Japan	2	1	190	43	
Baltiyskiy	St. Petersb.	Russia				32	
Alexandria S.Y.	Alexandria	Egypt		2	180	15	
A.E.S.A.	Sevilla	Spain		2	201		

Definition of medium sized shipyards: Yards able to produce ships of 10,000 to 90,000 dwt or a length between 140 and 250 m.

Table XIV: Medium sized shipyards

Shipbuilder/Shipyard			Capacity				
Yard	Owner	Country	No. Docks	No. Berths	Length (m)	dwt (tonne)	cgt (1,000)
Kyokuyo Zosen	Schimonos.	Japan	1		110	7	50
IJsselwerf B.V.	Capelle	Netherl.				2	45
Higaki Zosen	Imabari	Japan		1	110	7	45
Ørskovs Staal.	Frederiksh.	Denmark		1	130	6	34
Dea Dong S.B.	Busan	S. Korea		4	210	8	34
Flensburger S.B.	Flensburg	Germany	1		161	9	30
Brod. J.L. Mosor	Trogir	Croatia		3		5	30
Fukuoka S.B.	Fukuoka	Japan		1	110	8	24
Singmarine S.Y.	Singapore	Singapore		10	100		22
Nishi S.B. Co.	Imabari	Japan		2	120		21
Malaysia S.Y.	Johore	Malaysia		1	123	8	21
Cant. Benetti	Viareggio	Italy		5	70		14
Sembawang	Singapore	Singapore			213	20	8
Brattvaag Skipsw.	Brattvaag	Norway				3	13
Sovikses Verft	Sovikgrend	Norway				5	11
Kochi H.I.	Kochi City	Japan		2	80	7	10
Kodja Bahari	Tanjung Pr.	Indonesia					8
Ching Fu S.B.	Kaohsiung	Taiwan				6	8
Cant. Nav. Pesaro	Pesaro	Italy				5	7
Ferguson S.B.	Glawgow	UK					6
Wuhu Shipyard	Wuhu	China				8	
Italthai Marine	Bangkok	Thailand				8	
Volkswerft	Stralsund	Germany	1		101	4	
Nordsøvaerftet	Ringkøbing	Denmark		1	90	3	
C.N.S.	Vigo	Spain		1	160	2	
Van der Giesen	Krimpen	Netherl.		3	110		
Frysian S.Y.	Harlingen	Netherl.		1	110		
Qiuxin Shipyard	Shanghai	China	1		88		
Marytown S.Y.	Marytown	Canada		4	76		
Rodriquez	Messina	Italy		4			

Definition of small shipyards: Yards able to produce ships of less than 10,000 dwt or a length less than 140 m.

Table XV: Small shipyards

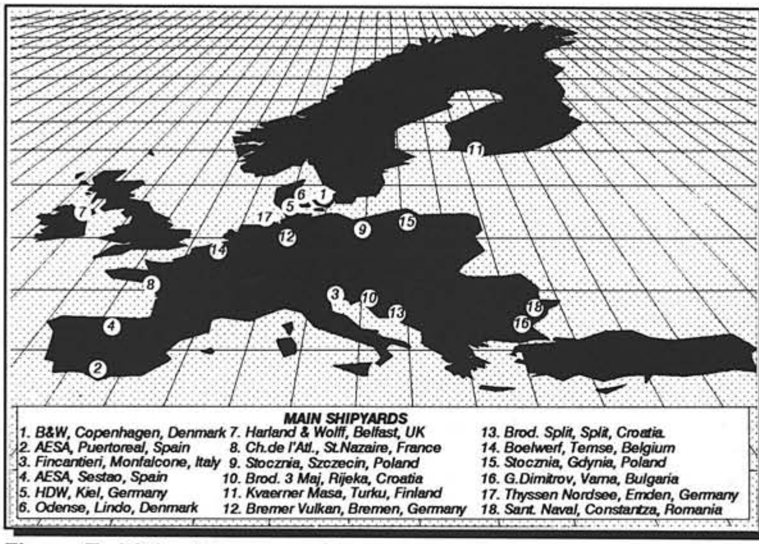


Figure 7: Major European shipyards

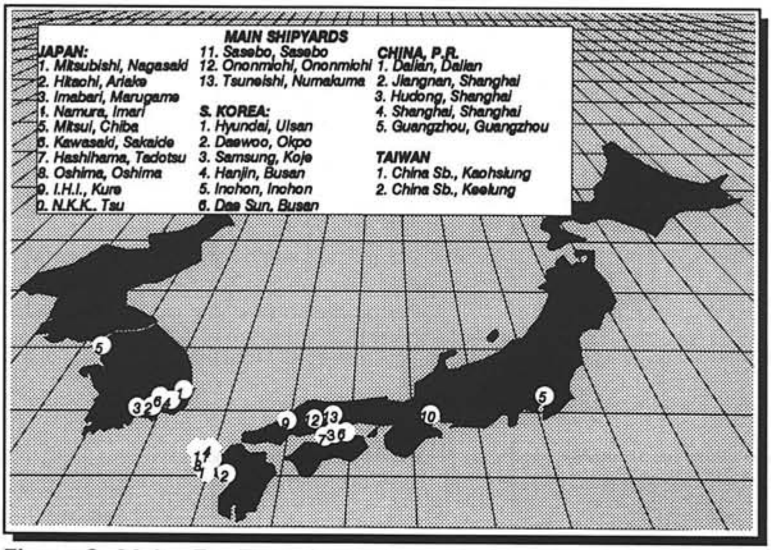


Figure 8: Major Far East shipyards

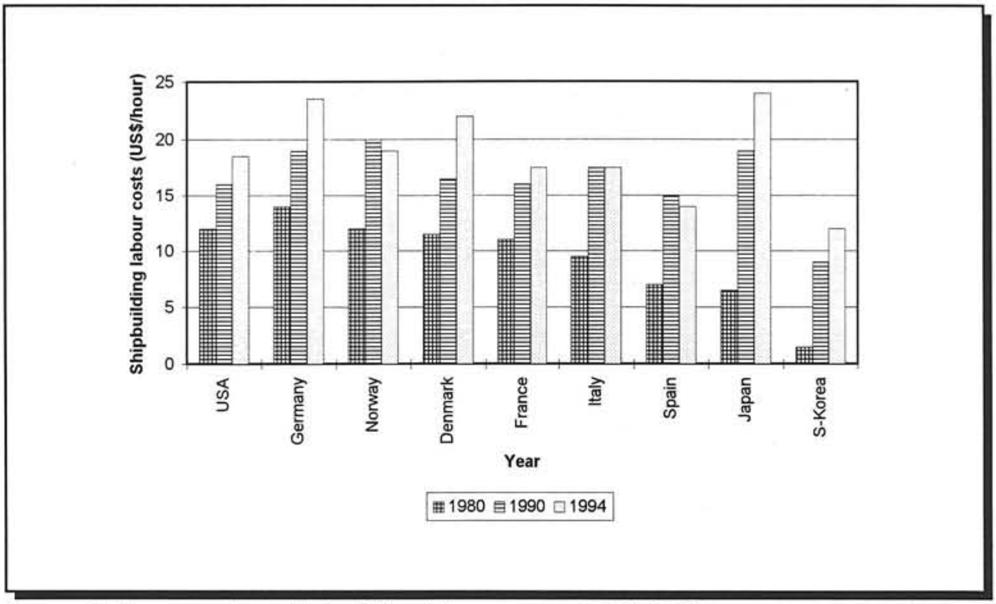


Figure 9: Comparative shipbuilding labour costs 1980-1994

Table XVI shows the basic prices of steel plate in Japan and the UK in local currencies and in US$. The price in dollars of the major factor input into a ship, steel, has sharply risen in Japan, while the price in Yen is more or less constant. This illustrates the importance and impact of the foreign exchange rates movements for the competitiveness of the yards.

Figure 10 shows the ratios of three currencies (Yen, Won, Deutschmark) to the USdollar as an index over the period 1990-1995. The appreciation of the Yen has been 40%, while the USdollar increased in value in relation to the Won. The impact of the exchange rate fluctuations can be illustrated by the newbuilding prices of a Panamax bulk carrier, expressed in three different currencies: Yen, USdollar and Won. **Figure 11** shows the value of the same ship over time in each currency.

	Japan		UK	
	Yen/tonne	US$/tonne	£/tonne	US$/tonne
1991	68,265	512	287.0	508
1992	65,792	518	273.0	484
1993	61,000	549	283.4	425
1994	52,000	532	241.0	367
- June	51,000	530	285.5	428
- Aug	51,000	510	285.5	440
- Sep	51,000	504	305.5	483
- Oct	52,000	511	305.5	486
- Nov	52,000	507	305.5	486
- Dec	52,000	521	305.5	486
1995				
- Jan	51,000	502	325.0	517
- Feb	51,000	519		
- Mar	52,000	573		
- Apr	52,000	627		
- May	51,000	588		
- Jun	51,000	605		

Table XVI: Basic steel plate prices

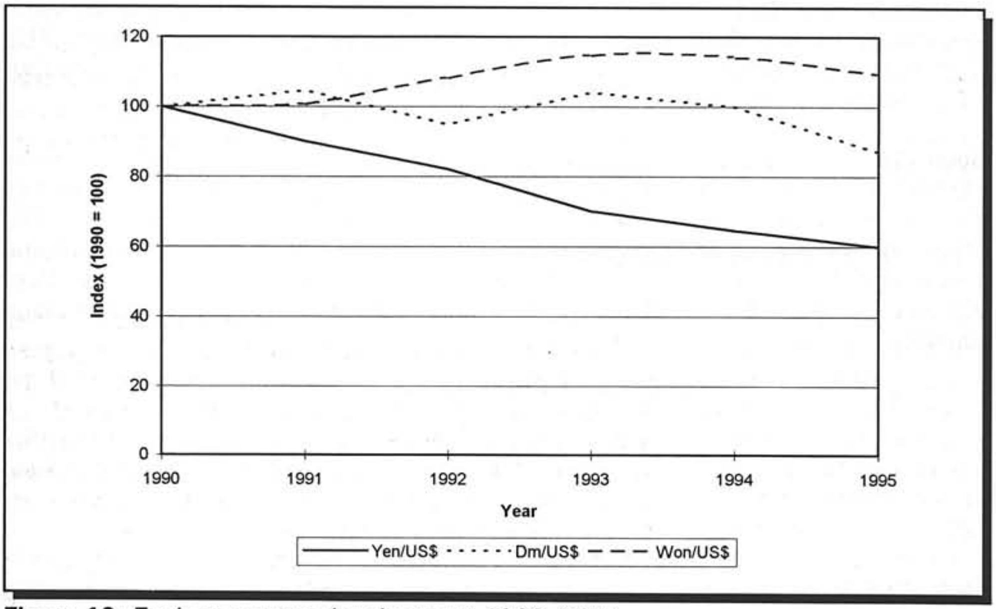


Figure 10: Exchange rates development 1990-1995

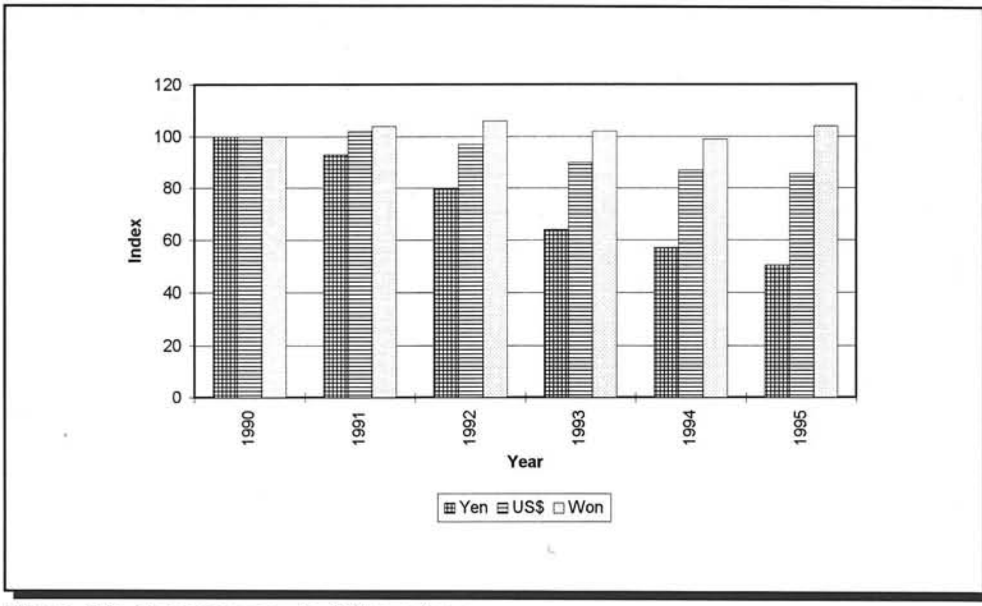


Figure 11: Panamax newbuilding prices

4.5 Methodology for analysing the shipbuilding industry

As seen in previous sections, the world shipbuilding industry is spread over many countries and many yards. They are producing a multitude of different vessels, ranging from standard bulk vessels to highly sophisticated gas carriers, cruise vessels and research vessels. It is, therefore, not obvious how one should go about analysing the many markets for building ships.

4.5.1 One, global shipbuilding market

From an economic point of view, the main question must be: Is it relevant to talk about one world market for the building of ships? It may be relevant to aggregate if either the products are very homogeneous (which they are clearly not) or if the capacity offered is fairly homogeneous and technology diffusion fairly rapid, so that the links between the various segments are strong. It can be argued whether this is the case in shipbuilding. To see this, one can inspect the price development for a number of different ship types. If prices are strongly correlated, this is a clear indication of market segments being closely connected.

In **Figure 12**, some newbuilding prices are given for the period 1970-1994, and in **Table XVII** the partial correlation coefficients among prices for 12 different ship types are given for the same period. The prices behind **Table XVII** have been corrected for the purchasing power of US$ and are deflated by a general US$ deflator to give comparable prices over time, while **Figure 12** contains actual prices in the money of the day.

	Ro-Ro	Bulk	Prod.c.	LPG	Cont.	Bulk	Tank	LPG	LNG	Bulk	Tank	Tank
Size (1000 dwt)	5 dwt	30 dwt	30 dwt	24 m^3	3.5 TEU	70 dwt	80 dwt	75 m^3	125 m^3	120 dwt	130 dwt	250 dwt
Ro-Ro 5	1											
Bulk 30	0.68	1										
Prod.c. 30	0.81	0.92	1									
LPG 24	0.85	0,97	0,84	1								
Cont. 3.5	0.79		0.63	0.82	1							
Bulk 70	0.66	0.90	0.91	0.96		1						
Tank 80	0.90	0.93	0.98	0.82	0.65	0.66	1					
LPG 75	0.78	0.93	0.91	0.84	0.86	0.91	0.86	1				
LNG 125	0.66	0.60	0.65	0.95	0.83	0.48	0.78	0.60	1			
Bulk 120	0.80	0.89	0.96	0.86	0.80	0.94	0.97	0.96	0.62	1		
Tank 130	0.94	0.98	0.96	0.84	0.67	0.80	0.97	0.92	0.78	0.97	1	
Tank 250	0.41	0.60	0.69	0.86	0.69	0.56	0.87	0.69	0.78	0.70	0.90	1

Source: Haddal & Knudsen (1996)

Table XVII: Correlation coefficients among newbuilding real prices 1970-1994

As the table quite clearly indicates, all segments show a price development where the prices are quite closely correlated to those of other segments. The lowest correlation is for the partial relation between the VLCC and the 5,000 dwt Ro-Ro, which is not too surprising. The average correlation coefficients for 12 ship types studied (average correlation with the 11 other ship types) is shown in **Table XVIII.**

Ship type	Average correlation	Ship type	Average
Ro-Ro 5.000 dwt	0.75	Tank 80,000 dwt	0.86
Bulk 30.000 dwt	0.77	LPG 75,000 m^3	0.83
Prod.c. 30.000 dwt	0.85	LNG 125,000 m^3	0.71
LPG 24.000 m^3	0.88	Bulk 120,000 dwt	0.85
Cont. 3.500 dwt	0.75	Tank 130,000 dwt	0.89
Bulk 70.000 dwt	0.79	Tank 250,000 dwt	0.70

Table XVIII: Average price correlation coefficients 1970-94

All coefficients are above 0.70, so the general conclusion must be that newbuilding prices are affected by the same market forces over time, so one of the criteria for aggregation seems to be fulfilled.

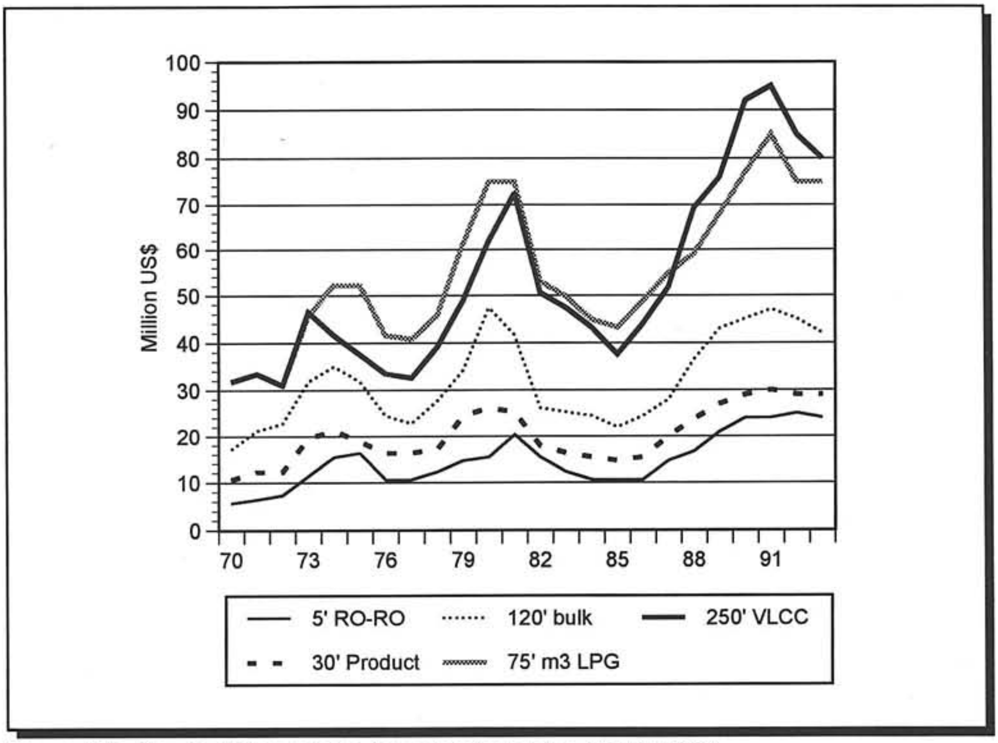


Figure 12: Newbuilding prices for selected ships 1970-1994

Technological diffusion is more difficult to observe and measure. One possibility is to examine a market segment where technological development is fairly rapid and the final product fairly advanced. In a study of fast passenger ferries, a database of about 1300 vessels was constructed. By comparing the total number of ships produced per year with the number of active yards in each year, a picture as **Figure 13** emerges.

It is very interesting to note that the number of active yards is directly proportional to the volumes produced. That means that it seems like almost any yard could produce fast ships if the demand is high. There does not seem to be a time lag in this mechanism either. This implies that technological diffusion is fast in shipbuilding and shipbuilding capacity is in principle very flexible, which is the important point if one wishes to aggregate.

A common measurement of capacity and production is important if one wants to compare individual productions that may be very different in composition. The usual measurement of dwt or gt is not particularly good, as there is hardly a one to one correspondence between each of these measures and the amount of work a yard must put into producing different vessels. For that purpose a new measurement was introduced to better reflect the amount of work that goes into the various ship types. By multiplying the gross tonnes with a correction factor, which

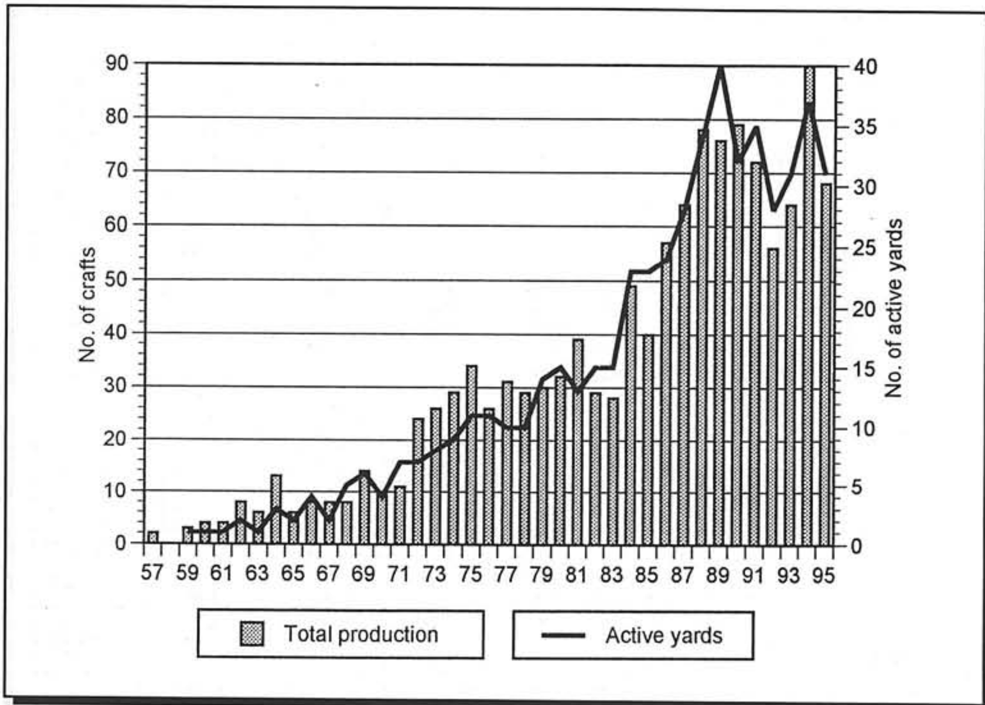


Figure 13: Production of fast ships vs. number of active yards

varies from ship type to ship type, the compensated gross tonne (cgt) is obtained. This gives the shipbuilding industry a common measure facilitating comparisons and making aggregation easier.

Table XIX shows some of the correction factors between cgt, dwt and gt. There is a planned revision of these cgt factors, but the work has taken longer than expected.

The conclusion is that it seems relevant to talk about one, global market for the building of ships. The price correlation is very high for most segments, so prices obviously adjust quickly to either regional or ship type differences. The technological diffusion process is also very rapid, making it difficult, if not impossible to protect a new innovation or design from strong competition.

4.5.2 The industry cost curve

Given that it is relevant to talk about one, global shipbuilding market, the next problem is to find a good way of analysing the various producers in this market. One possibility is to use the so-called industry-cost curve approach, or the Salter-

Ship type	Size (1000 dwt)	cgrt	dwt/ grt	cgrt/ dwt	dwt/ cgrt	grt/ dwt
Crude tankers	10-30	0.65	1.60	0.41	2.46	0.62
	30-50	0.50	1.60	0.31	3.20	0.62
	50-80	0.45	1.60	0.28	3.56	0.62
	80-160	0.40	1.70	0.24	4.25	0.59
	160-250	0.35	1.90	0.18	5.43	0.53
	250+	0.30	1.90	0.16	6.33	0.53
Product	10-30	0.80	1.60	0.50	2.00	0.62
	30-50	0.60	1.60	0.38	2.67	0.62
	50-80	0.50	1.60	0.31	3.20	0.62
Dry bulk	10-30	0.60	1.50	0.40	2.50	0.67
	30-50	0.50	1.50	0.33	3.00	0.67
	50-100	0.45	1.80	0.25	4.00	0.56
	100+	0.40	1.85	0.22	4.63	0.54
Combis	10-30	0.65	1.70	0.38	2.62	0.59
	30-50	0.55	1.70	0.32	3.09	0.59
	50-100	0.50	1.70	0.29	3.30	0.59
	100+	0.45	1.70	0.26	3.78	0.59
General cargo	0-4	3.00	1.35	2.22	0.45	0.74
	4-10	1.40	1.35	1.04	0.96	0.74
	10+	1.00	1.35	0.74	1.35	0.74
Container	4-10	1.40	1.10	1.27	0.79	0.91
	10-30	0.90	1.10	0.82	1.22	0.91
	30+	0.80	1.10	0.73	1.38	0.91
Vehicle	4-10	2.00	0.40	5.00	0.20	2.50
	10+	1.60	0.40	4.00	0.25	2.50
LPG	4-10	1.60	1.20	1.33	0.75	0.83
	10-30	1.00	1.20	0.83	1.20	0.83
	30+	0.80	1.20	0.67	1.50	0.83
Chemicals	4-10	1.60	1.80	0.89	1.13	0.56
	10-30	1.00	1.80	0.56	1.80	0.56
	30+	0.80	1.80	0.44	2.25	0.56
LNG	4-10	1.60	0.65	2.46	0.41	1.54
	10-30	0.90	0.65	1.38	0.72	1.54
	30-50	0.70	0.65	1.08	0.93	1.54
	50+	0.50	0.65	0.77	1.30	1.54

Table XIX: cgt conversion factors

diagramme[1] as it is also called. The idea behind the methodology is to recognise that variations in costs from producer to producer have to do with three elements: cost level in country of production, technology and productivity. If the technology is fairly equal, the local cost level and productivity become the two most important elements in comparing firms across nations. By ranking the producers according to their cost level, a simple industry cost curve can be obtained, as indicated in **Figure 14**.

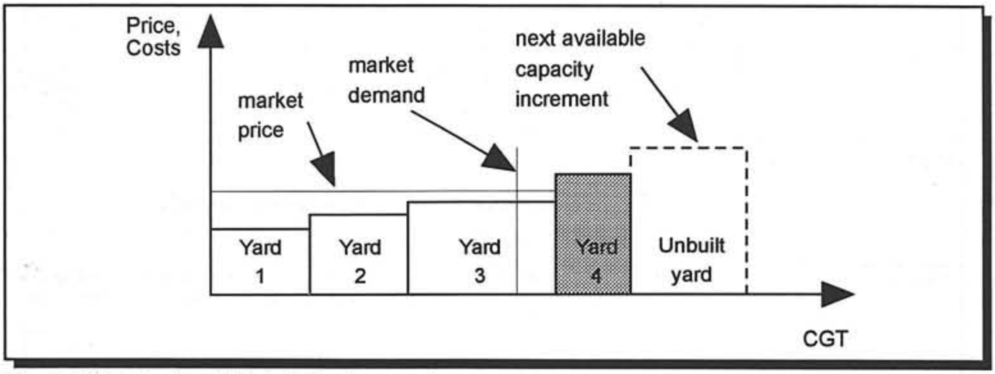


Figure 14: A simplified industry cost curve

In **Figure 14**, only 4 yards have been included. The height of each column is a measure of cost level, while the width of each column indicates the capacity of the yard. If the level of demand is as indicated in the figure, the price will be equal to the cost level of yard 3, and to this price yard 4 is not competitive and is assumed to close down. A marginal rise in the price level, however, as indicated, might make it worthwhile to reopen yard 4, which will put a downward pressure on the price and yards 1-3 will produce less than before.
To better understand what lies behind the industry cost curve, it could be useful to relate it to traditional production theory. In **Figure 15**, the cost structure for a typical producer is indicated.

A producer (assuming perfect competition) will produce optimally when price is equal to marginal costs. The producer will produce a positive amount as long as the price is at least equal to the average variable costs. Are prices lower than that, then the producer will not produce at all. This gives the heavy line as the relevant supply curve for a producer. If prices are P, then optimal output is y, and the firm has a profit Π(y) equal to the shaded area. Under perfect competition, a positive profit will attract newcomers, however. The long run effect in a situation where all firms have the same cost structure is that prices will be pushed down to a level equal to the average cost of the representative firm. This is indicated by the Pfkl in the figure, which gives the optimum production, where price is equal to marginal cost, which again is equal to average cost.

[1]From the book by W.E.G. Salter: *"Productivity and Technical Change"*, Cambridge University Press, 1960.

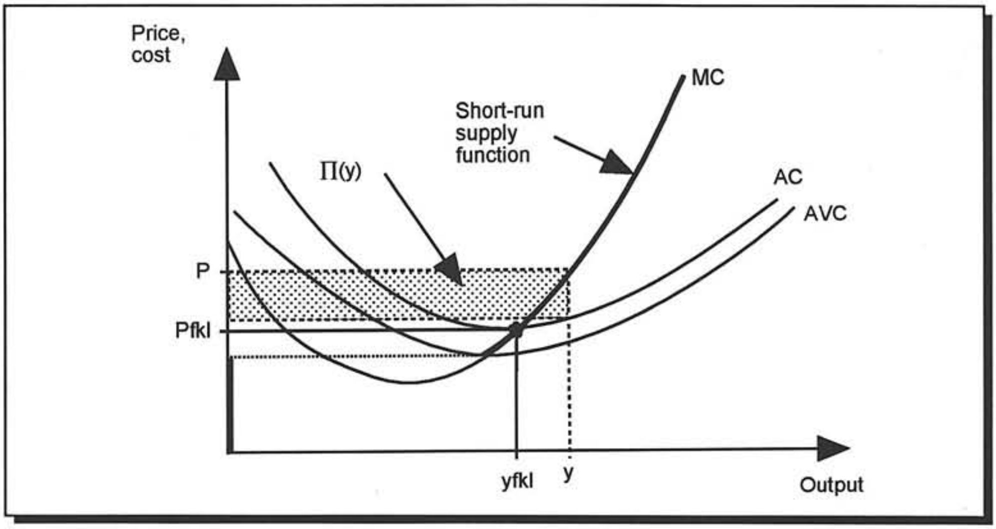


Figure 15: The cost structure for a producer under perfect competition

If cost differences do exist among producers, the picture becomes slightly more complicated. This is illustrated in **Figure 16.**

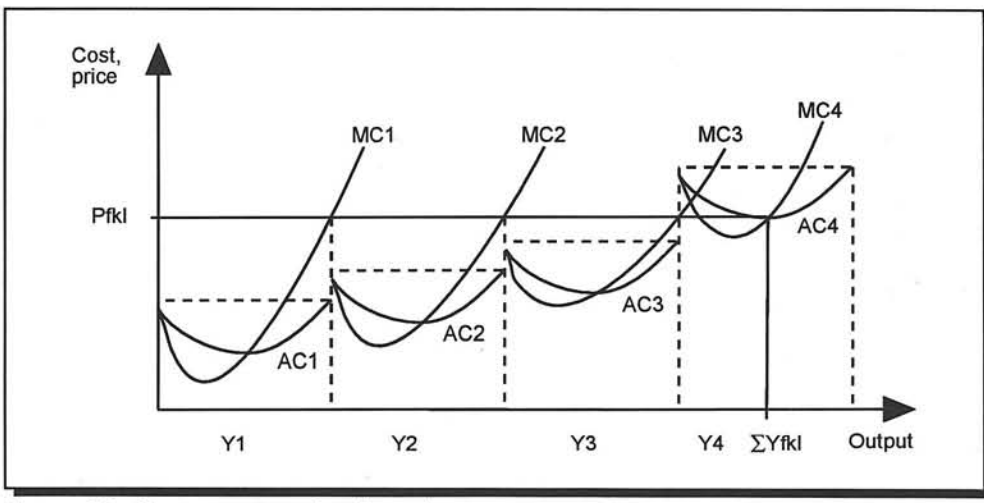


Figure 16: Cost structure for 4 producers

The four firms will supply where price is equal to marginal costs, so aggregate supply is equal to the sum of the four producer marginal cost curves. It is assumed in this type of analysis that the marginal producer will cut production down to the point where marginal costs are equal to average costs. At this price the more productive firms (to the left of the marginal producer) will produce where price is equal to marginal costs and best practise firms will earn a profit. To make the industry cost curve operational, one would in principle need to have data for each producer's marginal supply curves. If one assumes, however, that each producer is relatively small compared to the total production, an approximation can be made by collecting data on average costs and realistic production capacity. This is, however, only an approximation, and one should bear in mind that total capacity is actually a function of price.

Another problem is for which units to collect data. One possibility would be to simply collect data for all yards in the world and rank them according to cost levels. The advantage of this is that one would get a very accurate picture of relative competitiveness. The main disadvantage is caused by the difficulties in getting reliable data.
Another possibility is to use countries as a counting unit. The advantage is that data are normally obtainable at this level, the disadvantage is that the average data might not be a good indicator of the individual yards' competitiveness. The problem is illustrated in **Figure 17**.

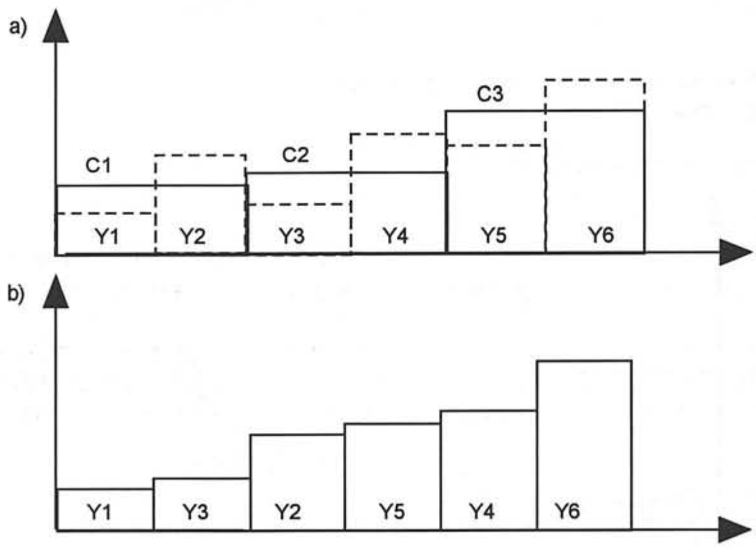


Figure 17: The counting unit problem

In **Figure 17a**, three countries are illustrated, each with two yards. The average costs for the countries are C1, C2 and C3 and their capacities are the sum of the two yards in each country. If individual yards had been used as the unit, the industry cost curve would look like **Figure 17b**, with a rather different ranking order of firms.

One argument in favour of using countries as the unit is that one important cost component, labour cost, is nationally determined. If there are large differences in labour costs across countries, then these differences are likely to affect the whole group of countries. This is, therefore, the approach normally taken.

4.5.3 The shipbuilding industry cost curve 1993

To better understand what is involved, an example from the construction of the 1993 industry cost curve could be useful[1]. The steps involved are

- Identifying the basis for cost comparisons;
- Collecting data for cost components;
- Collecting data for total capacities;
- Constructing the industry cost curve.

4.5.4 Cost components and their relative importance

to compare yards, a common unit for cost measurements must be found. The main components of costs for building ships are:

- Labour costs, adjusted for productivity;
- Steel costs;
- Costs of main engine;
- Costs of other equipment;
- Administration costs, etc.;

The first four of these cost components constitute some 90% of total costs, and it is within these four components that the biggest differences will be found.

It does not make sense to stipulate an average cost for the components mentioned. One needs to find a specific ship that can be representative for the average shipbuilding operation. In this connection two main considerations must be made:

1. The vessel type must be of average sophistication;
2. The size of the vessel must be reasonably representative.

On the low end of sophistication one finds the standard bulk carriers, ranging from the ULCCs, VLCCs and down to Handysize dry bulk carriers. On the other extreme one finds vessels like cruise vessels, research vessels, self-unloaders, etc. Somewhere in the middle range one finds on the one hand the advanced LNG and LPG vessels, the chemical tankers and on the other the combination vessels as well as the products tankers. The latter category was chosen partly because it is a vessel that easily could be built by any of the 23 shipbuilding nations considered, and it has a fairly high degree of equipment installed, higher than the standard bulk vessels with a very high steel cost. By comparing data from UK yards with those

[1] The study is documented in Hellesjø, Mohn and Wergeland (1994) (in Norwegian)

from Polish and Ukrainian yards and further checking this against the McKinsey study from 1989, the distribution of costs was established as given in **Table XX**.

Cost Components	40,000 dwt product tanker	VLCC VLCC
Labour	36%	43%
Steel	13%	19%
Main Engine	13%	11%
Equipment	38%	27%

Table XX: The cost composition of representative vessels

These distributions of costs were then utilised for the study of the general newbuilding market and a special study for the building of VLCCs.

4.5.5 Cost comparisons across shipbuilding nations

A main cost component in building ships is the labour cost. This consists of two main components: The general wage level of the country in question and the productivity of labour. Without going into details about how the various estimates were established, **Table XXI** gives a summary of wage cost comparisons for the countries in the study.

Similar evaluations were made for the other cost components, and a summary of all cost evaluations is given in **Table XXII**.

The most striking feature of the figures in the table is to be found in the productivity numbers. Japan is more than 2 times as productive as Germany, Russia has a productivity about 18% of that and China only 28%. The other striking figures are the extremely low wage rates in China and the former communist countries. For the other cost components, the variations are much smaller, mainly due to the fact that all components are available as products in a world market. Transportation costs and local suppliers are then main reasons for the cost differences.

4.5.6 Shipbuilding capacities

The next step then is to determine how much capacity each shipbuilding nation can offer. This is not an easy task, partly for capacity depends on prices, as discussed above, but also for other reasons.
There is no precise definition of shipbuilding capacity that is commonly used. Various studies have different approaches to capacity assessment. In a study from JAMRI (1989), S. Nagatsuka establishes a measure of maximum capacity, that assumes that:

Country	Exch. Rate	Rate vs. DM	Hourly rate	Social benefits	Nat. Curr.	DM	Wage index	Prod. index	Prod.adj. total index
Germany	DM	-	22.54	71.9%	38.75	38.75	100	100	100
Belgium	100 BEF	4.7467	360.68	87.0%	674.47	32.01	83	86	96
Denmark	100 DKK	24.3573	107.04	23.0%	131.66	32.07	83	125	66
Finland	100 FIM	29.0893	54.15	65.0%	89.35	25.99	67	109	61
France	100 FRF	28.6520	70.9	89.0%	134.00	38.39	99	98	101
Italy	1000 ITL	1.0559	17650	60.0%	28240.00	29.82	77	85	90
UK	POUND	2.5398	6.33	34.0%	8.48	21.54	56	73	76
Netherlands	100 NLG	88.9278	19.92	81.1%	36.08	32.08	83	118	70
Norway	100 NOK	23.0088	98.89	48.6%	146.95	33.81	87	109	80
Spain	100 ESP	1.2331	1424	30.2%	1854.05	22.86	59	70	85
Portugal	100 PTE	0.9850	979	33.5%	1306.97	12.87	33	39	85
USA	USDollar	1.6770	11.85	37.8%	16.33	27.38	71	0	
Japan	100 Yen	1.6214	2442	21.8%	2974.36	48.23	124	213	58
Korea	1000 Won	2.1808	5030	39.0%	6991.70	15.25	39	106	37
Taiwan	100 Dollar	6.2342	172.27	20.0%	206.72	12.89	33	60	55
China							3	28	11
Brazil							15	35	43
Ukraine	ECU	1.9118	0.39			0.74	2	22	9
Russia	ECU	1.9118	0.39			0.74	2	18	11
Poland	ECU	1.9118	1.90			3.63	9	39	24
Croatia	ECU	1.9118	1.25			2.39	6	37	17
Romania	ECU	1.9118	0.79			1.51	4	37	11
Bulgaria	ECU	1.9118	0.88			1.68	4	32	14

Table XXI: Wage rate and productivity comparison in world shipbuilding, 1993

Country	Labour	Productivity	Steel	Main Engine	Equipment	Total	Subsidies	Total after subsidies
Coefficient ->t	0.356		0.131	0.128	0.385	1.000		
Germany	100	100	100	100	100	100.0	15.4	84.6
Belgium	83	86	100	100	100	98.7	11.8	86.9
Denmark	83	125	100	100	100	87.9	7.0	80.9
Finland	67	109	90	90	100	83.7	2.5	81.2
France	99	98	100	100	100	100.3	12.0	88.3
Italy	77	85	90	110	100	96.5	14.5	82.0
UK	56	73	90	100	100	90.1	8.1	82.0
Netherlands	83	118	100	100	100	89.4	8.0	81.4
Norway	87	109	100	110	110	98.1	12.0	86.2
Spain	59	70	93	95	100	92.9	13.9	79.0
Portugal	33	39	93	95	100	93.1	9.3	83.8
	0	0	0					
USA	71	0	120	115	100			
	0	0	0					
Japan	124	213	110	110	110	91.7		91.7
Korea	39	106	87	95	90	71.5		71.5
Taiwan	33	60	92	95	100	82.4	4.1	78.3
China	3	28	97	85	85	60.1		60.1
	0	0	0					
Brazil	15	35	93	100	100	78.7		78.7
	0	0	0					
Ukraine	2	22	111	85	90	63.1		63.1
Russia	2	18	111	80	85	61.3		61.3
Poland	9	39	114	80	85	66.5		66.5
Croatia	6	37	119	85	90	67.0		67.0
Romania	4	37	111	85	90	63.8		63.8
Bulgaria	4	32	111	85	90	64.9		64.9

Table XXII: The composition of a general cost index for world shipbuilding 1993

- The yards have an optimum mix of ship types relative to the physical facilities;
- No bottleneck situations (e.g. crane or steel cutting capacity) occur;
- Sufficient number of workers with sufficient productivity can be supplied;
- Production planning and materials flows are optimal.

Normally, at least one, but often several of these conditions will not be fulfilled. Attempts have thus been made to establish a measure of 'realistic capacity'. This measure takes into account that the factors mentioned will not always be in optimum conditions. For Japan, lack of skilled workers is a main restriction, while in Croatia and Ukraine, crane capacity is a problem. The numbers in **Table XXIII** are a summary of the estimates made.

Country	Realistic capacity (thousand cgt)	Country	Realistic capacity (thousand cgt)
Germany	1,300	Korea	3,650
Belgium	125	Taiwan	400
Denmark	500	China	400
Finland	330	Brazil	414
France	220	Ukraine	548
Italy	325	Russia	221
UK	205	Poland	660
Netherlands	345	Croatia	440
Norway	350	Romania	580
Spain	400	Bulgaria	220
Portugal	80	Others*	2,000
Japan	5,700		
		World total	19,413

* USA, Singapore, Turkey, India, etc.

Table XXIII: Estimate of realistic shipbuilding capacities 1993

The former communist countries represent a major problem in these estimates. For some of the yards in these countries, the capacity utilisation factor has been as low as 20-30% in later years. What the realistic capacity is, is very difficult to estimate.

4.5.7 An industry cost curve for shipbuilding 1993

The cost data from **Table XXII** and the capacity data from **Table XXIII** are sufficient to construct an industry cost curve for the shipbuilding market for 1993. The result is given in **Figure 18**.

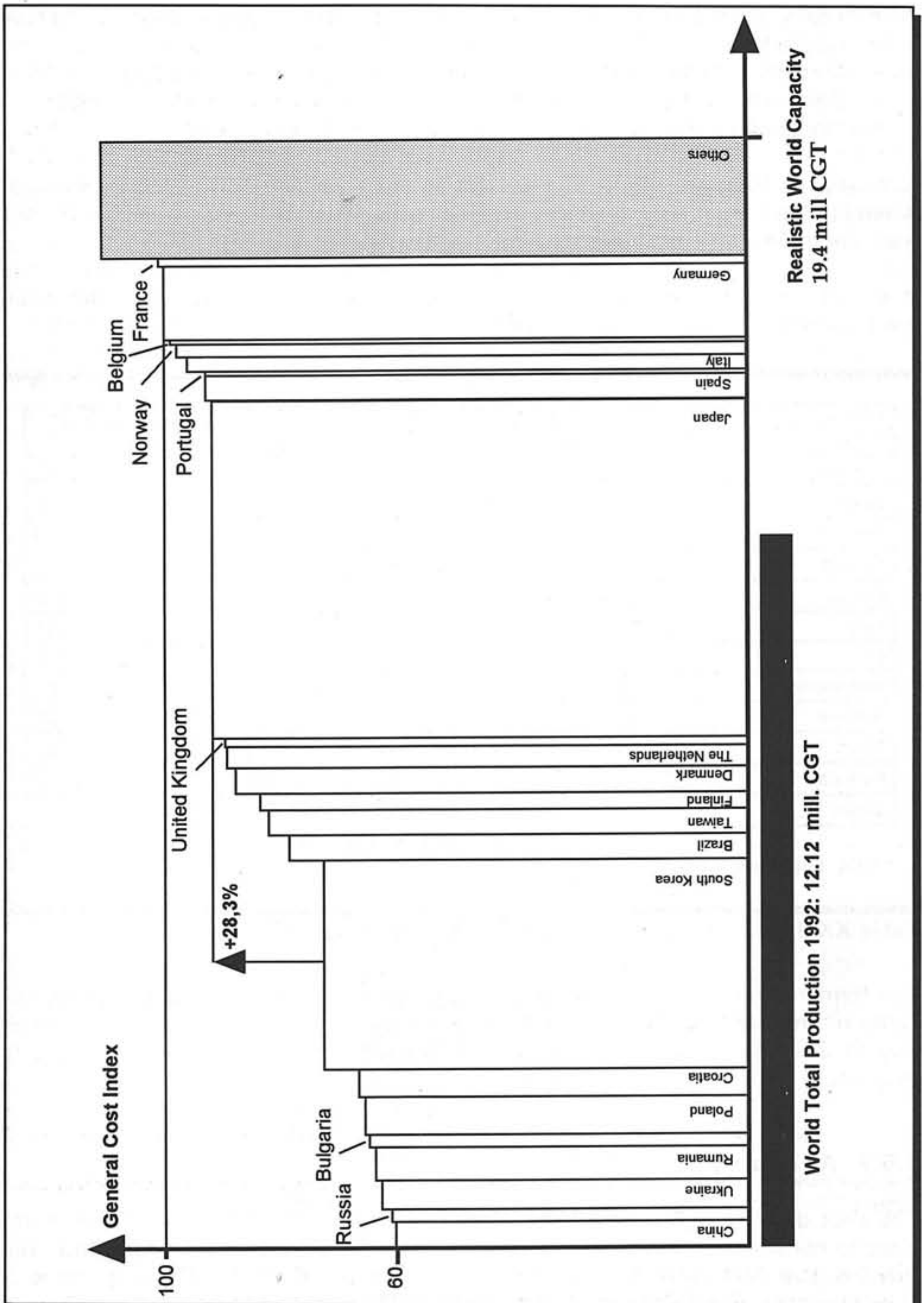


Figure 18: The industry cost curve for the shipbuilding industry 1993

With a total production of 12.12 million cgt in 1992, Japan appears to be the marginal producer and thus the country that determines the price level of shipbuilding. Many of the countries to the right of this production level, should according to this methodology, not be competitive to a price level set by Japan. In practice, however, and as indicated in **Table XXII**, heavy subsidising of national shipbuilding industries takes place. The industry cost curve would look different if drawn after subsidies. It is also important to remember that the industry cost curve is made up of country averages. Countries to the right of the marginal price may still have individual yards that are competitive.

It is interesting to note that Japan in 1993 had a cost level almost 30% above the South Korean. In a similar study made for the year 1989, Japan had slightly lower costs than South Korea. This reflects the dynamics of industrial development and is a phenomenon that can clearly be illuminated by constructing an industry cost curve. This is illustrated in **Figure 19**, where the current study is compared to one made by McKinsey & Co. in 1989.

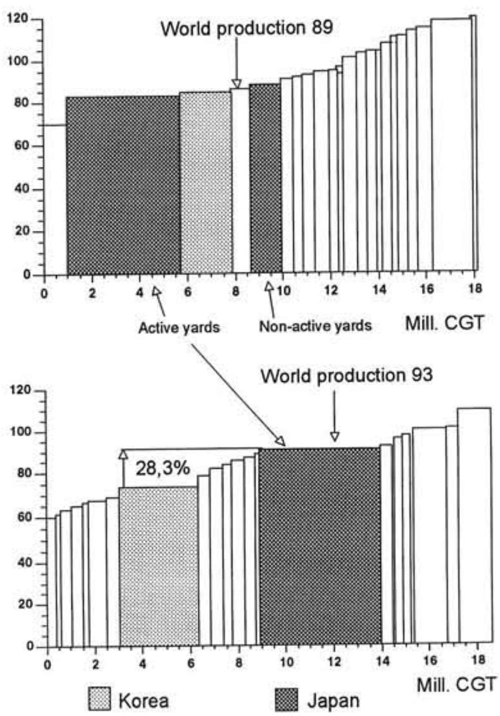


Figure 19: Shipbuilding industry cost curves 1989 and 1993

The industry cost curve can be used as an estimate of what the supply curve in shipping looks like in the short run. This could be put together with a demand curve like indicated in **Figure 20**.

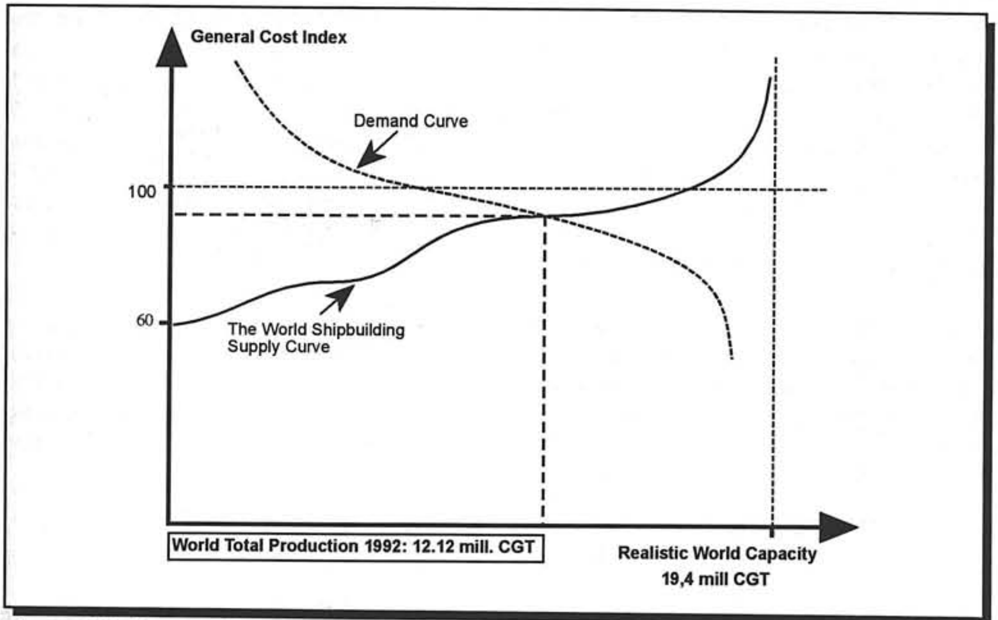


Figure 20: Demand and supply picture - world shipbuilding 1992/93

The shape of the demand curve for shipbuilding has been argued for by Martin Stopford and others. The lower elasticity in the right end of the curve is due to the fact that at this high price level, only those very few shipowners with very profitable trading opportunities (or unrealistically high expectations) will order ships. At the lower end orders will be limited by lack of trading opportunities, financial limitations and longer delivery times from the yards.

This demand and supply picture gives a very static picture of the state of the market, and is of limited value for a more dynamic analysis of the shipbuilding market. **Figure 21** illustrates what may happen if demand suddenly increases. In this figure both demand and supply have been drawn as straight lines for simplicity.

Initially one has an equilibrium at level X_0 with corresa ponding price P_0. If demand shifts, this will lead to a temporary jump in prices, as supply will move along the short term marginal cost curve for the marginal producer. This will give a price increase up to P_1. This new price leads, however, to increased production from all the others and more efficient producers and shifts the supply to the right, giving a new equilibrium at X_L. If the price increase also leads to investments in new yards (or the opening up of closed ones), long term supply may even shift further and actually lead to a lower price X_N.

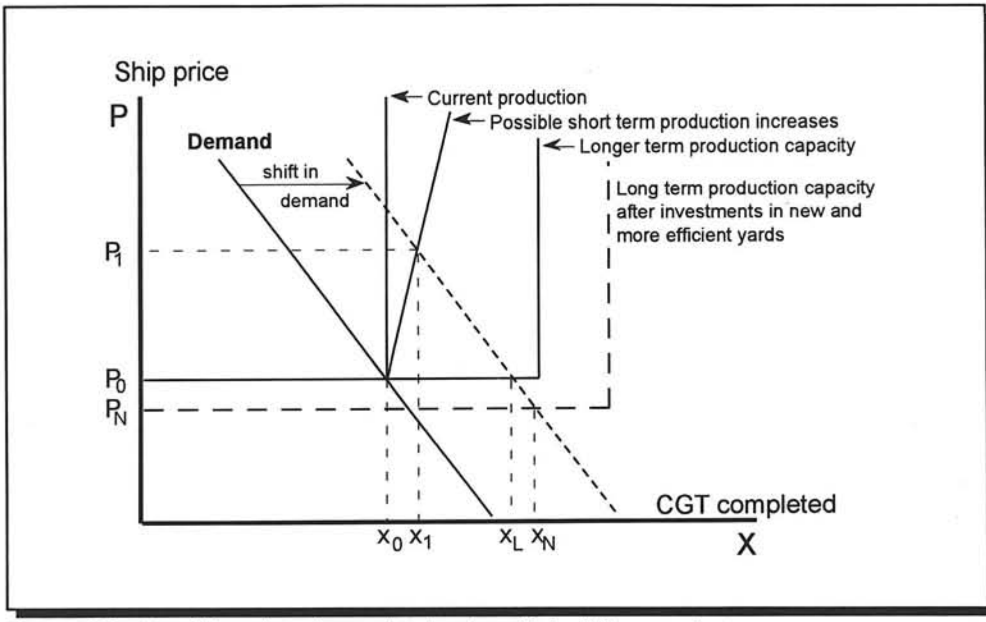


Figure 21: Possible price dynamics in the shipbuilding market

4.5.8 Industry cost curve for building of large tankers 1993

Although it has been argued that it is relevant to talk about one, global market for shipbuilding, there is, in principle, nothing that prevents one from making a study on a segment of the market. The market for large tankers is an obvious candidate, as the cost structure for VLCCs is different from that of the representative vessel above and because there is a clear limit to how many yards will have sufficient capacity to build large tankers.

In **Table XXIV** a list of yards capable of building VLCCs is given.

A similar exercise as that of **Table XXII** could be done by establishing a cost structure for the production of VLCCs, using the cost shares of **Table XXI** for VLCCs. The results are given in **Table XXV**.

The industry cost curve can again be made on the basis of the two previous tables and looks like **Figure 22**.

An exercise like this can illuminate the problem discussed in the market about a possible lack of shipbuilding capacity for the renewal of the old tanker fleet. This analysis seems to indicate that this is not a serious problem and prices will only have to rise some 12-13% to activate the capacity required.

Country	Shipyard	Low Case	High Case	Capacity per Country * (thousand cgt)
Korea	Hyundai	4	6	1085
	Daewoo	6	12	
	Samsung	0	3	
Japan	Mitsubishi	3	4	1470
	IHI	3	3	
	Hitachi	4	5	
	Mitsui	2	2	
	Kawasaki	2	2	
	NKK	2	2	
	Sumitomo	2	2	
	Sasebo	2	2	
China	Dalian	1	2	105
Taiwan	CSBC	1	3	140
Brazil	Ishibras	1	2	105
Denmark	Odense	2	3	175
Germany	HDW	1	2	175
	Bremer Vulkan	1	1	
UK	H & W	1	2	105
Spain	AESA	1	2	105
France	Chantiers	1	3	140
USA	Bethlehem	2	2	315
	Newport News	2	3	
World total		**44**	**68**	**3920**

Table XXIV: Yards with VLCC building capacity and country totals

Country	Labour	Productivity	Steel	Main Engine	Equipment	Total	Subsidies	Total after subsidies
Coefficient ->	0.431		0.193	0.107	0.269	1.000		
Germany	100	100	100	100	100	100.0	15.4	84.6
Belgium	83	86	100	100	100	98.5	11.8	86.7
Denmark	83	125	100	100	100	85.3	6.8	78.5
Finland	67	109	90	90	100	80.4	2.4	78.0
France	99	98	100	100	100	100.4	12.0	88.4
Italy	77	85	90	110	100	94.9	14.2	80.7
UK	56	73	90	100	100	87.6	7.9	79.7
Netherlands	83	118	100	100	100	87.2	7.8	79.4
Norway	87	109	100	110	110	95.3	11.6	83.7
Spain	59	70	93	95	100	91.4	13.7	77.7
Portugal	33	39	93	95	100	91.6	9.2	82.5
USA	71	0	120	115	100			
Japan	124	213	110	110	110	87.8		87.8
Korea	39	106	87	95	90	67.3		67.3
Taiwan	33	60	92	95	100	78.7	3.9	74.8
China	3	28	97	85	85	55.3		55.3
Brazil	15	35	93	100	100	73.9		73.9
Ukraine	2	22	111	85	90	58.4		58.4
Russia	2	18	111	80	85	57.4		57.4
Poland	9	39	114	80	85	63.8		63.8
Croatia	6	37	119	85	90	63.4		63.4
Romania	4	37	111	85	90	59.3		59.3
Bulgaria	4	32	111	85	90	60.6		60.6

Table XXV: Composition of a cost index for VLCC production 1993

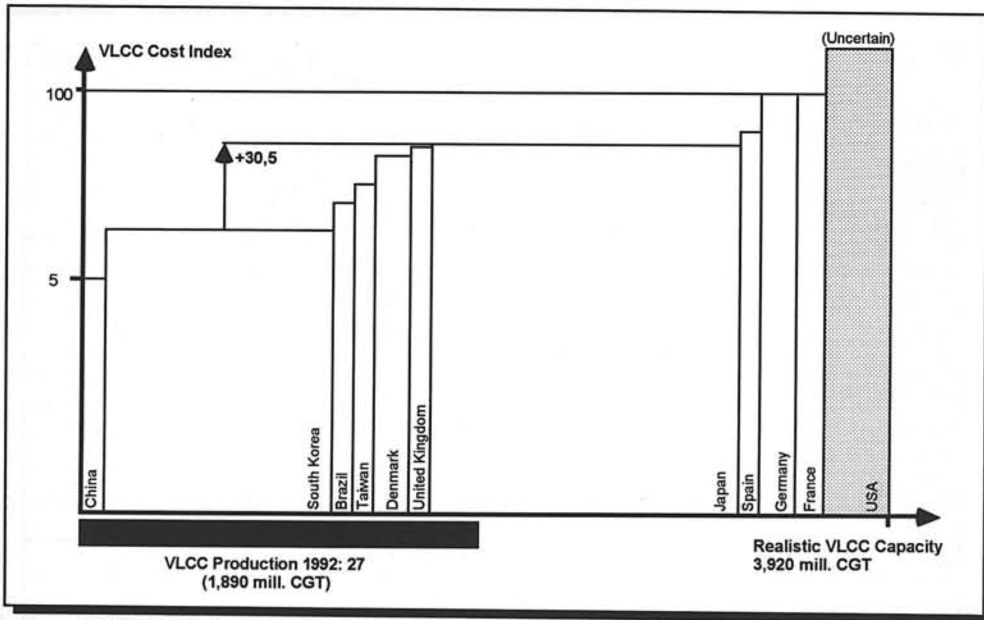


Figure 22: The industry cost curve for the VLCC shipbuilding segment 1993

4.6 The importance of exchange rates for shipbuilding prices

In the period 1985-1988, ship prices (and secondhand values) of ships increased fairly markedly as can be seen from **Figure 12**, where e.g. a VLCC doubled in value in three years. This is difficult to understand from figures like **Figure 20**, as no dramatic shift in either demand or supply seems to have taken place in this period. Referring back to **Figure 10**, however, much of the explanation can be found. In this period Yen appreciated against the USdollar, with a value in 1985 around 250 Yen/US$ to about half of that in 1988.

In a study in 1989, McKinsey & Co. analysed in detail what had happened to the components of the price of a VLCC built in Japan. This is illustrated in **Figure 23**.

In 1985 a VLCC could be purchased in Japan for 8.8 billion Yen, and in 1988 the price had increased to 9.4 billion Yen - an increase of about 7%. This was mainly due to a 1.2 billion increase in equipment costs, but a reduction in steel costs of about 0.24 billion and a remarkable reduction in labour costs of 429 million Yen. This was due to an incredible increase in productivity in a period where wage rates increased rapidly in Japan.

The same ship paid for in USdollars, had a price of 39.5 million US$ in 1985 and 73 million US$ in 1988, or an increase of 97%. About 90% of this was due to the appreciation of Yen, so the price increase was not primarily a signal of lack of

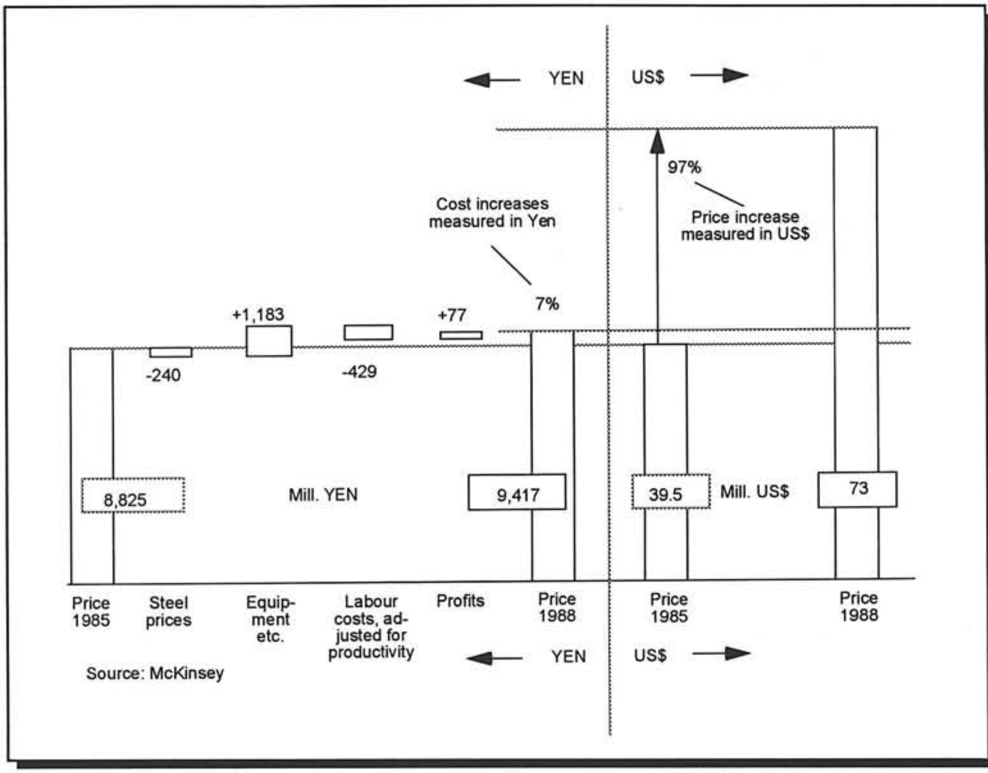


Figure 23: Price component development 1985-88 for VLCC built in Japan.

shipbuilding capacity or dramatic increases in demand, but simply an adjustment of exchange rates. Since Japan was the marginal supplier and USdollar is the main accounting unit for shipping income, this change had a marked and fairly dramatic impact on the freight markets (mainly because the long term break-even rate level shifted substantially upwards). This was a development many shipping analysts completely misunderstood.

CHAPTER 5: SHIPPING COSTS

In this chapter the costs of running a ship will be discussed. There are four main cost categories distinguished in the running of ships. These are:

- *Capital costs*, which cover the depreciation of the ship over its economic life, as well as the interest payments over the non-equity financing of the ship;
- *Operating costs*, which comprise the costs necessary to enable the ship to sail, such as manning costs, stores, etc.;
- *Voyage costs*, which comprise the variable costs associated with the actual sailing of the ship, such as bunkers, port charges, canal dues;
- *Cargo handling costs*, which are the costs for loading and discharging of the ship's cargo.

5.1 Capital cost

5.1.1 Capital cost variables

Capital costs depend to a large part on the newbuilding price of the ship, which is related to the type and size of the vessel. Drewry's study *"Ship Costs: Their structure and significance"* contains for a number of ship types their newbuilding price, see **Table I**.

When a ship is purchased or built, the price of the ship is the capital value of the ship. This value can be turned into costs per year in several ways. A simple method would be to calculate the yearly payments needed to pay back the cost of the ship at a given interest rate and a given time period. This will reflect the yearly costs of recovering the capital used for the ship. The problem would be to choose the appropriate interest rate to use and to determine the economical life of the investment.

Table II shows the yearly average capital costs, measured as a percentage of the initial price for various interest rates and various choices of economic life of the vessel.

As one would expect, the capital costs increase with the interest rate and decrease with the economical life of the vessel.

Capital costs are normally divided into two parts, however, the payment for borrowed money (interest payment and repayment of loan) and the capital depreciation of the vessel. One should remember that these are two fundamentally different cost components. The payments for borrowed money are a cash outflow for the company, but depreciation is not a cash item, for accounting purposes

Ship type	Subtype	Delivered 1990 (million US$)
Tankers	ULCC VLCC Million barrel	85.0-90.0 60.0-70.0 40.0-43.0
Gas	LNG (130,000 m^3) LPG (75-80,000 m^3)	150.0-155.0 55.0-60.0
Dry bulk	Handysize Handymax Panamax gearless Capesize	11.5-12.5 18.0-20.0 24.5-25.5 33.0-36.0
General	20,000 dwt	22.5-25.0
Container	Post-Panamax Feeder (250-500 TEU)	65.0-70.0 8.5-9.5
Reefer	500-600,000 m^3	25.0-27.5
Shortsea	Dry (3,000 dwt)	5.0-5.5

Table I: Newbuilding prices of ships

Economic life of the ship	Interest rate					
	5.0%	7.5%	10.0%	12.5%	15.0%	25.0%
5	23.1%	24.7%	26.4%	28.1%	29.8%	37.2%
10	13.0%	14.6%	16.3%	18.1%	19.9%	28.0%
15	9.6%	11.3%	13.1%	15.1%	17.1%	25.9%
20	8.0%	9.8%	11.7%	13.8%	16.0%	25.3%
30	6.5%	8.5%	10.6%	12.9%	15.2%	25.0%

Table II: Yearly capital costs (annuity) as percent of initial purchasing price.

only. The idea behind depreciation is to spread the initial capital outlay (which is a cash item) over the time horizon over which the asset is supposed to bring income.

The capital cost for a ship (or a shipping company) will depend on a number of different factors. Some of these factors are:

- The investment cost, i.e. either the newbuilding or secondhand price of the ship, including broker's commission, costs related to delivery of ship, etc.;
- The financial structure for the investment, which depends on how much equity (the owner's own cash) is allocated to the project and how much is borrowed;
- The interest rate for borrowed money, which depends on the size of the loan, the solidity of the owner, the security offered and the general level of interest rates;
- The economical life of the ship;
- Tax regulations, which may influence depreciation rates.

Often when calculating capital costs, too little emphasis is given to another capital cost element, the cost of equity. The owner of a ship normally puts quite a lot of own capital into the project. This cash has an implicit cost, which is the alternative cost (or opportunity cost) of placing the money in some other investment project. This cost element is of particular importance for the initial investment calculations for a new project.

There are several methods for depreciation. The only way that depreciation can have cash flow consequences, is that it may affect the tax bill. It is, therefore, national tax authorities that normally decide how depreciation will be dealt with. Often the system used is based on book values, rather than market values. Sometimes a residual value of the asset is assumed, sometimes not. **Figure 1** shows an example of a common model for ship depreciation, called the straight-line method (equal amounts of depreciation each year). Here a building price of 100 million US$, an economical life of 15 years and a residual value of 25 million US$ is assumed.

The shipowner will buy the ship partly with his own capital and borrow the remainder from a bank. His own capital is called equity and he only receives a return on this capital after the other creditors, such as the bank, have been paid. The bank loan is characterised by a loan amount, a loan period, a repayment schedule and an interest rate. As collateral or security for this loan, the bank usually demands a first mortgage on the ship. This gives the power and right to sell the ship in case the shipowner does not honour his obligations towards the bank. The loan amount does hardly ever exceed 80% of the newbuilding value, and is often lower.
The loan period is usually between 8 and 15 years, with half yearly repayments, sometimes with a year grace period during which the repayment does not have to take place, sometimes with a balloon repayment at the end of the loan period.
The loan can be in various currencies. As a rule, the shipowner finances the ship in the currency in which his revenues and/or costs are, typically US$. The interest rate can be fixed for the entire period or float from year to year; the interest rate on the ship loan is usually expressed as the Libor (London Interbank Offered Rates) rate plus a margin that will depend on the borrower's solidity and financial reputation, but on average is 1.5%.

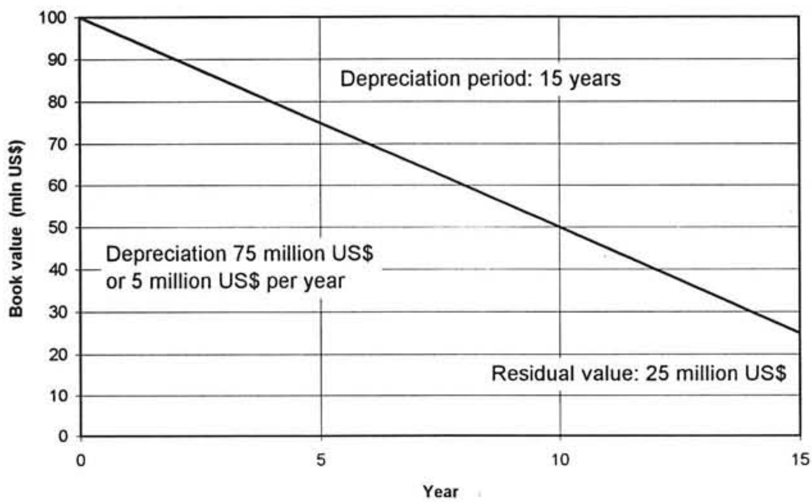


Figure 1: Ship depreciation calculation

The interest payments normally decrease over time, as the loan gets repaid. This places a heavy burden on the cash flow of the shipowner during the initial years, as interest payments are at their maximum. However, the shipowner can also opt for an equal amount of loan repayment (redemption) plus interest payment, the so-called annuity. **Figure 2** shows the calculation of the interest costs of a bank loan of 75%, repayable over 15 years in equal instalments, with an interest rate of 8%.

The capital cost of the hypothetical ship thus becomes the sum of the annual depreciation plus the annual interest payments. On top of this the owner wants a return on his equity,which will depend on th ealternavie cost of equity. In short, the depreciation, interest payment and return on owner's equity determine the capital cost of the ship.

5.1.2 Cash flow

The cash flow is the actual inflows in the form of freight revenues over the lifetime of the ship minus the cash outflows. The shipowner and banker will estimate the cash flow of the operation of the ship in great detail before buying a ship or commit to the financing. The instrument that both parties use in order to judge whether the owner can repay the loan and pay the interest is the cash flow calculation. From the total revenues one deducts all outgoing cash flows to cover all direct costs, like cargo handling, voyage costs, operating costs, interest payment and repayment of loan. The tax calculation is an accounting matter, and after payment of taxes (and perhaps dividend) the nett cash flow is found. This is illustrated in **Figure 3**.

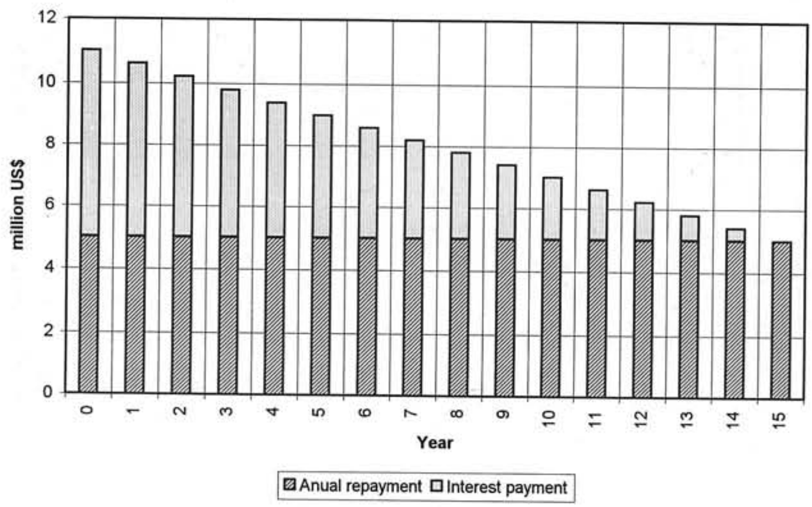


Figure 2: Calculation of interest costs

Reefer ship cash flow calculation

In order to illustrate the principle of cash flow calculation, an example of a reefer ship is presented. **Table III** contains the calculation.
This example shows the risk of financing in Dutch guilders, while the revenues are in USdollars. At the time of the cash flow calculation, in 1989/90 the USdollar stood at NLG 2.04, while it dropped to NLG 1.60 in 1995. This means that cash flows in Dutch guilders get a heavy blow and the shipowner and bank may get into problems.

5.2 Operating costs

The operating costs of a ship are defined as those cost items that are related to the purely operational aspects of the running of the ship. The operating cost only comprises the fixed costs and not the variable costs, which depend on the actual sailing of the ship. The fixed costs of the ship, which are the costs that the shipowner should incur in order to make the ship ready to sail, constitute the following elements:

- Manning costs;
- Maintenance and repairs;
- Stores, supplies and lubricating oils;
- Insurance costs;
- Management overhead, including administration.

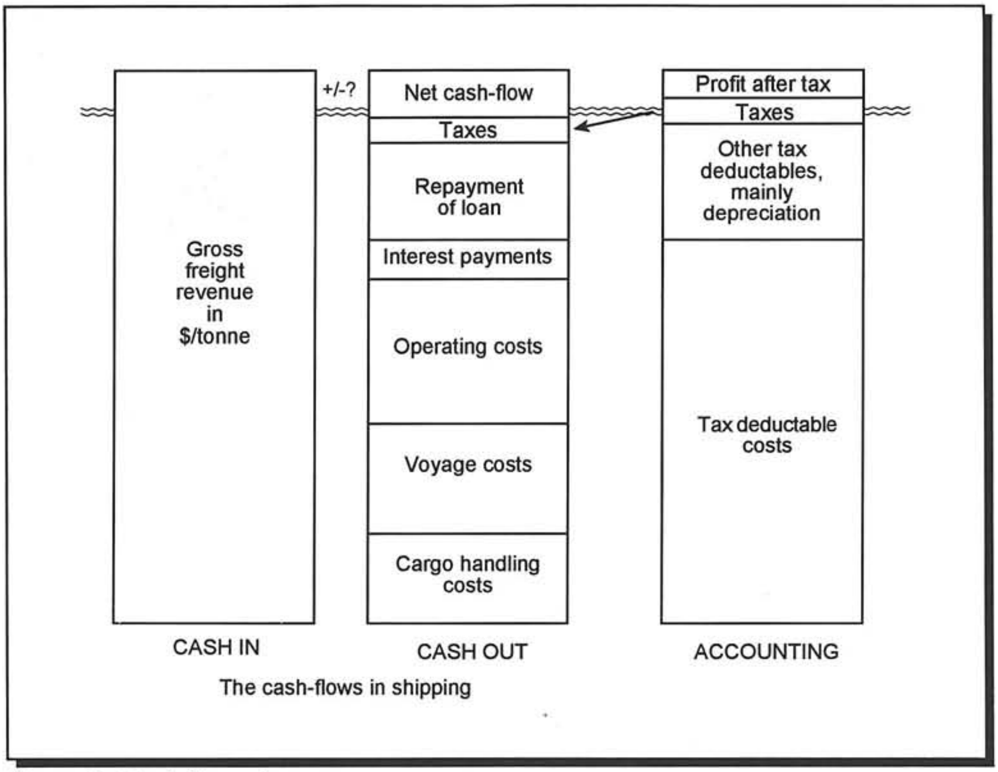


Figure 3: Cash flow diagram

5.2.1 Manning costs

The manning costs of a ship are determined by a number of factors, such as the type of the vessel, the level of automation, the employment characteristics, the flag of registration, the nationality of the crews and the relieve schedule.

The size of the crew and their professional qualifications are determined by different authorities. In the first place, the minimum crew requirements are set by the safety aspects of sailing a ship as defined by the International Maritime Organisation. Apart from that, the individual flag states, i.e. the countries that keep an official register of ships, may stipulate additional requirements. On top of that the shipowner, who operates the ship, may employ additional seamen onboard his ship depending on the operational requirements of the trade.
For example, a chemical tanker can be safely sailed by a crew of 12 men, while the shipowner will employ double that number for the cargo handling in port. Under the Dutch regulations, the composition of the crew of a ship was related to the size of the vessel, measured in gross tonnage, as well as the power range of the main engine measured in kW. **Table IV** illustrates this classification. Shipowners anticipated the detailed regulations by maximising the ship design

Table III: Cash flow calculation

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total revenues	*5965*	*4846*	*5595*	*6338*	*6985*	*7456*	*7456*	*7456*	*8202*	*6617*	*7456*	*7456*	*7456*	*7456*	*7357*
Manning costs	1380	1408	1436	1464	1494	1524	1554	1585	1617	1649	1682	1716	1750	1785	1821
Insurance	250	253	255	258	260	263	265	268	272	273	276	279	282	285	287
Maintenance	470	470	470	470	470	470	470	470	470	470	470	470	470	470	470
Other costs	200	202	204	206	208	210	212	214	217	219	221	223	225	228	230
Total operating costs	*2300*	*2333*	*2365*	*2398*	*2432*	*2467*	*2501*	*2537*	*2576*	*2611*	*2649*	*2688*	*2727*	*2768*	*2808*
Interest payments	1594	1373	1152	931	828	724	621	517	414	310	207	103			
Total costs	*3894*	*3706*	*3517*	*3329*	*3260*	*3191*	*3122*	*3054*	*2990*	*2921*	*2856*	*2791*	*2727*	*2768*	*2808*
Gross profit (total cash flow)	2071	1140	2078	3009	3725	4265	4334	4402	5212	3696	4600	4665	4729	4688	4549
Tax deductables (depriciation)	1508	1508	1508	1508	1508	1508	1508	1508	1508	1508	1508	1508	1508	1508	1508
Profit before tax	*563*	*-368*	*570*	*1501*	*2217*	*2757*	*2826*	*2894*	*3704*	*2188*	*3092*	*3157*	*3221*	*3180*	*3041*
Tax (35%)	197	-129	200	525	776	965	989	1013	1296	766	1082	1105	1127	1113	1064
Profit after tax	*366*	*-239*	*371*	*976*	*1441*	*1792*	*1837*	*1881*	*2408*	*1422*	*2010*	*2052*	*2094*	*2067*	*1977*

Cash flow calculation

Total cash flow	*2071*	*1140*	*2078*	*3009*	*3725*	*4265*	*4334*	*4402*	*5212*	*3696*	*4600*	*4665*	*4729*	*4688*	*4549*
Tax	197	-129	200	525	776	965	989	1013	1296	766	1082	1105	1127	1113	1064
Repayment of loan	3102	3102	3102	1427	1427	1427	1427	1427	1427	1427	1427	1427			
Nett cash flow	*-1228*	*-1833*	*-1224*	*1057*	*1522*	*1873*	*1918*	*1962*	*2489*	*1503*	*2091*	*2133*	*3602*	*3575*	*3485*
Loan principal	22150	19048	15946	12844	11417	9990	8562	7135	5807	4281	2854	1427			

Unit: 1,000 NLG

The newbuilding price of the reefer ship is NLG 25.125 million

I	II	III	IV	V
A. > 9,000 gt				
Captain 1st mate 2nd mate 3rd mate Chief engineer 2nd engineer 3rd engineer 4th engineer Cook radio officier 4 sailors	Captain 1st mate 2nd mate Chief engineer 2nd engineer 2 mar.offic. N/W Radio officer 1 technician Cook 3 sailors	Captain 1st mate Chief engineer 1 mar.off. W+ 1 mar.off. N/W+ 1 mar.off. N/W Radio officer 2 technicians Cook 2 sailors	Captain Chief engineer 1 mar.off. N+ 1 mar.off. W+ 1 mar.off N/W+ 1 mar.off. N/W Radio officer 2 technicians Cook 2 sailors	Captain 1st officer 1 mar.off. N+ 1 mar.off. W+ 2 mar.off. N/W radio officer 2 technicians Cook 2 sailors
B. 6,000 - 9,000 gt, 3,000 - 8,000 kW				
Captain 1st mate 2nd mate 3rd mate Chief engineer 2nd engineer 3rd engineer Radio officier Cook 3 sailors	Captain 1st mate Chief engineer 1 med. off. M+ 1 med. off. M Radio officer 1 technician Cook 2 sailors	Captain 1st mate Chief engineer 1 med.off A+ 1 med.off. M+ 1 med.off. M Radio officer 1 technician Cook 2 sailors	Captain 1st officer 1 med.off A+ 1 med.off M+ 1 med.off M Radio officer 1 technician 2 sailors	
C. 4,000 - 6,000 gt, 3,000 - 6,000 kW				
Captain 1st mate 2nd mate 3rd mate Chief engineer 2nd engineer Radio officier Cook 3 sailors	Captain 1st mate Chief engineer 1 med. off. A+ 1 med. off. M Radio officer 1 technician 2 sailors	Captain Chief engineer 2 med.off. A+ 1 med.off. M radio officer 1 technician 2 sailors	Captain 1st officer 1 med.off A+ 1 med.off M Radio officer 1 technician 2 sailors	
E. 2,000 - 4,000 gt, < 3,000 kW				
Captain 1st mate 2nd mate Chief engineer 2nd engineer Radio officier 2 sailors	Captain 1st mate Chief engineer 1 med. off M Radio officer 1 technician 1 sailor	Captain Chief engineer 1 med.off. M+ 1 med.off. M Radio officer 1 technician 1 sailor	Captain 1st officer 1 med.off. M+ Radio officer 1 technician 1 sailor	
G. < 2,000 gt, 750 - 1,500 kW				
		Captain 1st officer 1 med.off. M 2 sailors		

Table IV: Minimum crew of Dutch cargo ships (up to 1 Januari, 1996)

Shipowners anticipated the detailed regulations by maximising the ship design around the discrete jumps in manning scales. For example, if the required crew increased in number at 2000 gt, no ships were built of 2200 gt, as the marginal increase in capacity was not warranted by the increase in crew costs. The same is true for the power of the main engine.

Some flag states are very specific in their manning requirements and prescribe in great detail the minimum crew size and composition, while other flag states leave this entirely up to the shipowners. An overview of the different flag state and registry options open to the owner, will be discussed later.

The nationality of the crews is another important factor for the level of crew costs. Dutch officers are more expensive than their Philippino counterparts. As many flag states require the enlisting of national seamen on ships registered under their flag, this has lead to a massive flagging out of ships from the traditional western ship registers to the more exotic countries as Liberia, or Vanuatu.

A crew has to be relieved by another crew in order to rest and take a vacation. This requires a spare crew, which also must be available in case a crew member gets ill. The standard crew of a ship thus has to be multiplied by a factor 1.6 in order to arrive at the actual number of seamen that are required to operate the ship.
The impact of all the above factors on the manning costs has been and still is the subject of many studies around the world. An example is the Dutch study into the competitiveness of the Dutch flag (MERC, 1989), which contains a number of manning comparisons. Although the information is outdated, its findings explain the flight from the high-cost ship registers towards the cheap or flag of convenience registers such as Panama.

Table Va shows the crew composition of eight ships: multi-purpose ship 1 & 2, reefer ship 1 & 2, container ship 1 & 2, bulk carrier, chemical tanker. The crew is all-Dutch. The manning costs range from NLG 856,488 per year for multi-purpose ship 1 to NLG 2,058,416 for container ship 2.
Table Vb shows the same ship types and crews, but then under the Panamese flag, with a cheap crew. This also leads to a reduced leave factor of 1.5 as these crews from developing countries have a less favourable relieve schedule.

5.2.2 Repairs and maintenance

A ship has to be repaired when damage occurs, also preventive maintenance has to take place. Repairs can be necessary when a ship hits a jetty, or break a propeller blade. Maintenance can be divided into *routine* maintenance of such items as the main engine, cranes, cleaning and painting of the hull, and maintenance that is necessary to stay in *class*. The design and construction of each merchant ship in the world has been approved by a classification society, such as Lloyds Register, Bureau Veritas, Det Norske Veritas and American Bureau of Shipping.

Dutch Crew	MP 1*	MP 2*	Reefer 1	Reefer 2	Cont. ship 1	Cont. ship 2	Bulk carrier	Chem. tanker
Crew	431.5	696.0	576.5	911.0	911.0	1013.0	911.0	939.0
Captain	75.0	90.0	75.0	110.0	110.0	130.0	110.0	120.0
1st mate	51.0	65.0	51.0	80.0	80.0	90.0	80.0	85.0
2nd mate	48.0	55.0	48.0	70.0	70.0	75.0	70.0	72.0
3rd mate		48.0		48.0	48.0	50.0	48.0	48.0
Chief eng.	67.5	81.0	67.5	99.0	99.0	117.0	99.0	108.0
2nd eng.	48.0	55.0	48.0	70.0	70.0	75.0	70.0	72.0
3nd eng.				48.0	48.0	50.0	48.0	48.0
Radio off.		62.0	55.0	62.0	62.0	62.0	62.0	62.0
4th eng.				40.0	40.0	40.0	40.0	40.0
Sailors	102.0	176.0	132.0	264.0	264.0	264.0	264.0	264.0
Cook		6.0		60.0	60.0	60.0	60.0	60.0
No. of crew	8	13	9	16	16	16	16	16
Cost social security	113.8	187.9	128.7	246.0	246.0	273.5	246.0	253.5
Leave factor	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Total costs	856.5	1,414.2	968.2	1,851.5	1,851.5	2,058.4	1,851.1	1,908.0

Panamese crew	MP 1*	MP2*	Reefer 1	Reefer 2	Cont. ship 1	Cont. ship 2	Bulk carrier	Chem. tanker
Crew	29.6	34.4	29.7	36.8	36.8	36.8	36.8	36.8
Captain	5.2	53	5.3	5.3	5.3	5.3	5.3	5.3
1st mate	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
2nd mate	2.8	2.9	2.8	2.8	2.8	2.8	2.8	2.8
3rd mate		1.9		1.9	1.9	1.9	1.9	1.9
Chief eng.	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
2nd eng.	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
3nd eng.		1.9		1.9	1.9	1.9	1.9	1.9
Radio off.	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Sailors	5.9	6.0	6.0	7.1	7.1	7.1	7.1	7.1
motorman	2.4	2.4	2.4	3.6	3.5	3.5	3.5	3.5
Cook	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Steward		1.0		1.0	1.0	1.0	1.0	1.0
No. of crew	14	17	14	19	19	19	19	19
Cost social security	-	-	-	-	-	-	-	-
Leave factor	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Total costs	534.4	619.6	534.4	662.1	662.1	662.1	662.1	662.1

Unit: NLG 1,000

*) MP = Multi-purpose

Table V: Manning costs Dutch and Panamese crew

These societies give as a prove of seaworthiness of the ship different certificates valid during a limited period of time. These certificates have to be regularly renewed. This process is called the classification survey. Drewry's study *"Ship Costs"* gives an indication of the different M&R costs in US$ per year (**Table VI**).

Ship type	Ship size	Cost (1,000 US$)
Tankers	<10,000 dwt 70-100,000 dwt >300,000 dwt	164 482 776
Dry bulk carriers	<10,000 dwt 20,35,000 100-150,000 dwt	134 207 286
General cargo ship	10-15,000 dwt	157
Container ship	2,000 TEU	448
Reefer ship	350,000 cu.ft.	515

Table VI: Costs repair and maintenance

In *"Running Costs"*, the budget structure of the technical and nautical management department is discussed and shown in **Table VII**. The shipowner or ship manager estimates each year the detailed cost elements as specified in this table. During the lean shipping years, this is the area in which shipowners first start to cut the corners, as some of the expenditures are only necessary for preventive maintenance.

The large tankers built in 1972-74 were all designed for a technical life of about 15 years. Today many of these ships are still sailing and for each new class it is an investment project in itself to calculate if one should go through class and upgrade the ship to the minimum standards required by the classification societies. In a study of class renewal costs[1] for VLCCs facing the 4th class, estimates have been made of total renewal costs as given in **Table VIII**.

5.2.3 Stores, supplies and lubricating oils

The crew needs food and the costs associated with this item are part of the supplies and are called victualing. The costs per man are between US $3-6 per day.
Stores and supplies are expenditures that are necessary to maintain the ship such as ropes and wires, paints, grease, but also spares. These costs are usually

[1]Espen Kjær and Olav R. Remman: *"Sell or upgrade?"*, Master Thesis in MBA in Shipping Management, Norwegian School of Economis and Business Administration, Bergen, 1996 (forthcoming).

M.A.S. Code	Item	M.A.S. Code	Item
4100	Hull	4700	Consultants
4110	Hull, decks, fittings	4710	Safety
4120	Heating coils	4720	Engine
4130	Tank washing equipment	4730	Work study
4140	Anodes	4740	Other
4150	Drydock costs		
4160	Refrigeration ftgs.		
	Total hull		Total consultants
4200	Engine and electrical	4800	Registry
4210	Main engine	4810	Surveys
4220	Auxiliaries	1820	Fees
4230	Refridgeration		
	Total engine and electrical		Total registry
4300	Radio and navigational aids	4900	Accommodation
4310	Rentals	4910	Galleys
4320	Maintenance	4920	Other
4330	Renewals		
	Total radio and navigational		Total accomodations
4400	Spare gear	9000	Modifications
4410	Engine	9100	Safety
4420	Electrical	9200	Anti-pollution
4430	Radio	9300	Work study
4440	Navigational	9400	Operational
		9500	Classification
	Total spare gear		Total modifications
4500	Marine	4000	Summary totals
4510	Charts	4100	Hull
4520	Safety equipment	4200	Engine and electrical
4530	Disinfestation	4300	Radio and navigation aids
4540	Life rafts	4400	Spare gear
	Total Marine	4500	Marine
		4600	Surveys
4600	Surveys	4700	Consultants
		4800	Registry
		4900	Accommodation
4610	Classification	9100	Modifications
4620	Others		
	Total surveys		Total technical

Table VII: Budget structure of the technical and nautical management department

Item	Costs in US$
Steel renewal/repair	2,300,000
Main propulsion system	400,000
Cargo/ballast system	800,000
Auxiliary systems	800,000
Dry dock fee	500,000
Condition assessment	200,000
Total costs	**5,000,000**

Table VIII: Estimates of 4th class renewal costs for VLCCs 1996

divided into three categories: Marine stores, engine room stores and steward's stores.
An important part of the engine room stores are the lubricating oils. It could be argued that these are in fact variable costs, dependent upon the sailing of the ship, and thus logically part of the voyage costs. However, lubricating oils are very expensive, and the consumption depends on the type and quality of the engine. A charterer of a ship does not wish to be responsible for this unforeseen cost item and, therefore, it is customary to consider it part of the operating costs.
According to Drewry's study these costs may amount to US$ 45-85,000 per year for small ships rising to US$ 550,000 for ULCCs. The costs tend to increase with the age of the ship.

5.2.4 Insurance

The ship has to be insured against all sorts of risks. Apart from cargo risks, which is a variable item dependent upon the specific voyage, the shipowners usually seek protection against two sorts of risk: Physical damage or loss of the hull & machinery (H&M), and liability to third party claims (P&I). In special situations the owner may insure the ship against war risks, or he takes out a loss of hire insurance, which protects him against the interruption of earnings.
The H&M insurance is obtained through a broker, which acts on behalf of underwriters. These are consortia of large insurance (and reinsurance) companies, which each take a part of the risk. One ship can thus be insured indirectly via twenty or more companies, all through one broker.
The Protection & Indemnity cover is provided by a limited number of clubs, which are in fact mutual funds. They insure the shipowner against liabilities from third parties, in case for example the ship hits a jetty or a crane, or creates an oil spill, or when seamen lose their lifes while on duty.
The premiums to be paid for these types of H&M and P&I covers have sharply risen over the last years. **Table IX** shows the indicative values from some years ago (Drewry 1990).

Ship type	H&M insurance cost (1,000 US$)	P&I insurance cost (1,000 US$)
Shortsea	23-55	2-8
General cargo ship	120-125	15-20
Dry bulk carrier	165-420	45-180
Tanker	240-1,150	19-95
Container ship	145-480	4-20

Table IX: Insurance costs

In the large tanker market a new insurance product has been created over the last years in connection with the US Oil Pollution Act (1990) - OPA90 - which requires that ships which call at the US with crude oil must carry a Certificate of Financial Responsibility (COFR). This certificate shall document a financial responsibility sufficient to meet the maximum amount of liability stated under OPA90. For a VLCC this amounts to some 300-350 million US$. No P&I club will guarantee coverage for such amounts, and special COFR-guarantee clubs have been established along the same principles as the P&I clubs. For a 20 year VLCC trading to the US, the insurance premiums in 1996 are much larger than those given in **Table IX**. The premiums vary a lot today, because the insurance companies have started to differentiate premiums much more than they used to do. P&I premiums may vary from US$ 70,000 to US$ 350,000. H&M premiums will partly depend on the value of the vessel, but also on the condition of the ship and the evaluation of the management. H&M premiums will probably vary from US$ 900,000 to US$ 1,600,000 for an old VLCC. The COFR guarantee premiums will be about the same as for P&I. An old VLCC in poor condition may, therefore, face total insurance costs of more than US$ 2 million per year, but the average for old VLCCs is around US$ 1.4 million.

5.2.5 Management

A shipowner has to manage the commercial exploitation of the ship as well as the operational aspects, such as technical/nautical management, crew management and the various administrative functions ranging from purchasing equipment to arranging insurance. The whole of these management functions is often called administration or overhead. The management cost per ship depends on the size of the shipping company and the number of ships that are managed. As an order of magnitude, the management cost per ship per annum are US$ 90,000.

5.3 Voyage costs

The capital and operating costs are incurred by the shipowner irrespective of the sailing of the ship. The voyage costs come into the picture when the ship actually starts sailing, or in other words, commences a voyage. The elements that constitute this category of costs are: The fuel or bunker costs for the main engine and auxiliary engines, the harbour dues, pilotage, tugs and canal dues.

5.3.1 Bunker costs

The fuel consumption of a ship is determined by many variables such as the size of the ship, the ship's hull, the laden condition (full or ballast), the speed, the weather (waves, currents, wind), the type and capacity of the main engine and auxiliaries, the type of fuel, the quality of the fuel.
The fuel on board a ship is called bunkers. The bunker costs of a voyage depend on the fuel consumption during the sea voyage and in port, as well as the price of the fuel. The fuel price depends on the world oil price and the location where the bunkers are being taken onboard. **Table X** (Fairplay) shows the prices of three main fuel types: MDO (Marine Diesel Oil), IFO (Intermediate Fuel Oil) and HFO (Heavy Fuel Oil), in different ports around the world. At a few ports, in which major refineries exist, such as Rotterdam, Los Angeles, and Singapore, the prices are the lowest as the logistical costs are low.

The oil price has fluctuated considerably over the last 25 years. This has had a profound impact on the shipping industry. For example, the fuel inefficient steam burners disappeared almost overnight in the aftermath of the first oil crisis. The bunker costs became the single largest cost item in the running of ships after the second oil crisis in 1979, which is illustrated by **Figure 4**.

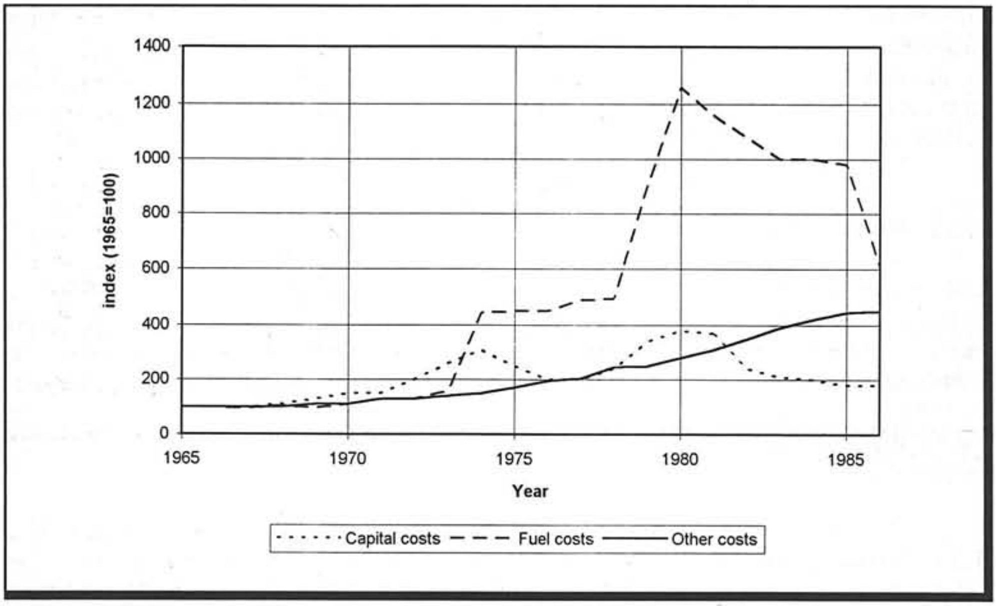


Figure 4: Ship costs

	380 CST	180 CST	MDO
Rotterdam	102.00	106.00	159.00
Hamburg	115.00	119.00	173.00
Le Havre	123.00	128.00	188.00
Falmouth	121.00	125.00	204.50
Gothenburg	117.00	121.00	185.00
Fos/Lavera	117.00	123.00	188.00
Augusta	120.00	126.00	198.00
Malta	125.00	132.00	211.00
Piraeus	119.00	125.00	189.00
Istanbul	119.00	122.00	160.00
Gibraltar	107.00	111.00	172.00
Algeciras	108.00	112.00	172.00
Las Palmas/Tenerife	117.00	121.00	176.00
Algeria	S/E	116.00	190.00
Jeddah	N/A	127.00	200.00
Damman	N/A	124.00	189.00
Dubai/Fujairah	111.00	117.00	195.00
Bahrain	N/A	123.50	219.00
Kuwait	120.00	125.00	205.00
Colombo	N/A	124.00	290.00
Singapore	108.00	115.00	188.00
Hong Kong	137.00	151.00	205.00
Japan (main ports)	152.00	156.00	243.00
Korea	134.00	139.00	206.00
Lagos	N/A	125-128	195-200
Durban	N/A	117-122	191-192
Santos	112.50	120.00	241.50-275
Venesuela	124.00	128.00	189.50
Sydney	N/A	153.00	250.00
New York	127.00	132.00	190.00
Philadelphia	132.00	137.00	195-197
Miami	132.00	138.00	200.00
New Oleans/Houston	102.00	105.00	165.00
Los Angeles	116.00	119.00	180.00
Puget Sound/Seattle	117-120	122.00	205-210
Vancouver	138.00	140.00	200.00
St. Eustatius	114-117	118-123	188-195
St. Croix	18.50	19.50	26.50
Aruba	118.00	123.00	190.00
Panama	117.00	122.00	185.00

Unit: US$/tonne

Prices at 15th january 1995

Table X: Fuel prices

The quality of the oil is very important and is therefore constantly monitored by, for example, the classification society Det Norske Veritas, **Table XI**. The shipowner should not only monitor the quality of the fuel while bunkering, but also the temperature of the fuel. Most of the measurement devices of liquids on board are based on the principle of flow meters that measure the volume. The volume of the oil (or rather the density) varies with the temperature as **Figure 5** illustrates.

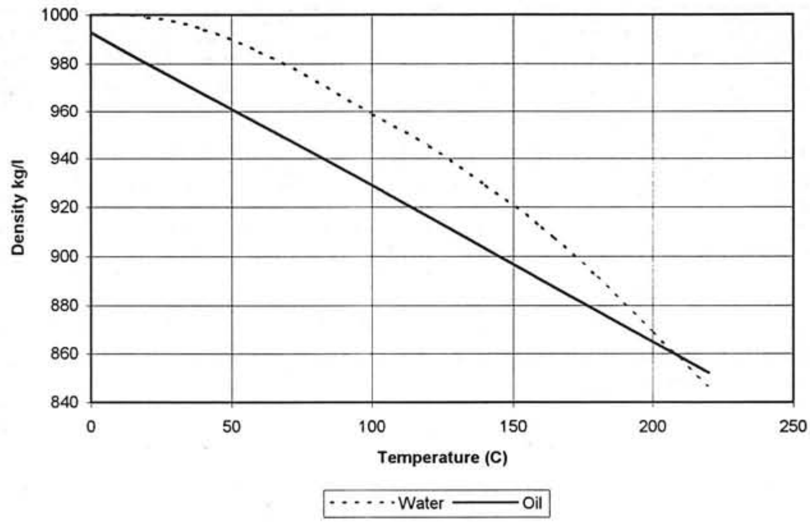


Figure 5: Relation between temperature and density of fuel oil

Figure 6 shows the relationship between the fuel consumption of container ships and their deadweight capacity. The graph suggests a sort of linear relationship, but this also depends on the speed of the vessels. The relationship between speed and fuel consumption is shown in **Figure 7**.

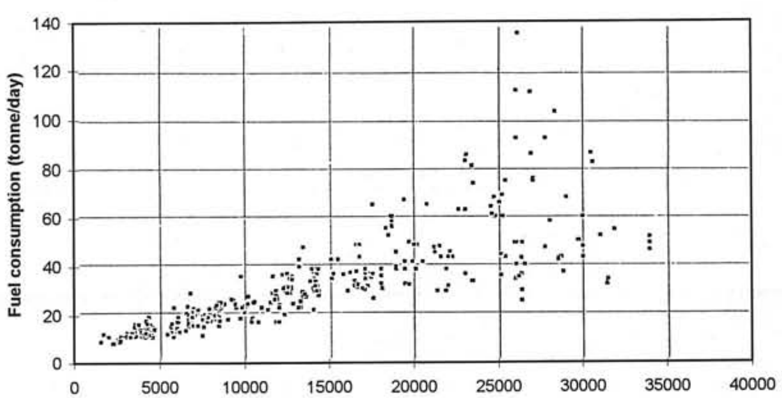


Figure 6: Fuel consumption - deadweight capacity relationship of container ships

	Period*	No. of samples	Density g/ml 15°C	Vis. CST 50°C	Water % V/V	SHF % M/M	Spec. Energy MJ/kg
Ravenna	**101-250 cSt**						
Agip	C	1	0.952	153	0.6	0.06	40.73
Recife	**15-100 cSt**						
Petrobras	R	1	0.938	33	0.2	0.02	41.38
	101-250 cSt						
Petrobras	%	1	0.958	108	0.3	0.02	40.84
Riga	**15-100 cSt**						
Latvian	C	1	0.922	29	0.2	0.01	41.44
Rijeka	**101-250 cSt**						
Ina	R	1	0.948	164	0.2	0.02	40.82
Ina	C	1	0.961	121	0.0	0.02	40.73
Rio grande	**15-100 cSt**						
Petrobras	C	1	0.032	23	0.1	0.02	40.90
	101-250 cSt						
Petrobras	R	14	0.990	164	0.1	0.02	39.87
Petrobras	C	8	0.984	183	0.1	0.02	39.93
	250-400 cSt						
Petrobras	R	2	0.950	72	0.2	0.01	40.93
Rio de Janairo	**15-100 cSt**						
Petrobras	R	2	0.950	72	0.2	0.01	40.93
	101-250 cSt						
Petrobras	R	15	0.981	167	0.2	0.01	40.36
Petrobras	C	2	0.974	179	0.2	0.02	40.57
	251-400 cSt						
Petrobras	R	9	0.977	308	0.2	0.02	40.40
Petrobras	C	4	0.985	318	0.1	0.01	40.28

*) R - Reference period - July 1988 to March 1989
C - Current period - April 1989 to June 1989

Table XI: Part of a fuel sample report by Det Norske Veritas

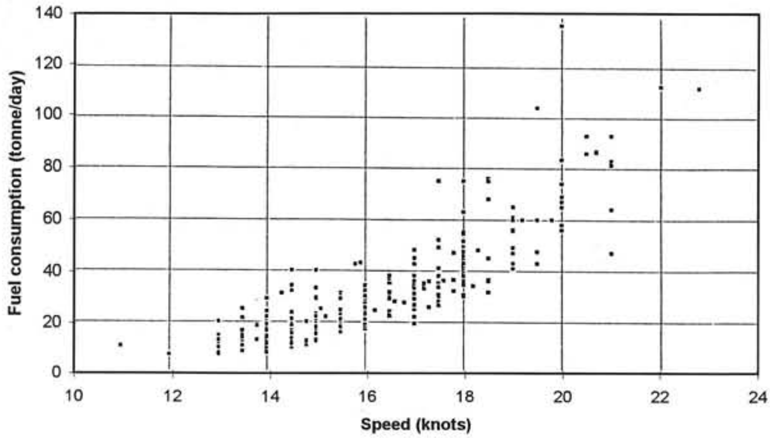


Figure 7: Relationship between speed and fuel consumption

The relationship between main engine fuel consumption and speed in laden and ballast condition is shown in **Figure 8** for a Panamax bulk carrier. The speed-consumption curve of the laden condition is of course different from the ballast condition. Over time the engine manufacturers have achieved remarkable increases in fuel efficiency, which can be illustrated by the following figures of the Panamax vessels in the world fleet.

Figure 9 shows the development over time of the average service speed of vessels, and the corresponding average fuel consumption. Although the average speed has dropped with one knot from 15 to 14 knots over the twenty year period, the fuel consumption decreased from 45 to 25 tonnes per day. **Figure 10** shows the speed and fuel consumption distribution of 850 Panamax bulk carriers in the world fleet. **Figure 11** demonstrates that the increase in fuel efficiency has not been limited to the Panamax bulk carriers.

5.3.2 Port costs and canal dues

Port charges are another important cost item of the voyage costs, and these include elements such as fees for the captains room, notification of vessels' Expected Time of Arrival (ETA), the port agency fee (for handling all the activities and paperwork during the port stay), the actual harbour dues (for the use of harbours, quays, mooring posts or buoys), the costs of pilotage (often divided into sea/river and harbour pilotage), tugboats and mooring crew.

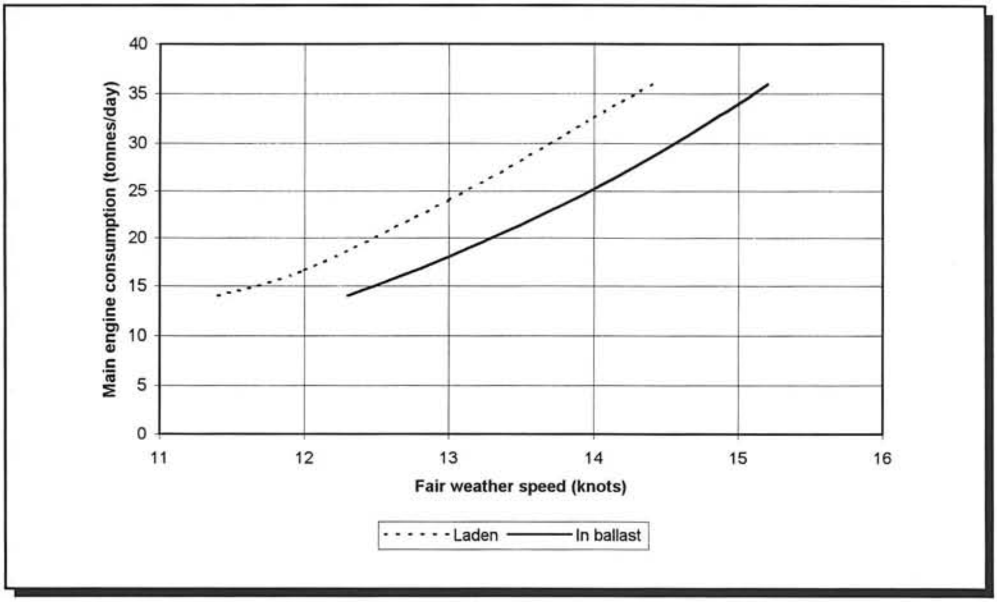


Figure 8: Relationship between main engine fuel consumption and speed

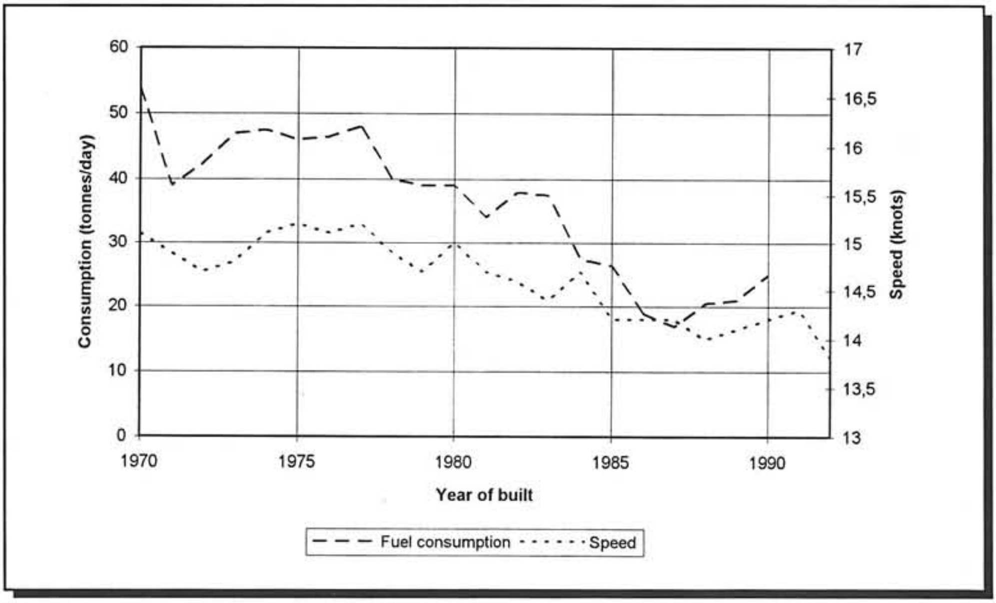


Figure 9: Development of the average service speed and fuel consumption

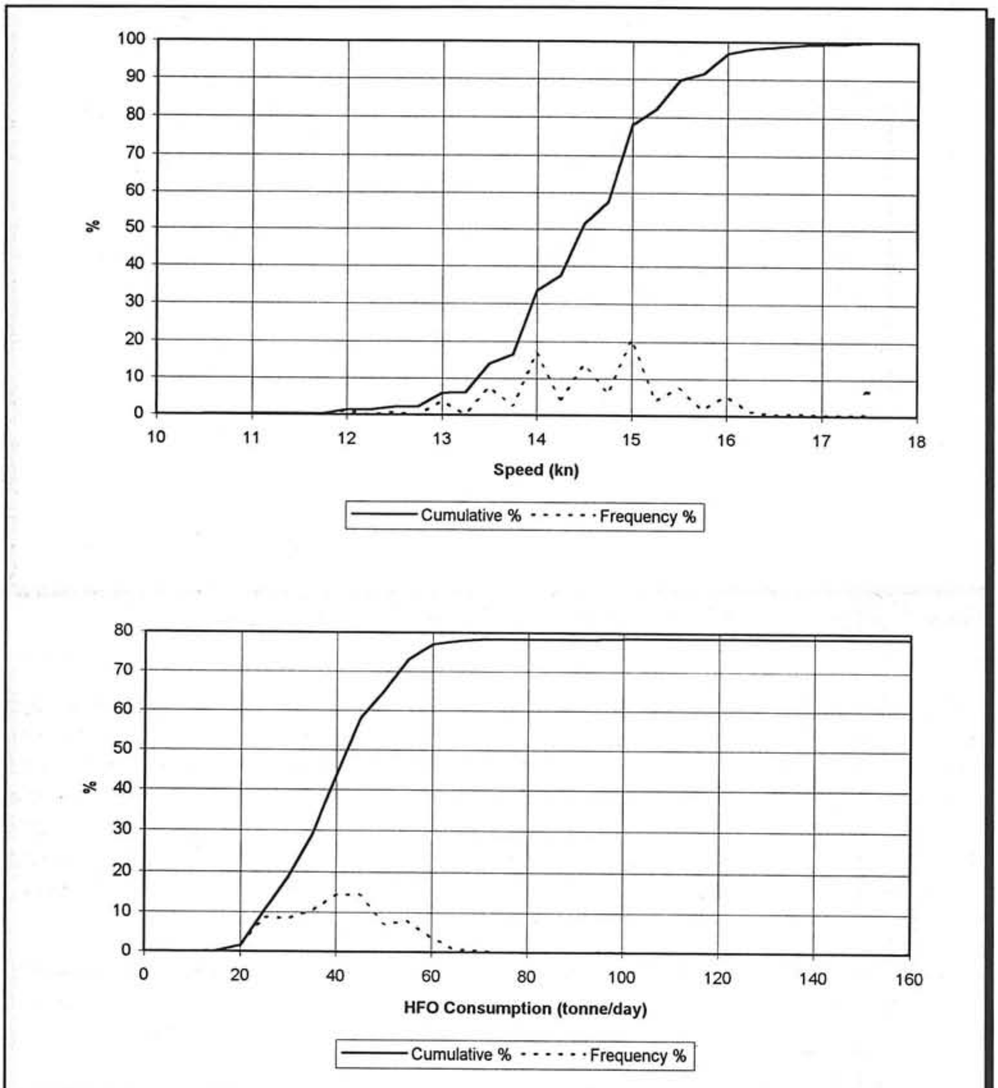


Figure 10: Speed and fuel oil consumption distribution of Panamax bulk carriers

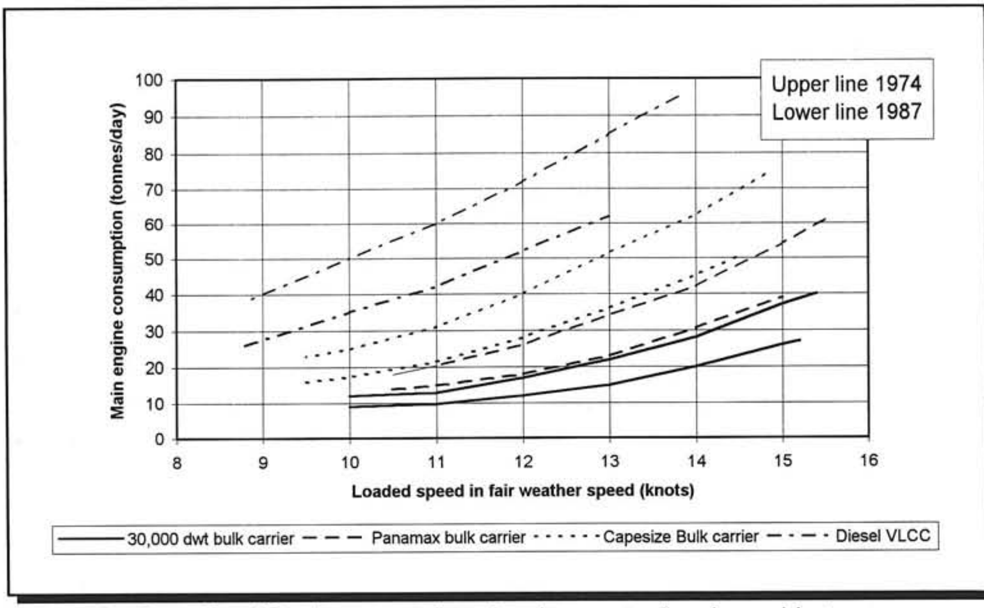


Figure 11: Speed and fuel consumption development of various ship types

A similar ship under similar loading conditions may be charged quite different costs in ports that are very close to each other like Rotterdam and Antwerp. **Table XII** shows the costs in these ports for 1985 of a fully cellular container ship of 58,000 gt (loa 289m, draught 11 m.) which operates in a liner service and discharges and loads 7,000 tonnes. The port call in Antwerp is approximately NLG 11,000 cheaper than in Rotterdam. For a fair comparison, the cost of the extra sailing time of 10 hours over the river Scheldt should be added to this amount, and then the balance tips in favour of Rotterdam.

	Rotterdam	Antwerp
Sea port dues	34.77	15.91
Sea/river pilot dues	13.84	16.71
Pilot due	3.67	6.55
Tug assistance	26.07	31.08
Mooring assistence	5.22	0
Quay dues	0	2.23

Unit: NLG * 1000

Table XII: Port costs for 50,000 grt container ship, 1985

The harbour dues, as such, are calculated on a rather straightforward basis for each ship category, as can be seen in the Tariffs brochure of the Municipal Port of

Rotterdam. The structure of the calculation of the harbour dues of crude oil tankers and container vessels in regular service are briefly discussed.

Harbour dues in the port of Rotterdam depend on the gross tonnage of the vessel and the amount of cargo loaded and/or unloaded. When the ship loads and unloads a significant amount of cargo compared to the gross tonnage of the ship (crude oil tanker 172.9% or more, container ship 51.3% or more) the harbour dues are calculated as a fixed sum per gt. Otherwise, the harbour dues are calculated as a fixed sum per gt and a fixed sum per tonne cargo loaded or unloaded. Tankers exclusively loading crude oil get a discount per gt of the vessel.

Canal dues have to be paid when ships sail through a toll based canal, such as the Panama Canal, the Suez Canal, the Saint Lawrence Seaway, the Kieler Canal, etc. The user fee charged by the operator of the canal is related to the size of the vessel in gt and the laden condition, as well as the cost of alternative routes for the canals. **Table XIII** shows the costs of using the Suez and Panama Canals for different ship types (Drewry).

Ship type	Sub-type	Suez Canal	Panama Canal
Tanker	ULCC (ballast)	258.8	
	Suezmax/million barrels	216.8	
	Products (35,000 dwt)	96.7	
Dry bulk carrier	Panamax	100.5	69.9
	Handysize/Handymax	125.2	42.9
	Capesize	160.0	
Container ship	2-2,500 TEU	190.6	92.4
Reefer ship	400,000 cuft.	46.4	16.2

Unit: 1,000 US$

Table XIII: Canal dues, 1990

5.4 Cargo handling costs

The objective of merchant ships is to transport cargo between different ports. To achieve this, cargo has to be transferred from ship to shore or vice versa, or directly from ship to ship or inland barge. The cargo handling costs can be seen in isolation from the total logistical process, but over the last decades a trend has developed in which shipowners look beyond their narrow confines and develop themselves into logistical operators.

The cargo handling costs are determined by a number of elements, such as the type of commodity (oil, chemicals, coal, grain, forest products, containers), the quantity, the ship type, the terminal and port characteristics. The loading and discharging of ships at the terminal is done by an independent stevedoring company or by the exporter or receiver of the cargo.

In the special purpose built iron ore export facility of Tubarao in Brazil, the terminal is just a part of the mining company that exploits the mines in the interior. The terminal layout (**Figure 12**) consists solely of ship loaders, which can also load ore into the bulk carriers at extreme loading rates.

The stevedoring costs of iron ore in this case are an integral part of the export price of the mining company. The ore is sold on the condition 'free on board', in short known as FOB. The discharge however may take place in Rotterdam with the independent stevedoring company EBS. The owner of the cargo has to pay in that case an amount between US $2-3 per tonne. If the ore is sold on the basis of CIF, then the stevedoring costs in Rotterdam will be paid by the exporting mining company. In dry bulk trades it depends on the condition in the sales contract whether the shipowner has to pay for the stevedoring/cargo handling costs.

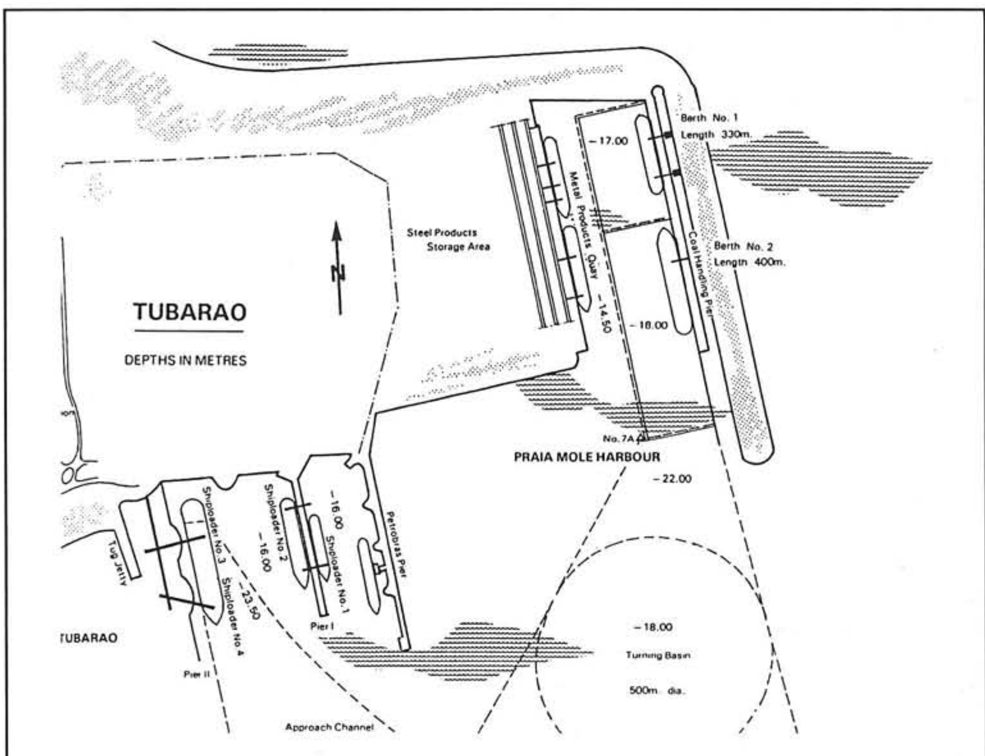


Figure 12: Tubarao terminal layout

Crude oil, transported in tankers, is simply pumped at oil terminals from the tank storage into the ship and vice versa. The cargo handling costs (loading) are of no concern to the shipowner, as these are often part of the sale or purchase contract or taken care of directly by the buyer of the oil in case it stored with independent tank storage companies, like Paktank or Van Ommeren Tank Storage. The discharging costs associated with the ship are paid by the shipowner.

The stevedoring costs of containers may range from US$ 100 to US$ 700 per unit, depending on the country. If one assumes an average weight of 15 tonnes per container and a cost of US$ 150 (Rotterdam-deepsea level), then the cargo handling costs per tonne are US$ 10. This is a sharp decrease since general cargo was started to be transported in units like the container around 1965.

A last example is presented from the reefer trades. **Figure 13** shows the development of the stevedoring costs of different types of reefer cargoes over a 30 year period in Rotterdam, in Dutch guilders of 1991. This clearly shows that the stevedoring costs of palletised cargoes have hardly increased, while the boxes with fruit, which are handled by hand, have more than quadrupled in cost.

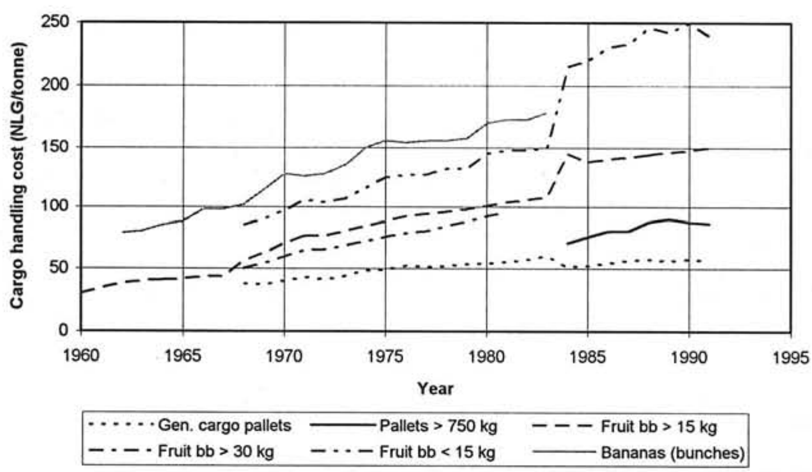


Figure 13: Stevedoring costs in the port of Rotterdam

Information on stevedoring charges is not well documented, in contrast tothe information of ports. Two important sources of port information are:

- Lloyd's of London Press, Ports of the World ;
- Shipping Guides Limited, Guides to Port Entry.

Self-loaders and unloaders

All tankers, like crude oil tankers, chemical tankers and gas carriers, are self-unloading, i.e. that the cargo is pumped on board by the terminal, and the ship's

pumps discharge the cargo into the receiving terminal storage facility. Liquids are easy to handle as it is continuous transport.
On the same basis dry bulk commodities like coal and grain can be discharged by elaborate conveying systems on board the ship. These so-called self-unloaders achieve phenomenal discharge rates. Some dry bulk ships are able to self-load and self-unload, and are in fact completely closed systems. These are mainly used in the cement trades, due to the extreme sensitivity of cargo for weather conditions, and environmental requirements (dust).
The advantage of self-unloading bulk carriers is that the stevedoring rates are a fraction of the traditional stevedoring costs, which are based on shore based grab crane operations. Low value commodities may thus be transported internationally, like for example aggregates and sea sand for the construction industry. The drawback of the ship is that its employment is more restricted due to the fixed installations on board, the higher investment and the loss of deadweight from the installation's weight and volume. The shipowners who invested in this type of ship have carved out special niches in various regions of the world.

5.5 Voyage calculation

Before an owner or charterer plans a shipment of cargo, he spends much time on voyage calculations. As there are often multiple options for the routing and chartering of the vessel, he uses software programmes to figure out the best result. Not only for the trip, but also to reposition his ship to an area where the likelihood for the next cargo is as high as possible. An overview of the available software can be found in Fairplay's *"Marine Computing Guide"*. In this section the structure of the voyage calculation will be illustrated by two examples, the first one from the heavy lift sector and the second one from the dry bulk sector.

5.5.1 Heavy lift shipping example

Mammoet Shipping is an operator of a fleet of medium sized multi-purpose ships, equipped with heavy lift cranes for the transport of all sorts of modules. The operator, based in Amsterdam, has developed a dedicated voyage calculation programme, which enables the commercial staff to make all sorts of route and cargo calculations quickly.
Table XIV gives an overview of possible cargoes that can be transported within a certain time window (lay-can). **Figure 14** shows the location of the different loading and discharging ports.

Table XV to **Table XVIII** show four possibilities for the scheduling of the ship. Voyage 1 has a duration of 47 days, and an operating result of US$ 2,975 per day; voyage 2 takes 30 days and results in US$ 5,737 per day; voyage 3 lasts 48 days and results in US$ 7,949 per day; finally, voyage 4 takes 54 days and delivers an operating result of US$ 15,101 per day, which is clearly superior to the other three possibilities. The calculations are self-explanatory. The corresponding sailing schedule is shown in **Table XIX**.

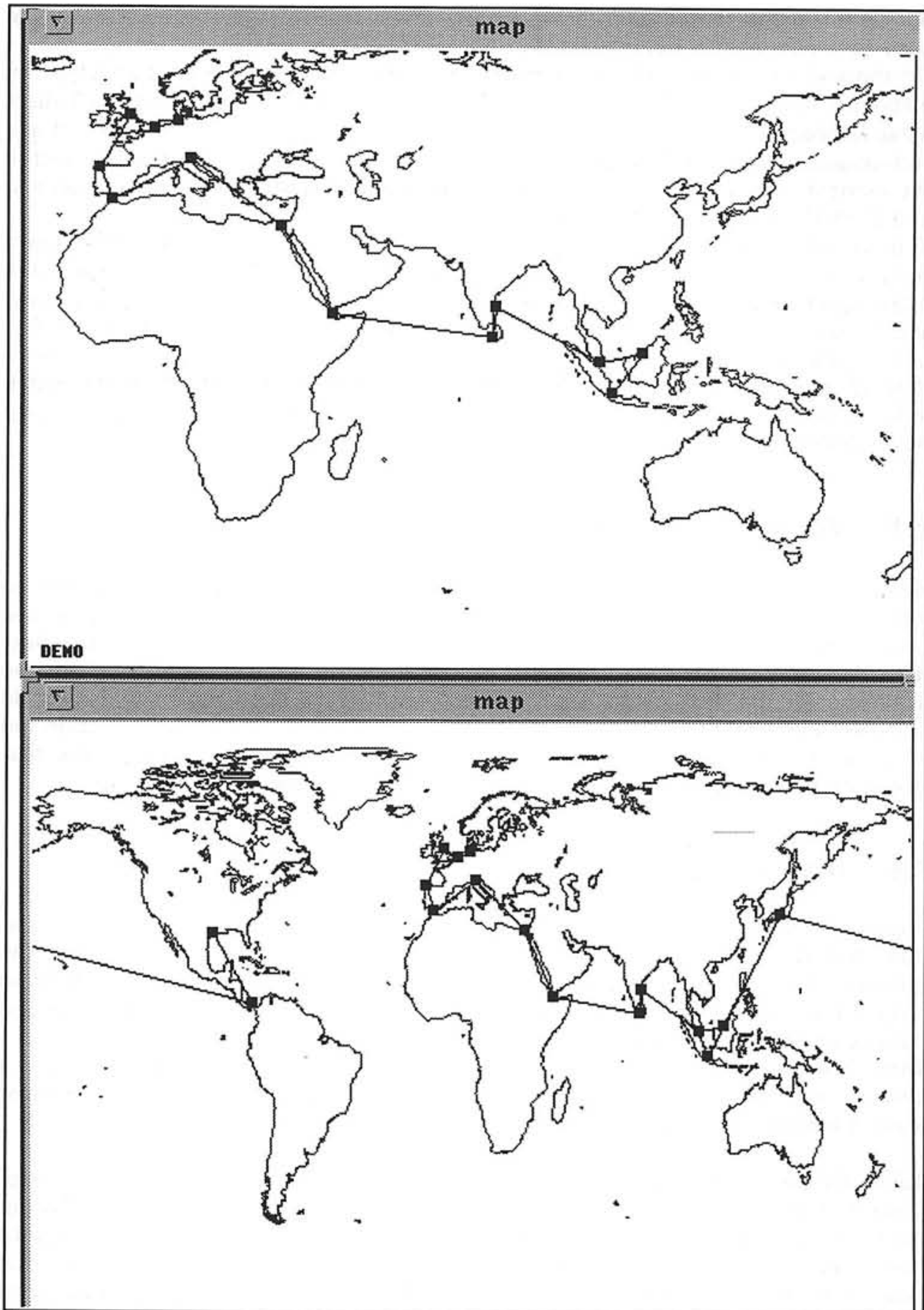


Figure 14 Loading and discharging ports

Lay-can		Cargo	Description	Port from	Port to
18-Nov-91	28-Nov-91	72157	Pressure vsls	Venice	Bintulu
01-Nov-91	05-Nov-91	72190	Hammers	Rotterdam	Singapore
05-Nov-91	15-Nov-91	72191	1 casco	El Ferrol	Jakarta
08-Dec-91	08-Dec-92	72192	Empty containers	Madras	Singapore
05-Nov-91	07-Nov-91	72193	1 yaught	Hartlepool	Gibraltar
01-Nov-91	10-Nov-91	72194	Dredgers	Rotterdam	Colombo
01-Nov-91	30-Nov-91	72195	Gens	Venice	Djibouti
15-Jan-92	31-Jan-92	72200	Turbine + generator	Nagoya	Houston
20-Dec-91	25-Dec-91	72202	Trucks	Reunion	Singapore

Table XIV: Cargoes within time window

Table XV: Voyage calculation 1

1991 October 14 2:58:49 pm		**PreCalculation**		Mammoet Shipping, Amsterdam
Mammoet Demo	**Voyage 1**	**47 days**	**From: 91/11/01**	**To: 91/12/18**

Cargo

Description	*Mton*	*M3.*	*From*	*To*	*Base*	*Freight*	*Comm amount*	*Loading costs*	*Discharge costs*
pressure vsls	700	3800	Venice	Bintulu	LT	446500	37906	35000	30000
						446500	**37906**	**35000**	**30000**

Voyage-routing

Port	*Arrival*	*Departure*	*Portdays*	*Miles*	*Costs*
Hamburg	91/11/01:12	91/11/01:12	00:00	3278	11603
Venice	91/11/18:00	91/11/21:00	03:00	1398	13689
Suez Canal Zone	91/11/26:12	91/11/26:12	00:00	5485	70000
Bintulu	91/12/15:19	91/12/18:19	03:00	0	7487
			06:00	**10161**	**102780**

Bunkers

Code	*Price*	*Activity*	*Days*	*Quantity*	*Costs*
IFO380	86	SE	0034:18	869	74776
IFO380	86	SF	0000:00	0	0
MDO	193	LO	0006:00	15	2895
MDO	193	LN	0000:00	0	0
					77671

Total Freight	:	446500
Total costs	:	283357
Result before MF	:	**163142**
Man Fee 5 %	:	22325
Out of Operation correction	:	0
Operating result	:	**140817**

Off Hire hours	:	00:00
Average per day	:	**2975**

Table XVI: Voyage calculation 2

1991 October 14 2:59:08 pm

PreCalculation

Mammoet Shipping, Amsterdam

Mammoet Demo | **Voyage 2** | **30 days** | **From: 91/11/18** | **To: 91/12/18**

Cargo

Description	*Mton*	*M3.*	*From*	*To*	*Base*	*Freight*	*Comm amount*	*Loading costs*	*Discharge costs*
pressure vsls	700	3800	Venice	Bintulu	LT	446500	37906	35000	30000
						446500	**37906**	**35000**	**30000**

Voyage-routing

Port	*Arrival*	*Departure*	*Portdays*	*Miles*	*Costs*
Venice	91/11/18:00	91/11/21:00	03:00	1398	13328
Suez Canal Zone	91/11/26:12	91/11/26:12	00:00	5485	70000
Bintulu	91/12/15:19	91/12/18:19	03:00	0	7487
			06:00	**6883**	**90816**

Bunkers

Code	*Price*	*Activity*	*Days*	*Quantity*	*Costs*
IFO380	86	SE	0023:13	589	50675
IFO380	86	SF	0000:00	0	0
MDO	193	LO	0006:00	15	2895
MDO	193	LN	0000:00	0	0
					53570

Total Freight	:	446500
Total costs	:	247293
Result before MF	:	**199207**
Man Fee 5 %	:	22325
Out of Operation correction	:	0
Operating result	:	**176882**

Off Hire hours	:	00:00
Average per day	:	**5737**

Table XVII: Voyage calculation 3

1991 October 14 3:09:48 pm

PreCalculation

Mammoet Shipping, Amsterdam

Mammoet Demo **Voyage 1** **48 days** **From: 91/11/01** **To: 91/12/19**

Cargo

Description	*Mton*	*M3.*	*From*	*To*	*Base*	*Freight*	*Comm amount*	*Loading costs*	*Discharge costs*
dredgers	550	1600	Rotterdam	Colombo	LT	318627	23897	7353	7353
pressure vsls	700	3800	Venice	Bintulu	LT	446500	37906	35000	30000
						765127	**61803**	**42353**	**37353**

Voyage-routing

Port	*Arrival*	*Departure*	*Portdays*	*Miles*	*Costs*
Hamburg	91/11/01:12	91/11/01:12	00:00	305	11603
Rotterdam	91/11/02:23	91/11/04:11	01:12	3025	15024
Venice	91/11/18:00	91/11/21:00	03:00	1398	13689
Suez Canal Zone	91/11/26:12	91/11/26:12	00:00	3394	70000
Colombo	91/12/08:18	91/12/10:06	01:12	1960	3553
Bintulu	91/12/16:22	91/12/19:22	03:00	0	7487
			09:00	**10082**	**121358**

Bunkers

Code	*Price*	*Activity*	*Days*	*Quantity*	*Costs*
IFO380	86	SE	0034:15	865	74468
IFO380	86	SF	0000:00	0	0
MDO	193	LO	0009:00	22	4342
MDO	193	LN	0000:00	0	0
					78810

Total Freight	:	765127
Total costs	:	341678
Result before MF	:	**423449**
Man Fee 5 %	:	38256
Out of Operation correction	:	0
Operating result	:	**385192**

Off Hire hours	:	00:00
Average per day	:	**7949**

1991 October 14 3:53:45 pm

PreCalculation

Mammoet Shipping, Amsterdam

Mammoet Demo **Voyage 1** **54 days** **From: 91/11/01** **To: 91/12/25**

Cargo

Description	*Mton*	*M3.*	*From*	*To*	*Base*	*Freight*	*Comm amount*	*Loading costs*	*Discharge costs*
1 yaught	200	600	Hartlepool	Gibraltar	LT	109075	8181	8080	4848
pressure vsls	700	3800	Venice	Bintulu	LT	446500	37906	35000	30000
gens	150	650	Venice	Djibouti	FIOS	95000	7125	0	0
1 casco	250	1200	El Ferrol	Jakarta, tanjung priok	LIFO	265000	16625	20000	0
hammers	180	600	Rotterdam	Singapore	FIOS	88235	1103	0	0
dredgers	550	1600	Rotterdam	Colombo	LT	318627	23897	7353	7353
empty containers	95	0	Madras	Singapore	FIOS	65000	4875	0	0
						1387437	**99712**	**70433**	**42201**

Voyage-routing

Port	*Arrival*	*Departure*	*Portdays*	*Miles*	*Costs*
Hamburg	91/11/01:12	91/11/01:12	00:00	305	11603
Rotterdam	91/11/02:23	91/11/04:23	02:00	267	15343
Hartlepool	91/11/06:02	91/11/06:08	00:06	908	32903
El Ferrol	91/11/09:13	91/11/09:19	00:06	620	2721
Gibraltar	91/11/11:22	91/11/12:04	00:06	1664	16910
Venice	91/11/18:00	91/11/21:12	03:12	1398	13689
Suez Canal Zone	91/11/27:00	91/11/27:00	00:00	1290	70000
Djibouti	91/12/02:04	91/12/02:16	00:12	2203	9999
Colombo	91/12/10:06	91/12/11:18	01:12	590	3553
Madras	91/12/13:19	91/12/14:07	00:12	1586	6856
Singapore	91/12/19:17	91/12/20:17	01:00	1	3713
Bintulu	91/12/20:21	91/12/23:21	03:00	400	7487
Jakarta, tanjung priok	91/12/25:06	91/12/25:12	00:06	0	5644
			13:00	**11232**	**200427**

Bunkers

Code	*Price*	*Activity*	*Days*	*Quantity*	*Costs*
IFO380	86	SE	0038:20	971	83556
IFO380	86	SF	0000:00	0	0
MDO	193	LO	0013:00	32	6272
MDO	193	LN	0000:00	0	0
					89828

Total Freight	:	1387437
Total costs	:	502602
Result before MF	:	**884835**

Man Fee 5 %	:	69371
Out of Operation correction	:	0
Operating result	:	**815463**
Off Hire hours	:	00:00
Average per day	:	**15101**

1991 October 15 11:01:10 am
Amsterdam

Sailing Schedule

Mammoet Shipping,

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Mammoet Demo

01	Hamburg	91/11/01	91/11/01
	Rotterdam	91/11/02	91/11/04
	Hartlepool	91/11/06	91/11/06
	Ferrol	91/11/09	91/11/09
	Gibraltar	91/11/11	91/11/12
	Venice	91/11/18	91/11/21
	Suez canal zone	91/11/27	91/11/27
	Djibouti	91/12/02	91/12/02
	Colombo	91/12/10	91/12/11
	Madras	91/12/13	91/12/14
	Singapore	91/12/19	91/12/20
	Bintulu	91/12/20	91/12/23
	Jakarta	91/12/25	91/12/25
	2Nagoya	92/01/15	92/01/19
	Panama canal zone	92/02/20	92/02/20
	Houston	92/02/20	92/02/24

Project Orient

23

	Osaka	91/08/04	91/08/08
	Tsu	91/08/09	91/08/10
	Inchon	91/08/13	91/08/19
	Chungmu	91/08/20	91/08/26
	Muroran	91/08/29	91/08/29
	Suez Canal Zone	91/09/22	91/09/22
	Benghazi	91/09/25	91/09/28
	Marsa El Brega	91/09/29	91/10/03
	Trieste	91/10/07	91/10/07
	Setubal	91/10/13	91/10/14
	Rouen	91/10/17	91/10/17
24	Corpus Christi	91/10/30	91/10/31
open 00:14 (days:hours)			
	Charleston	91/11/06	91/11/07

Table XIX: Sailing schedule

5.5.2 Dry bulk shipping example

This section is based on the *"Quantative Methods in Maritime Economics"* by J.J. Evans and P.B. Marlow.

Voyage: New Orleans to Yokohama. 25,500 tonnes ± 5% Scrap. Feb. US$ 25.00 fio. 3,000 Load/4,500 discharge both SHEX. 3.75%.

Find the Gross surplus/day and the Time charter Equivelent (TCE) (5%) given:

1. *Universe Cardiff* in Rotterdam: Summer dwt 26,000 tonnes. Draught 32'09", Hold Capacity 1,120,000 cu.ft.
2. Speed 14.5 knots
3. Fuel consumption
   40 tonnes/day H.F.O. at sea, 1 tonne/day in port
   1 tonne/day D.O. throughout
4. Port disbursements

New Orleans	US$ 25,000
Yokohama	US$ 36,000
Panama	US$ 7,000
Canal Dues	US$ 27,000

5. Distances

Rotterdam-New Orleans	4,880 miles
New Orleans-Panama	1,430 miles
Panama-Yokohama	8,400 miles

6. Fuel prices

Rotterdam	Fuel oil US$ 110/tonne
	Diesel oil US$ 180/tonne
Panama	Fuel oil US$ 105/tonne
	Diesel oil US$ 180/tonne

   Remain on board Rotterdam
   Fuel oil 200 tonnes (US$ 120/tonne)
   Diesel oil 50 tonnes (US$ 200/tonne)
7. Safety margin
   Fuel oil 150 tonnes
   Diesel 50 tonnes
8. Running costs
   US$ 4,000/day
9. Load Line Zones
   New Orleans-Summer; Balboa-Tropical;
   Yokohama-Summer

Also find the optimum speed and the corresponding Gross Profit/day.

It is first necessary to be certain whether 25,000 tonnes ± 5% is at owner's or charterer's option. In this case it is at owner's option, in which case the vessel must load a minimum of 24,225 tonnes up to a maximum available of 26,775 tonnes. The scrap stows at about 35 cu.ft./tonne, which means that the quantity loaded will be weight rather than volume constrained.

Voyage Legs

Port	Distance (nm)	Days	Fuel (tonnes)	Diesel (tonnes)
Rotterdam	-	-	-	-
New Orleans	4,880	14.02	561	14
Panama	1,430	4.11	165	4
Panama	-	-	-	-
Yokohama	8,400	24.14	966	24
	14,710	42.27	1,692	42

Port Details

Port	Days	Port costs	Fuel (tonnes)	Diesel (tonnes)
Rotterdam	-	-	-	-
New Orleans	10.7	25,000	11	11
Panama	1.0	7,000	1	1
Yokohama	8.0	36,000	8	8
	19.7	68,000	20	20

Time in port is based upon an estimated cargo of 24,500 tonnes loaded at 3,000 tonnes/day; discharged at 4,000 tonnes/day; a 5½ day working week augmented by one day to allow for notice. It is assumed that all lay time will be used.

Bunkering plan

Port	Fuel (tonnes)	Price (US$)	D.O. (tonnes)	Price (US$)	Total Costs (US$)
ROB	200	120	50	200	34,00
Rotterdam	688	110	62	180	86,840
Balboa	974	105	-	-	102,270
Yokohama	-	-	-	-	-
ROB	150	105	50	180	(24,750)
					198,360

Fuel remaining on board at the beginning of the voyage is charged at the price paid on the previous voyage. Fuel remaining on board at the end of the voyage is credited at prices paid during the current voyage.

Cargo details

	Amount (tonnes)
Summer deadweight	**26,000**
Supplies	**1,606**
Stores etc.	400
Fuel oil	974
Diesel oil	32
Safety margin	200
Available for cargo	**24,394**
+ 4½ days (allowance for tropical zone)	185
Total cargo	**24,579**

Since the vessel is bunkering at Balboa, the critical time for determining cargo weight is at Balboa. An extra allowance of 185 tonnes is made since vessel leaves Balboa in a Tropical Cargo carried complies with the C/P terms of 25,000 tonnes ± 5%.

	Expenses (US$)		Revenue (US$)
Fuel oil/diesel oil	198,360	24,579 t of US$ 25 each	614,475
Port expenses	68,000	Less Comm. (3.75%)	23,043
Cargo handling	-		
Canal dues	27,000		
Taxes	-	Net Revenue	591,432
Sundries	-	Less Expenses	293,360
Warrenties	-		
	293,360	Voyage surplus	298,072

Total Days on Voyage = 62
Hence, Daily Surplus = US$ 4,808
Gross Profit/day = US$ 4,808 - US$ 4,000 = US$ 808
(running costs = US$ 4,000/day)
TCE = US$ 4,808 plus allowance for commission US$ 5,061

5.6 Composition of cost over time

As shown in previous sections, there have been fairly dramatic changes in the cost picture over time. This is important to remember when studying the economics of shipping supply. Of particular interest are the bunker costs in relation to all the other elements. A couple of studies illustrate this important point well.

To see what happened to the cost structure before and after the two oil price shocks in 1973 and 1979, **Table XX** is illuminating.

The voyage cost shares increased dramatically from 1973 to 1981 and particularly for large vessels. Operating costs, where manning accounts for about 50%, was

Vessel type and cost share	1973	1981
Container vessel - 1000 TEU		
Capital costs*	57%	59%
Operating costs	33%	20%
Voyage costs	10%	21%
25,000 dwt bulk carrier		
Capital costs*	52%	40%
Operating costs	33 %	23%
Voyage costs	16%	37%
110,000 dwt bulk carrier		
Capital costs*	60%	42%
Operating costs	25%	18%
Voyage costs	14%	40%

* Annual equivalent of 80% debt finance at 8.5% over 8 years and 15% return on equity over 15 years.
Source: Heaver (1985)

Table XX: The structure of costs before and after the oil crisis

dramatically reduced. In the total cost picture fixed costs (capital cost and operating costs) were reduced from 85-90% to 60-79%.

For even larger vessels, like the VLCCs, the changes are even more dramatic. This is illustrated in **Figure 15**[1], showing the costs of carrying one tonne of crude oil from the Arabian Gulf to Rotterdam.

After the second oil price shock, the voyage costs rose to as much as 50% of the total costs, of which fuel costs amounted to 45% of the total costs.

The running expenses were in 1980 reduced to 16% of total costs and 24% of variable costs, compared to 25% of total costs and 52% of variable costs in 1967.

This dramatic change in cost structure has had at least three main effects for large tankers:

- Lay-up becomes a less likely alternative to trading;
- Slow steaming becomes much more profitable;
- The technological development moves from labour saving to energy saving.

[1]The figure is based on Norman (1980), but updated with own data for 1991.

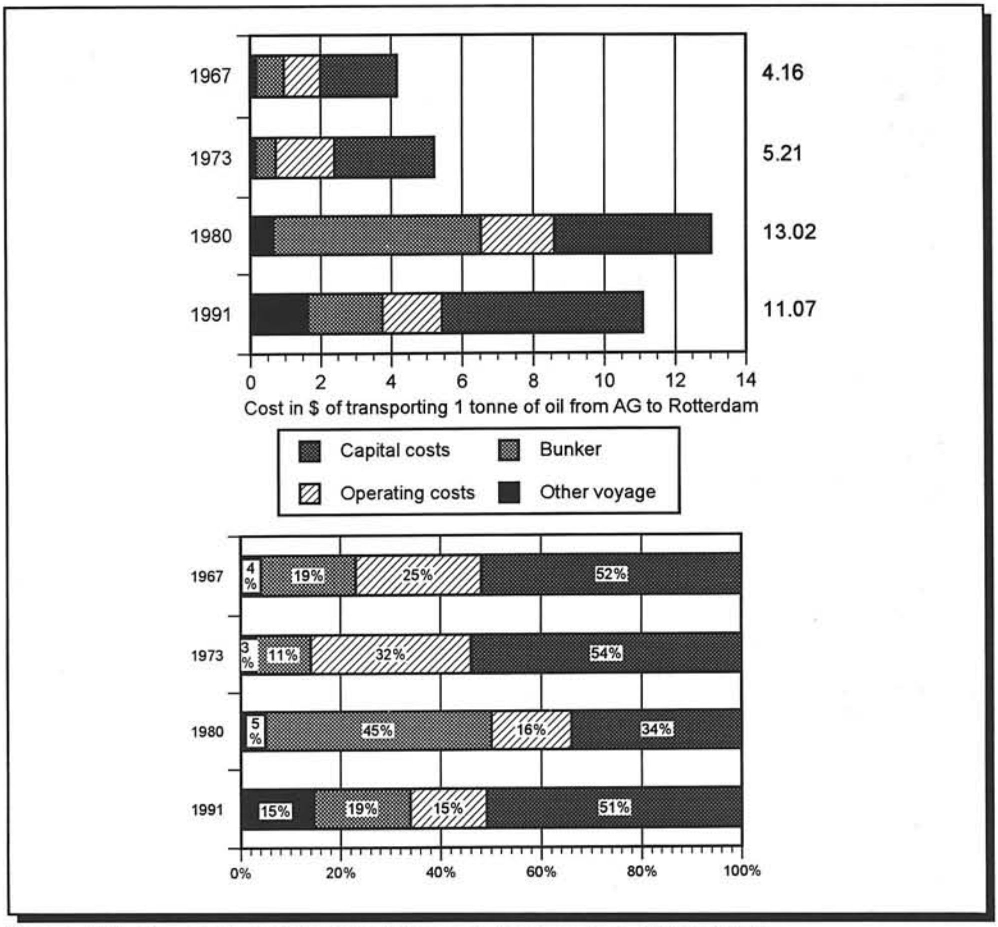


Figure 15: The costs of transporting one tonne of oil 1967-1991

Since running expenses with high oil prices constitute only 24% of variable costs compared to 52% with low oil prices, and lay-up simply is a question of comparing freight rates with running expenses, lay-up is less likely with very high oil prices.

Slow steaming, i.e. reducing the speed of the vessel, has the effect that fuel consumption is reduced exponentially, and with high oil prices this gives a much greater cost saving than with low oil prices. This will be discussed in great detail in chapter 9. Since slow steaming is determined by balancing the reduced costs against the cost of spending longer time on a trip, high oil prices makes slow steaming more likely to take place.

Finally, the change in relative costs affects the priorities of technological development. When manning constitutes some 15% of the total costs, the advantage of reducing manning (either by making the ships larger, or by equipping them with electronic instruments allowing a cut in manning) is much higher than when crew costs are only 7-8% of the total. In 1967 it was 35% more profitable to invest in a technical development of a ship to save 10% in daily running expenses compared to an investment in fuel savings. In 1980 this was the other way around. Then it was almost 3 times as profitable to invest in energy saving technology compared to technology investments saving 10% on daily running expenses.

CHAPTER 6: FREIGHT, REVENUE AND USER COST

6.1 The user cost of shipping

The freight rate is a revenue for the shipowner, but a cost for the final consumer. It is, therefore, interesting to analyse how important freight costs are for the price of the final product. This is important in understanding how demand fluctuations for final goods may influence shipping, through the cost element that shipping constitutes for final consumers.

6.1.1 The freight element as share of import values

A product that is exported can either be sold at terms FOB (Free On Board) or CIF (Cost, Insurance and Freight). FOB means the price of the commodity delivered on the ship that shall carry it and CIF means the price when the commodity has been delivered to the receiver of the shipment. Since the element cost in the CIF-term is equal to the FOB value, the difference between a CIF price and a FOB price is insurance and freight, of which freight normally is the dominating component. As international export statistics quote values of cargo in FOB-prices and import statistics quote values in CIF-prices, a study of the differences in the value of total world exports and total world imports can give an indication of the proportion of insurance and freight in the final price to receivers of cargo.

The International Monetary Fund regularly publishes tables of the CIF value of the total world trade divided by the FOB value of the same trade. From this, one can see the insurance and freight share of the CIF price. This is illustrated by **Figure 1**. Several interesting observations can be made on the basis of this figure. First of all, there is a dominating difference between the trade of industrial countries and the trade of developing countries with a much lower share of transportation costs for the former group. This is mainly due to the composition of trade. This appears from **Table I**.

North America and Europe are dominantly trading in manufactured commodities. Japan's export is extremely oriented towards manufactures. Japan's import, on the other hand, is much more raw material oriented, which is also the case for the average exports of the rest of the world. As raw materials are mainly low value products and manufactures are high value products, one would generally expect countries with a high raw material share in trade to show a higher insurance and freight share of final product values.

In **Table II**, the share of insurance and freight in the CIF-value of trade has been indicated for selected countries for 1965, 1980 and 1994.

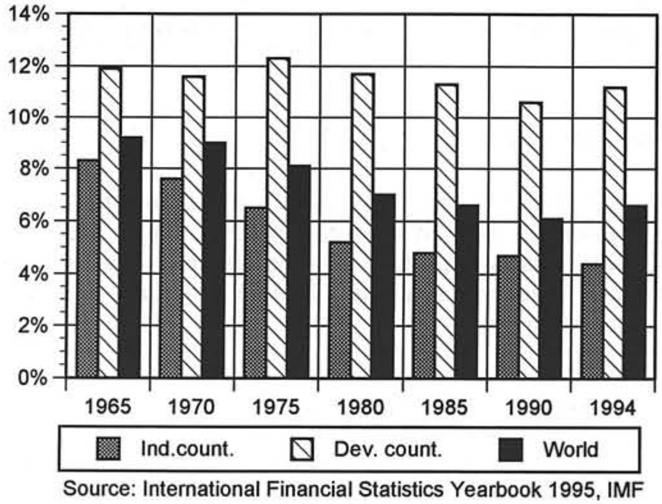


Figure 1: Insurance and freight as % of CIF value of world trade

	1994 US$ value of		Share of total trade	
Region	Export	Import	%	%
North America	501	662	73.9	79.1
Europe	1418	1319	78.9	73.5
Japan	378	136	95.2	49.2
All other nations	745	973	61.6	74.6
World	3042	3089	74.4	73.4

Source: WTO, International Trade, Trends and Statistics 1995

Table I: World trade in manufactured commodities 1994

As can be seen from this table, there are considerable differences from country to country. One can note the dramatic reduction in trade costs for UK, which is primarily a change in trading partners from trade with the former colonies to trade within Europe. Most nations have experienced a significant reduction in trade costs in this period, much of which can be attributed to a higher efficiency in international shipping.

Country	1965	1980	1994
USA	8.7	4.8	3.8
Australia	11.4	10.1	7.0
Japan	21.4	8.8	9.0
France	7.7	3.5	4.4
Germany	6.8	3.0	2.8
The Netherlands	6.0	5.7	5.6
Norway	2.8	2.1	2.6
UK	11.3	8.7	1.7

Source: IMF International Financial Statistics Yearbook 1995

Table II: Insurance and freight as percentage of CIF value of trade

6.1.2 Shipping costs of bulk products

Crude oil

Transportation costs for the largest bulk commodity, crude oil, has come down quite dramatically since the 1960s. From the oil transportation cost figure in section 5.6, the freight rates are as in **Table III**, where the price of crude oil has been added.

Year	Freight rate in US$/tonne AG - West	Crude oil price in US$/tonne	Transportation costs as % of value AG - West
1967	4.16	13.19	31.5%
1973	5.21	20.16	25.8%
1980	13.02	197.91	6.6%
1991	11.07	146.67	7.5%

Table III: Oil value and freight costs

When crude oil was cheap and being sold at around 2 US$ per barrel, or 15-20 US$ per tonne, the transportation costs constituted some 25-30% of this value. Since then, crude oil prices have increased much more than freight rates, so currently the transportation costs for crude oil constitute 2-8% of the value of the cargo, as shown in **Figure 2.**

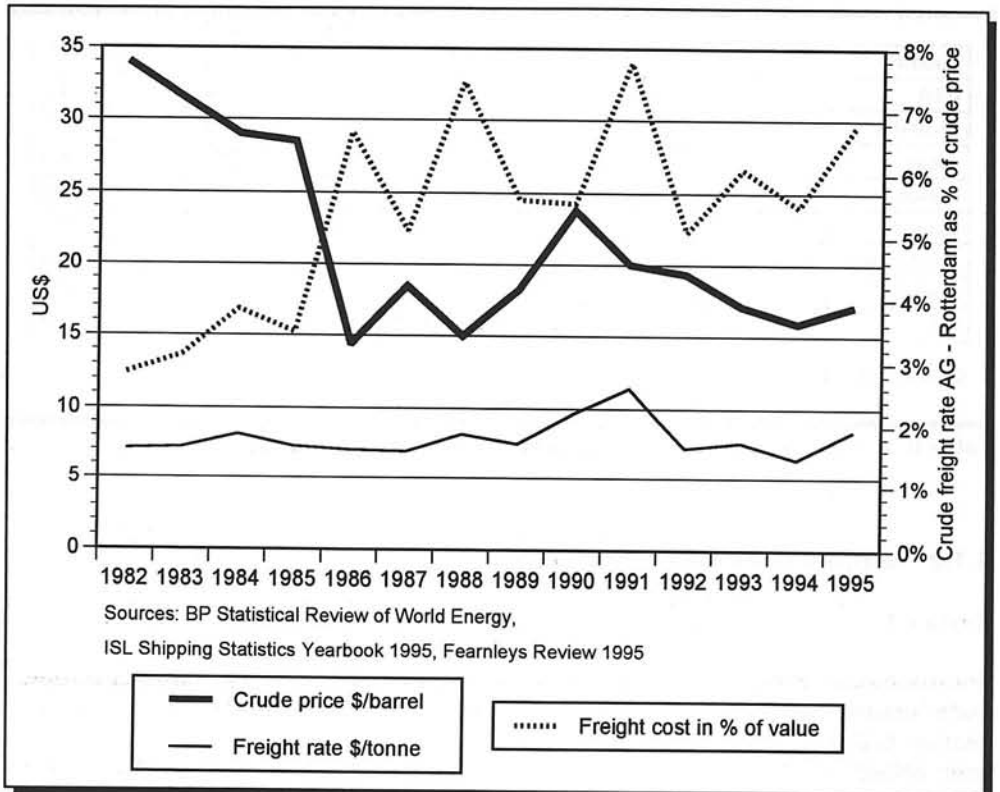


Figure 2: Crude oil prices, freight rates and freight cost shares 1982-1995

Iron ore

There are 5 dominating sources of iron ore: Brazil, Australia, South Africa, Sweden and Chile. **Table IV** names two of the companies most often referred to for price quotations for ore.

Firm	Abbr.	Quality	US$cents per DMT* Unit	US US$/tonne
Companhia Vale do Rio Doce	CVRD	64.5% Fe	28.1	18.10
Hamersley Holdings Ltd.	HH	64% Fe	31.4	20.1

* DMT is dry metric tonne, one unit is 1% Fe

Table IV: Main producers of iron ore and prices in the Japanese market 1992

Iron ore is normally priced according to the dry weight contents of iron, so the price is per unit (%) of Fe. CVRD is used as the benchmark price in Europe, while Hamersley is the benchmark in Japan. The development of the CVRD price together with the freight rate for the route Brazil to the Continent is given in **Figure 3**.

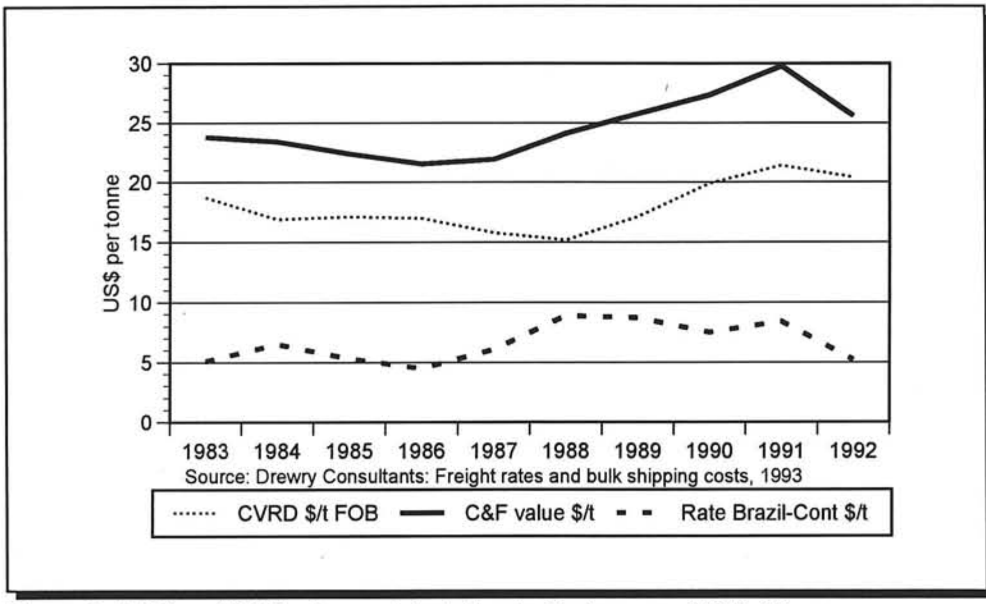


Figure 3: FOB and C&F price and freight rate for iron ore 1983-92

The transportation cost share for iron ore is illustrated in **Figure 4**, which shows that for iron ore, transport costs constitute some 20-35% of the C&F value of ore, a much higher figure than for oil, mainly due to the low value of ore.

Chrome ore

Other important ores shipped in bulk carriers are chrome ore and manganese ore. Chrome ore - or more correctly - chromite, is used for several purposes. The main grade is a high chromium (46-48% Cr_2O_3) metallurgical grade used to produce chromium alloys like the ferro-chrome. There are also chemical grades and refractory grades of chrome ore.

South Africa is a main exporter of chrome ore and so is Turkey. Japan and China are the main importers. Since chrome ore can be found in many different grades, prices also vary. Both the contents of Cr_2O_3 and the chromium to iron ratio matters. In the beginning of the 1990s chrome ores were available at prices varying from 60-110 US$ per tonne, where the highest prices are for metallurgical ores with 48% Cr_2O_3 and a chromium to iron ratio of at least 3:1. The transportation costs for ore will of course depend on the trade. A typical shipment would be 20-25,000 tonnes of Transvaal chrome concentrate from Maputo, South Africa to a US Gulf Port, where the cost per tonne would be in the 15-20 US$ range. The freight element in the C&F price of chrome ore would then typically be 15-20%, a little lower than for iron ore.

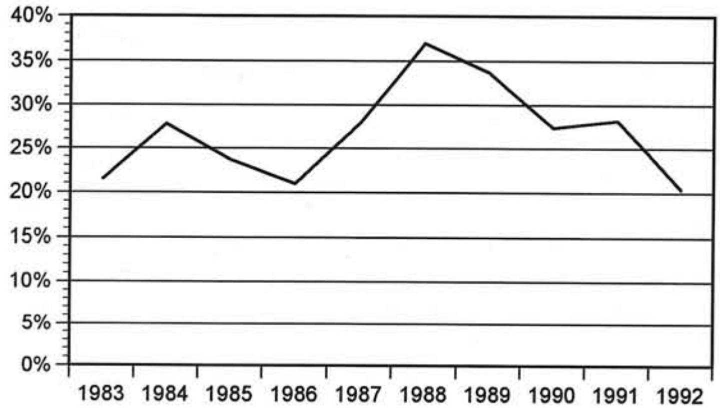


Figure 4: Freight rate Brazil-Continent as % of C&F value of iron ore 1983-92

Manganese ore

Manganese ore is normally classified both according to end use (metallurgical, chemical, battery grades) and the content of manganese. Higher grade ores for production of ferro-manganese alloys can have up to 50% Mn. The largest exporters of manganese ore are South Africa, Gabon and Australia and the largest importers are the EU countries and Japan (about 50%), but also Norway is a large importer with almost 10% of world imports.

The prices of manganese ores showed high fluctuations in the 1980s, rising from a level of 1.05 US$ per unit of Mn in 1987 to a record level of 3.35 US$ in 1990-91. For a 48% Mn grade, this corresponds to a price increase from 50 US$/tonne in 1987 to 161 US$/tonne in 1991. A shipment from Port Elizabeth in South Africa to Europe could be done in a Panamax size ship, with freight rates around 10-12 US$/tonne. The freight element in the C&F price of manganese ore is therefore as little as 5-10%.

Coal

Coal can be used for two main purposes. Bituminous coals are intended for metallurgical purposes and are called coking coals as opposed to non-bituminous steam coals (thermal coals) intended for power production, also known as anthracite. The coking coals (also called 'met coals') are used to form coke, which is essential in pig iron production. The various coals are distinguished according to coking properties, the contents of volatile matters, sulphur, ash and moisture. The prices are normally benchmarked by the heating value, which can be measured in British thermal units per pound (BTU/lb.) or in kilocalories per kilogramme (Kcal/kg).

Australia and the USA are the two dominating exporters of coal. In the USA the dominating coal port is Hampton Roads, large ports in Australia are Abbot Point, Hay Point, Newcastle and Port Kembla. Other large export volumes come from Roberts Bank in Canada, Richards Bay in South Africa, Bolivar in Colombia and Gdansk in Poland.

The main importers of coal are Japan and the EU. Coking coal for the steel industry is mostly sold at FOB prices under medium term contracts, while steam coal is more influenced by spot prices and are sold mostly on CIF-terms. There are many reference prices that could be used for the value of coal, but as Europe is a main importer, the cost picture for the EU is chosen. **Figure 5** shows the average CIF value of imported coal to the EU for the period 1983-91, together with the freight rate for coal transports from Hampton Roads to the Continent.

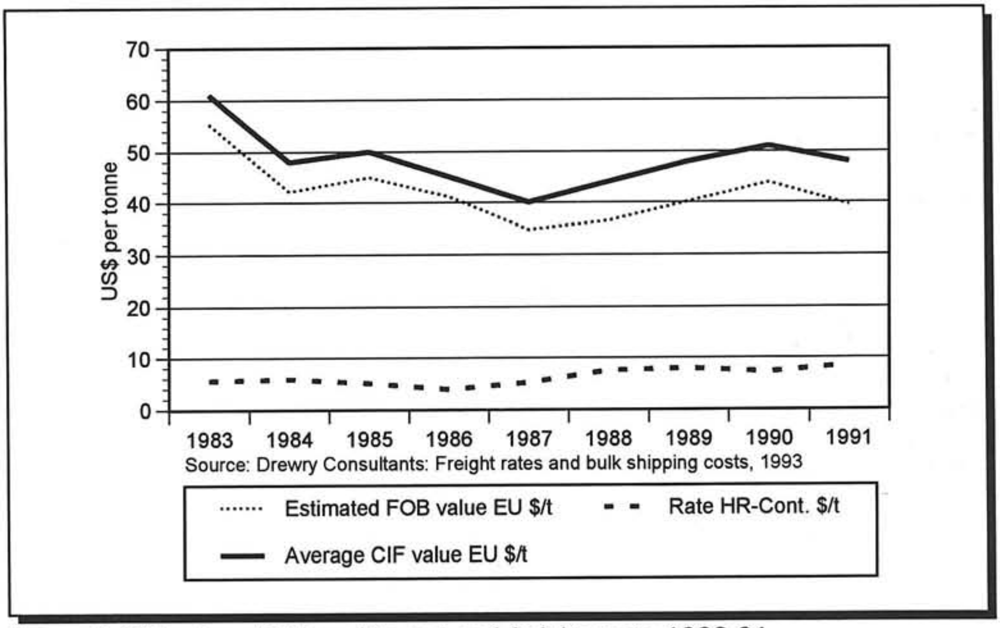


Figure 5: CIF value of EU coal import and freight costs 1983-91

From this, one could calculate the average transport costs for coal imports to the EU as shown in **Figure 6**.

For Europe the transport cost element in the CIF-price is around 10% with fairly large fluctuations. For Japan, where most of the imports come from Australia, shipping costs will be lower than this.

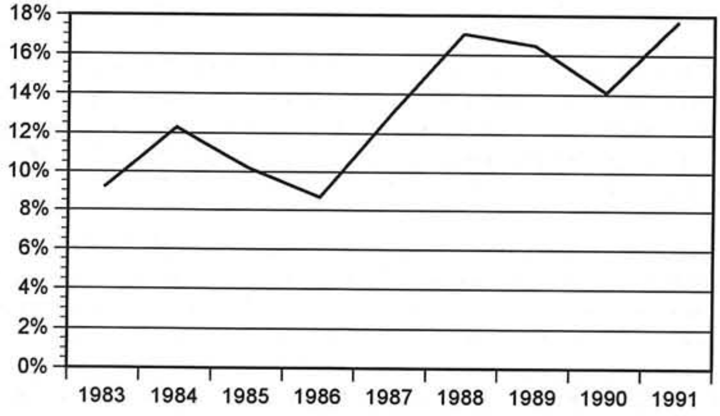


Figure 6: Freight rate Hampton Roads-Continent as % of CIF value of coal

Phosphate rock

Fertiliser is manufactured from naturally occurring raw materials, including natural gas and air, which are main sources of nitrogen (N). Other important feedstock materials are those containing phosphorus (P) - phosphate rock, potassium (K) - mainly potash salts and sulphur (S) - mainly brimstone. The export of phosphate rock amounts to some 35 million tonnes per year, potash about 30 million tonnes and brimstone about 15 million tonnes.

Phosphate can be exported in various forms, from the unprocessed phosrock via intermediates like phosphoric acid or ammonium phosphates or in the form of finished phosphate fertilisers. The trend over the last 15-20 years is that more and more crude materials are processed locally, which means a shift away from phosrock to the export of finished fertilisers.

Morocco is the leading exporter of phosrock, followed by the USA, Jordan and Togo. The main importers are Europe, India and South Korea.

Phosrock is normally graded after its percentage of bone phosphate of lime (BPL). High grade phosrock has 70-86% BPL and the average is around 72%. Phosrock is a fairly low priced commodity with a medium grade 70-72% BPL having a FOB price of around 30 US$/tonne. With shipping costs for a shipment of 14,000 tonnes from Jordan to India of around 20 US$/tonne, or even 35 US$/tonne from the US to India, the freight cost might exceed the FOB value. This is exceptional, however, because the shorter hauls from Morocco to Europe would give transportation costs of 5-6 US$/tonne and from the US to Europe around 10 US$/tonne. Still, phosrock has a very high transportation cost.

Bauxite and alumina

The process of producing primary aluminium, which is sold as ingots, requires input of bauxite. This ore, typically 45-47% Al_2O_3 material with some 3% silica, is a wet, clayey ore, which must be dried and crushed before the next stage of production, the refining of bauxite into the intermediate material alumina (aluminium oxide). Guinea is the main exporter of bauxite, followed by Brazil, Jamaica and Australia. The main importers are the USA, Canada and Europe.

To produce 1 tonne of alumina, 2-3 tonnes of bauxite is used, with an average of 2.3 tonnes. Alumina is mainly found in two types, the 'floury' alumina, which is a fine-grained product and the 'sandy' alumina, a coarser and more porous product, which is mainly produced in the USA.

The alumina then goes into the final production stage, which consists of a series of potlines (reduction cells), where the alumina is electrolytically reduced in a molten bath consisting of fluxes. Almost 2 tonnes of alumina are required to produce 1 tonne of aluminium ingot. For each tonne of aluminium, more than 4 tonnes of bauxite are consumed.

The prices of bauxite and alumina are closely related to the final price of aluminium. Aluminium ingots can vary substantially in price and in the 1980s the price of 1 tonne ranged from 1,001 US$/tonne in 1982 to the record high 2,586 US$/tonne in 1988. In the beginning of the 1990s the price has been down to about 1,200 US$/tonne. As a rule of thumb, the cost of 1 tonne of bauxite will be no less than 2% of the ingot price for aluminium. In addition come a variety of export taxes and royalties. The prices of bauxite might therefore vary both with supplier and the state of the market for aluminium ingots. The order of magnitude for the value of bauxite will be something like 20-30 US$/tonne. Transportation costs will very much depend on the trade route. A shipment from Guinea to Europe is normally done in Panamax sizes, and would thus give a transportation cost of 5-7 US$/tonne. The freight element in tin C&F price of bauxite is therefore around 15-25%, but could be higher, particularly for the longer hauls from Brazil and Australia.

For alumina, the picture is different as the value of alumina could be more than 10 times that of bauxite. In the 1980s, the spot prices of alumina varied between 94 US$/tonne in 1985 to an amazing 544 US$/tonne in 1989. The average price in the beginning of the 1990s was 200-230 US$/tonne. Alumina is shipped in slightly smaller quantities than bauxite, Handymax sizes, and will thus have a slightly higher transportation cost. With the much higher raw material value, the cost of transportation is, however, only around 5% of the C&F value.

Grain

Grain is the most important agribulk commodity. The USA is a dominating exporter together with Canada, the EU, Argentina and Australia. The USA exports about 1/3 of all wheat exports, 2/3 of all maize exports and 2/3 of all soya beans exports.

Premium US No. 2 hard red wheat is often used for price quotations. Prices for this grain type have varied around 150 US$ per tonne in the 1980s and beginning of 1990s, with a low at 114 US$/tonne in 1987 and a high at 171 US$/tonne in 1989. Wheat from Argentina is around 20% lower than this. Maize is priced slightly lower than wheat, around 100-110 US$/tonne.

The transport costs for grain will depend both on trade route and parcel size. Freight rates for a Panamax shipment of grain from the US Gulf to Northern Europe have fluctuated from a low 6.40 US$/tonne in 1986 to an average of 13 US$ for the period 1990-94. For the trade US Gulf to Japan in Panamax bulk carriers, the freight rate average 1990-94 has been close to 24 US$/tonne, or almost twice the cost from the US-Continent. With prices of maize fluctuating around 100-110 US$/tonne, the freight element in the C&F price is be aorund 10% in Europe and around 18% for Japan, for grain from the US Gulf.

Rice

Transportation of rice does not show the same efficiency as grain for several reasons. First of all rice is normally shipped in bags, which makes the loading and unloading cumbersome. Then rice is shipped in smaller parcels than grain, often less than 10,000 tonnes. Thailand is the main exporter of rice, but the trade is fairly volatile. The main importers are found in the Middle East and in Africa.

Rice is measured in terms of paddy (rice in the straw or in the husk, from the Malay word paddi). The estimated world wide production is around 500 million tonnes per year, but only 12 million tonnes are exported. Paddy rice may pass through five stages of milling - cleaning, hulling, pearling, polishing and grading, but is normally shipped in two main forms: Brown rice (unprocessed, but with the husk removed) or milled rice, often called white rice. The quality of rice is measured in terms of percentage broken grains. High quality rice has as little as 1-5% broken, but poorer quality, like the one from Burma, can have up to 35% broken. Thailand typically sells rice in the 5-15% broken range.

The prices for rice can vary substantially. The FOB price of Thai 5% white grade has come down from 350 US$/tonne to around 250 US$/tonne. Far East export prices were in the beginning of the 1990s in the range 270-300 US$/tonne. Freight rates for rice are generally higher than for grain, but may vary a lot depending on lot sizes and trade route. For a shipment of rice from the USA to West Africa, some 50 US$/tonne is probably an indication. This implies that for rice, the average transportation cost is only about 15% of the C&F value even if transport is much more expensive, simply because rice is a fairly high value bulk commodity.

Oilseeds and soya beans

Oilseeds are the basis for the production of vegetable oils and fats, and protein-rich meals (oilcakes). There are many seeds being traded, like rapeseed, sunflowerseed, cottonseed, flaxseed, peanuts, copra and palm kernels and soya beans (which technically is not an oilseed but a pulse (seed from a leguminous plant)). Soya beans (and meals) are the dominating commodities within the group of oilseeds and are important for world bulk shipping with export volumes of more than 50 million tonnes per year. The soya beans are normally shipped as a bulk commodity and the whole bean resembles heavy grains. The bean is crushed and to obtains oil and meal. The general rule is that for every tonne of beans, about 70% becomes meal (oilcake) and about 30% oil. Oilcake is mainly used in animal feeding, so it is not the soya oil that is the main product from soya beans.

The USA is the dominating producer and exporter, followed by Brazil and Argentina. Europe is the main importer, followed by Japan and the other countries in the Far East. Shipments are normally made in fairly large consignments of 30,000-60,000 tonnes. The prices for soya beans have varied substantially during the 1980s with a high price close to 300 US$/tonne and a low price close to 200 US$/tonne. In the beginning of the 1990s the prices were around 230-240 US$/tonne. A Panamax shipment of soya beans from the US to Europe will probably cost some 9-10 US$/tonne, which means that the freight cost share of the C&F price is less than 5% and will hardly exceed 8-10%.

Sugar

Sugar is extracted from either sugar cane (a tall grass up to 6 m. high) or from the white beet root. About 2/3 of the more than 110 million tonnes of raw sugar being produced every year comes from cane. About 25% of all sugar is exported. Most sugar is exported raw, but the EU, which is the second-largest exporter of sugar after Cuba, exports the sugar in refined white form. The refined sugar, or white sugar, accounts for about 40% of all exports, coming from a level of 25% in the beginning of the 1970s. The former USSR, USA and Canada, Japan, China and the EU are the main importers of sugar.

Raw sugar is shipped in bulk, while white sugar needs to be bagged. The Australian BIBO (bulk-in-bags-out) system is a special carrier allowing refined white sugar to be loaded bulk, then inside of the ship is a bagging plant, so the sugar is delivered bagged at their destination.

The raw sugar prices have varied a lot in the 1980s with a low value of 89 US$/tonne (FOB Caribbean port) and a high value of 282 US$/tonne in 1989. In the beginning of the 1990s the prices fluctuated around 200 US$/tonne. Transport costs for raw sugar depend on the trade, but typically a shipment made on a Handysize bulk carrier from Mauritius to the UK would cost around 30 US$/tonne. The freight cost element for the transportation of sugar would thus be 10-15% of C&F.

6.1.3 Value and transport costs of non-bulk commodities

Non-bulk commodities will normally be shipped by general cargo ships or container vessels (or reefers). The value of these commodities varies substantially and the number of commodities is huge, so a detailed analysis of these commodities will not be made.

In **Table V** some examples are given of the enormous differences from commodity to commodity.

Commodity	Route	C&F value US$/t	Freight US$/t	F as % of C&F
Citrus fruit	Australia-Europe	626	329	52.6
Grapes	Australia-Europe	1,764	429	24.3
Bananas	Latin Am.- Europe	415	95	22.9
Frozen beef	Australia-Europe	4,826	270	5.6
Shellfish	Australia-Europe	12,290	275	2.2
Beef, 6000 t.	NW Europe-Atlantic	3,850	60	1.6
Metal ingots	Europe-ECSA	2,500	185	7.4
Electronics	Transpacific	8,570	107	1.2

Source: Drewry Consultants

Table V: Examples of values and transportation costs 1993

Low value food products have high transportation costs, high value food fairly low. The parcel size is important, so is the trade route. For high-value manufactured goods, which are fairly light and have a good stowage factor, transportation costs can be very low indeed, as seen by the last example in **Table V**.

As indicated in section 6.1.1, the average transportation costs in world trade is about 6-7% of the C&F value of cargo. As most of the important bulk commodities in world trade have higher transportation cost shares (with the exception of crude oil), this really reflects the fact that the average is weighted by values and not volumes, and world trade consists to a dominant degree of high value manufactures if measured by value.

6.2 Cost and revenues cases

In the previous chapter the cost structure of shipping has been described. This section illustrates the structure of the costs/revenues calculation in more detail. This will be done by three examples:

- Million barrel crude oil tanker (based on Drewry's study, Aug. 1990);
- Capesize bulk carrier;
- Container ship service.

6.2.1 The million barrel tanker

The million barrel tanker designed for light to medium crude oils of average specific gravity is equivalent to about 137,000 tonnes. Allowing for capacity taken up by bunkers, water and stores, a tanker requires a total deadweight of around 140,000 dwt tonnes in order to load a cargo of this size. There are two reasons why this million barrel tanker was developed in the seventies:

- The preference of oil traders and oil companies for a standard parcel size of oil, which allows for simple arithmetic;
- The dimensions of the Suez Canal, which used to allow for the fully laden transit of tankers of 140,000-150,000 dwt, the so-called Suezmax tankers. It should be noted that the Canal has been deepened since and the definition of a Suezmax tanker has changed accordingly.

The market for any specific size of tanker cannot be defined within a narrow range, as all ships compete with other ships, which are often larger. The million barrel tanker (125-150,000 dwt) fits in the category of medium sized tankers in the range 90-175,000 dwt, where the lower limit is called the Aframax tanker.
The draught of a tanker is often restricted by the geographical conditions of the ports they have to call upon. The draught/deadweight ratio is an important characteristic of a tanker. Ships in the 90-100,000 dwt size range tend to have a draught ranging from 14-15 metres; those in the next category, 100-125,000 dwt, have a draught between 15-16 metres; the 125-150,000 dwt ships 16-17 metres, while the larger vessels, 150-175,000 dwt have an average draught between 17-18 metres. A VLCC of 250,000 dwt needs at least 18 metres of water depth, although part-loading the ship can decrease this requirement.

Loading and discharging zones

The medium sized tankers load their crude oil cargoes in twenty loading areas, of which eight accounted for the majority of the cargoes. These are: West Africa, Arabian Gulf, East Mediterranean, Northern Europe, Southeast. Asia, Caribbean, North Africa and the Red Sea.
The loading ports are shown in **Figure 7**. In the Arabian Gulf, some twelve terminals are used for loading. The draught restrictions are shown in **Table VI**. There are also eight discharging zones which account for the majority of the medium-sized tanker employment. These are: US Eastern Seaboard, Southern Europe, Northern Europe, Southeast Asia, West-Central USA, Japan, East-Central South America, Australia. The discharge terminals in these zones are shown in **Figure 8**. The terminals and their draught limitations on the US Eastern Seaboard are shown in **Table VII**. Only the offshore LOOP terminal before the coast of Louisiana can receive VLCCs.

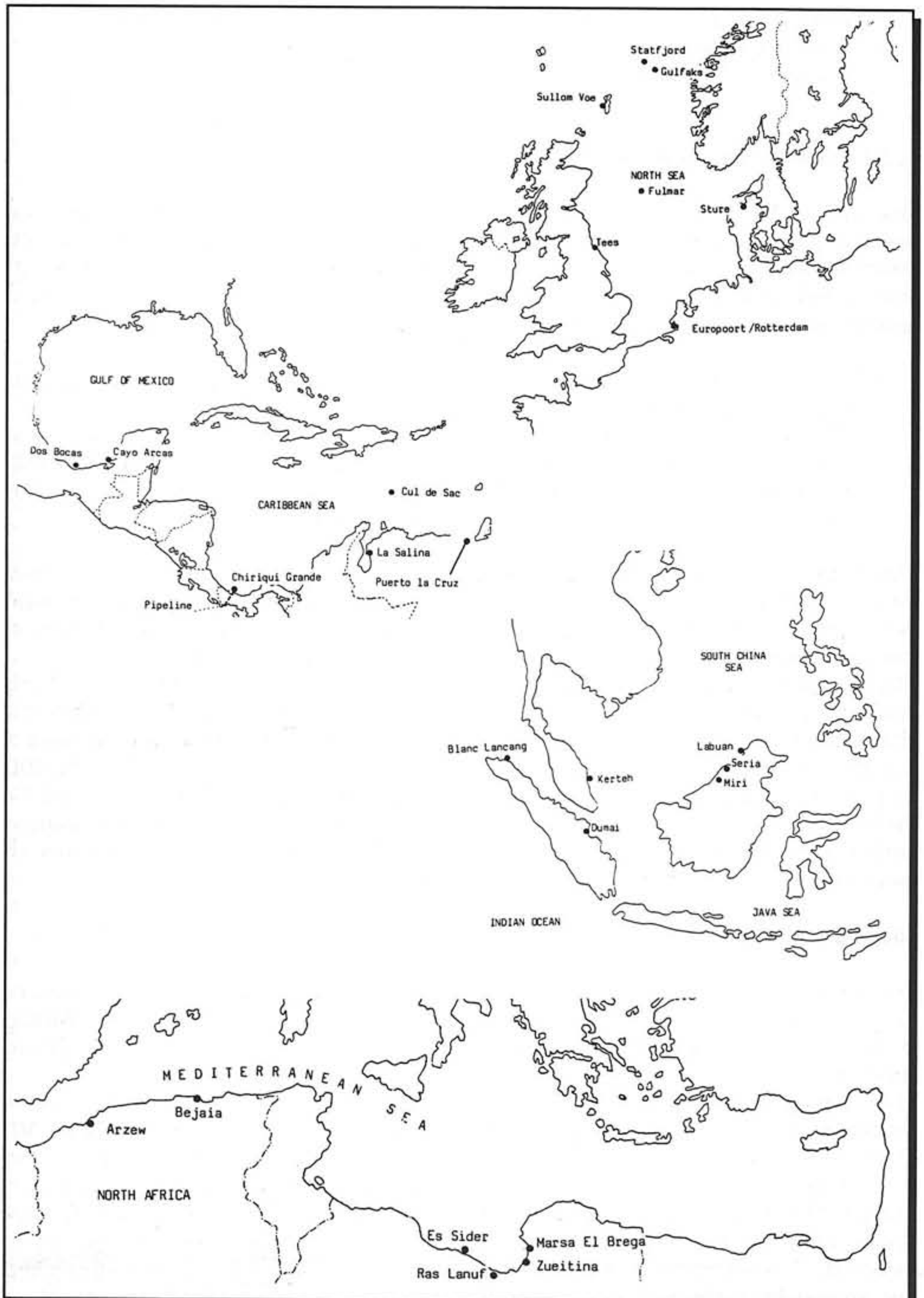


Figure 7: Loading ports

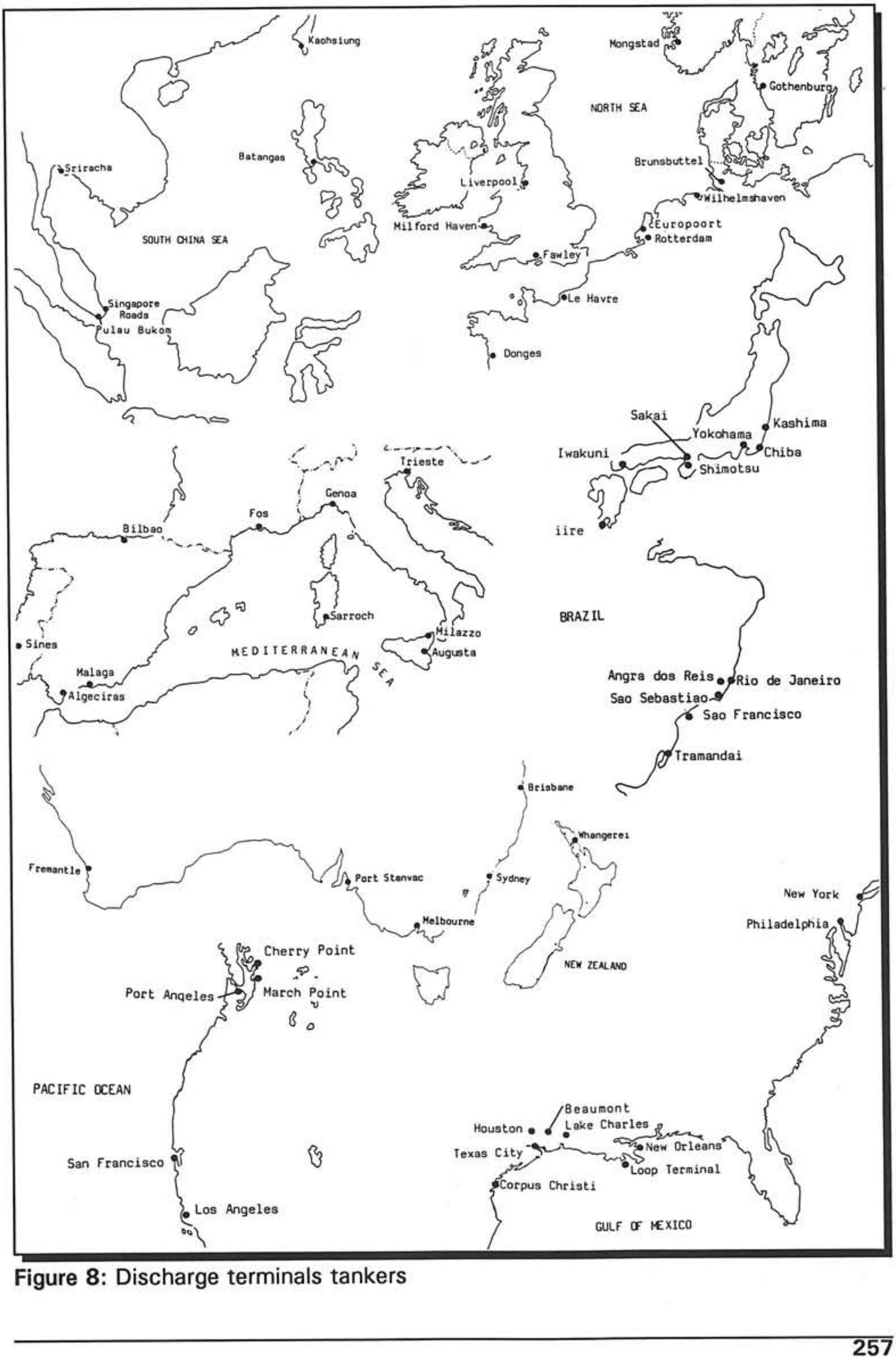


Figure 8: Discharge terminals tankers

Country	Terminal	Max. draught (m)	Ranking
Restricted draught ports			
Abu Dhabi	Jebel Dhanna	13.7/14.9	2
Abu Dhabi	Jebel Ali	14	8
Qatar	Umm Said	13.1/18.2	10
Kuwait	Mina Saud	12.5/15.8	12
Partly restricted draught ports			
Aubu Dhabi	Das Island	16,9/22.0	6
Saudi Arabia	Ras al khafji	14.3/15.2/16.5/20.1	9
Kuwait	Mina al ahmadi	13.1/14.9/28.0/28.7	11
VLCC ports			
Saudi Arabia	Ras Tanura		1
Oman	Mina al Fahal		3
Abu Dhabi	Sirku Island		4
Iran	Khard Island		4
Dubai	Fateh Island		7

Table VI: Draught restrictions of terminals in the Arabian Gulf

Terminal	Max. draught (m)	Ranking
Restricted draught ports		
Philadelphia	11.0/12.2/16.8	1
New Orleans	9.1/10.7	2
Texas City	12.2	3
Beaumont	10.4	4
Houston	12.2	6
Corpus Christi	12.2/13.7	7
New York	11.3/13.7	8
Lake Charles	11.0/12.2	9
VLCC ports		
LOOP Terminal		5

Table VII: Draught restrictions of ports in the United States

Revenues

The tanker revenues are created by performing voyages against the prevailing rate expressed in Worldscale points. **Table VIII** shows the trading pattern of a 135,000 dwt tanker during the year 1989. This ship performed 15 voyages in that year, during which 142 days were spent at sea in loaded condition, and 141 days in ballast condition. A total of 71 days was spent in port for loading and discharging, while 11 days accounted for delays due to repairs and waiting for instructions.
The Worldscale rate varied over the year from W40 to W112.5, which can be translated in US$ per tonne. Note that the W100 US$/tonne reference value is different for each route. The total revenues earned by this tanker during 1989 was US$ 8,670,000.

			Voyage analysis (days)*					Revenue		
Load	Discharge	Next Load	L	P	B	D	Cargo 1000 t	Rate	W100 (US$/t)	Freight 1000 US$
-	US Gulf	W. Africa	-	-	18	-	-	-	-	-
W. Africa	S. Europe	W. Africa	16	4	17	-	130	W75	6.53	640
W. Africa	Caribbean	Mexico	16	4	7	-	130	W72.5	7.25	685
Mexico	W. Africa	E. Med.	15	5	18	8	130	W40	6.68	350
E. Med.	S. Europe	Red Sea	6	4	5	-	130	W85	2.25	250
Red Sea	S. Europe	Red Sea.	6	5	9	-	120	W85	2.19	575
Red Sea	S. Europe	E. Med.	11	4	6	3	120	W87.5	4.41	715
E. Med.	S. Europe	E. Med.	10	9	5	-	133	W90	3.11	370
E. Med.	S. Europe	Red Sea	7	5	11	-	130	W82.5	3.47	370
Red Sea	S. Europe	E. Med.	10	4	7	-	130	W77.5	4.41	705
E. Med.	N. Europe	E. Med.	12	4	11	-	133	W78	6.48	670
E. Med.	S. Europe	Red Sea	9	4	14	-	130	W82.5	5.08	545
Red Sea	S. Europe	Red Sea	6	4	5	-	120	W95	3.19	615
Red Sea	S. Europe	Red Sea	5	5	5	-	120	W95	3.19	615
Red Sea	S. Europe	Red Sea	6	6	8	-	120	W120	4.41	885
Red Sea	S. Europe	Red Sea	7	4	3	-	120	W112.5	3.19	680
			142	71	141	11				8,670

*) L = Loaded
P = Port
B = Ballast
D = Delay

Table VIII: Trading pattern of a 135,000 dwt tanker

On the cost side, the relevant figures are shown in **Table IX**. The calculation of the bunkers (HFO and MDO) resulted in a total of US$ 1,930,000. The total port charges, including Suez Canal charges, amounted to US$ 3,000,000. The commissions paid to the brokers are 2.5% of the revenues. The operating costs of the tanker were US$ 1.2 million. The cash flow at the disposal of the shipowner to cover the capital cost thus amounted to US$ 2.5 million.

	Bunkers		Port charges (incl. Suez)	Commis-sion (2.5*)	Total
	FO	DO			
Days in port	71	71			
Days steaming	265	265			
Average speed	11.9	11.9			
Tonnes/day steaming	61	2			
Tonnes/day in port	27	2.5			
Tonnes steaming	16,165	530			
Tonnes in port	1,917	178			
Total tonnes	18,082	708			
Price (US$/tonne)	100	172			
Cost (1,000 US$)	1,810	210	3,000	220	5,150
Surplus over voyage costs (347 days)					3,520
Surplus over voyage costs (365 days)					3,700
Operating costs					1,200
Surplus over break-even costs					2,500

Table IX: Costs

A million barrel tanker ordered in 1989 would have cost around US$ 42 million; this would require a trading surplus of US$ 6.56 million to cover the capital costs in the first year. The message is clearly that the surplus is not enough to warrant the newbuilding investment with the indicated Worldscale rates.

6.2.2 Capesize bulk carriers

Capesize bulk carriers derive their name from the fact that they cannot sail through the Panama Canal, as their dimensions exceed those of the locks, and consequently they have to sail around the cape of South America or South Africa. These ships can be divided into the category of 100-125,000 dwt, the so-called *Babycapes*, 125-150,000 dwt, and 150-175,000 dwt.
In the study Trading Prospects for Cape Size Bulk Carriers to 2000 from Ocean Shipping Consultants the costs and revenues of this type of ship was analysed. **Figure 9** shows the actual and projected operating cost development of a 120,000 dwt bulk carrier and the breakdown into the major cost components in US$ per annum. **Figure 10** shows the development of the capital costs, operating costs, and bunker costs for a five year old vessel, while at sea (A) and in- port (B) in US$ per day. The capital costs were the largest cost element in 1992, which was not the case in 1986 when newbuilding and secondhand values were at a historically low value.
The timing of the ship's acquisition is thus crucial for the owner. **Figure 11** shows the development of the value of a five year old 120,000 dwt vessel over the period 1983-1993. **Figure 12** shows the scrap value over the same period.

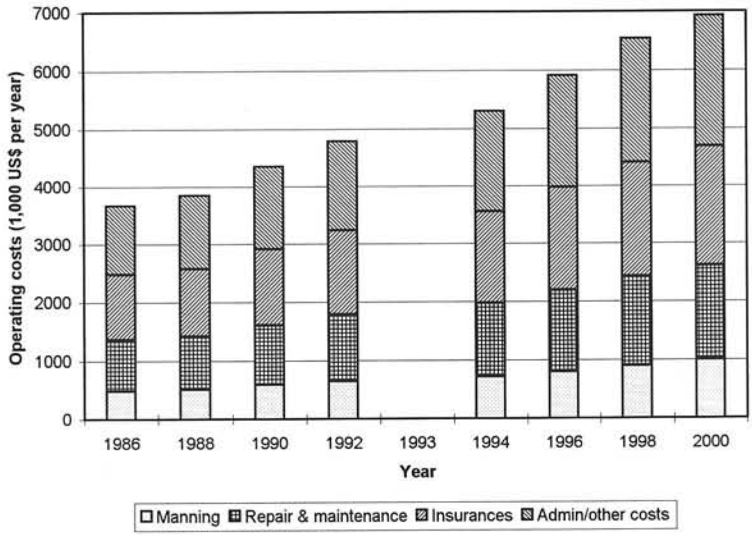


Figure 9: Operating costs of a 120,000 dwt bulk carrier

Table X summarises this information and adds the newbuilding value of the 120,000 dwt Capesize bulk carrier.

	Newbuilding (million US$)	Secondhand (5 year) (million US$)	Scrap (million US$)
1985-1	26.5	11.7	2.50
1985-2	26.5	9.5	2.43
1986-1	25.0	9.0	2.42
1986-2	25.0	11.7	2.73
1987-1	25.7	14.8	3.20
1987-2	25.7	18.6	3.47
1988-1	32.8	22.8	5.35
1988-2	32.8	25.9	5.08
1989-1	37.3	30.1	5.42
1989-2	37.3	32.7	5.68
1990-1	44.8	31.4	5.70
1990-2	44.8	27.6	4.93
1991-1	46.4	31.0	4.02
1991-2	46.4	36.0	3.83
1992-1	43.8	33.5	3.58
1992-2	43.8	28.8	3.32
1993-1	40.3	28.2	3.54

Table X: Prices of a 120,000 dwt vessel

Figure A: Costs at sea

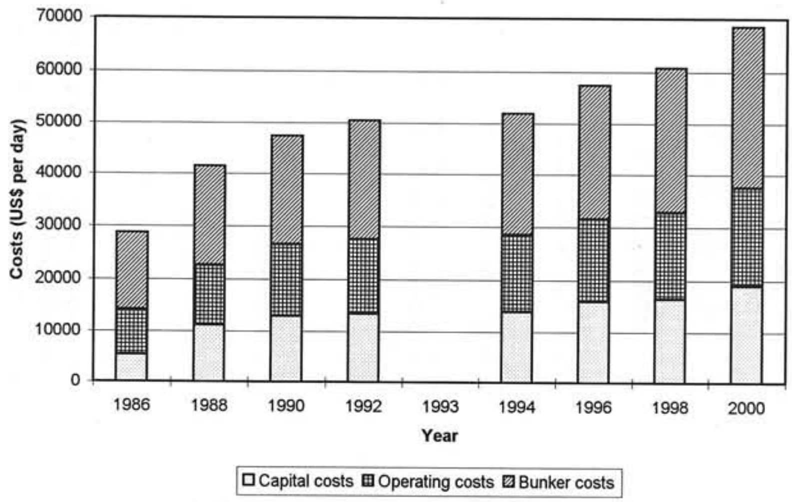


Figure B: Costs in port

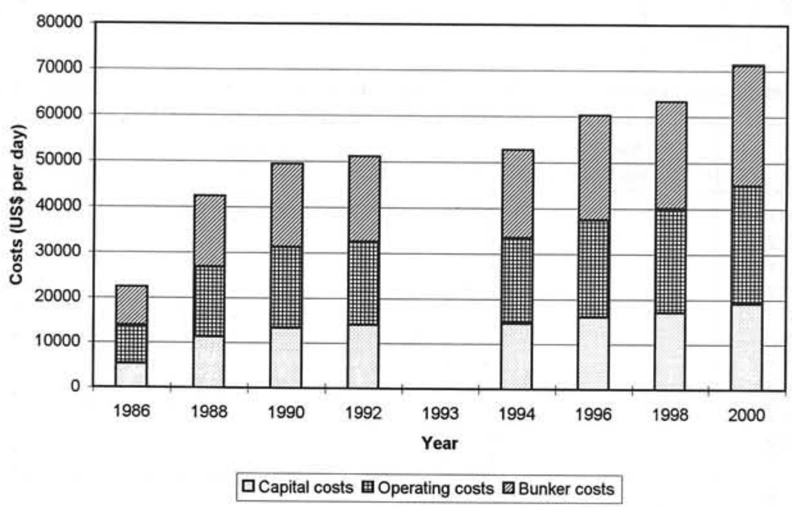


Figure 10: Development of costs of a five year oil bulk carrier

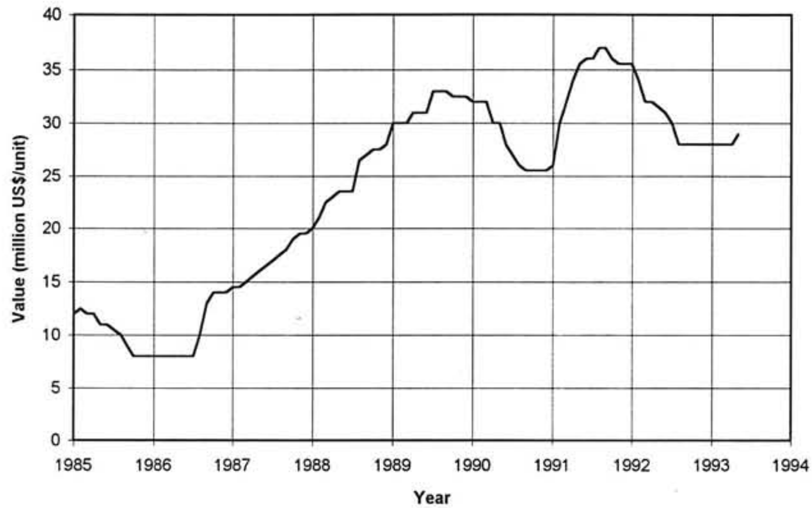


Figure 11: Value of a five year old bulk carriers

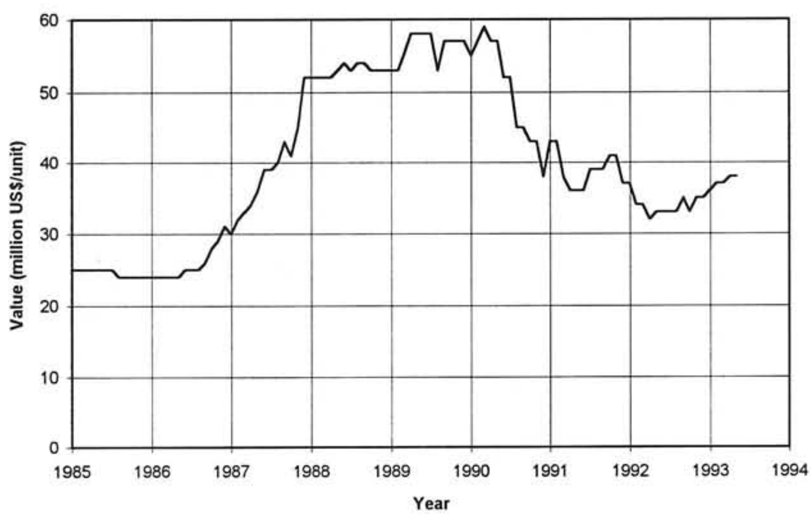


Figure 12: Development scrap value

To make a return on investment, then the freight revenues have to exceed these costs. The average daily charter hire of a 120,000 dwt bulk carrier in 1992 was US$ 10,868. **Table XI** shows the nett profitability of two cases: A secondhand vessel and a newbuilding vessel, acquired in 1986 or 1990. From this table it becomes clear that only the shipowner who acquired a secondhand vessel in 1986 made a return on investment.

	Secondhand acquired 1986	Secondhand acquired 1990	Newbuilding acquired 1986	Newbuilding acquired 1990
Time charter rev.	10,868	10,868	10,868	10,868
Operating costs	4,544	4,544	4,544	4,544
Capital costs	6,347	13,642	9,370	15,590
Total costs	9,891	18,186	13,914	10,134
Nett profitability	977	-7,318	-3,084	-9,266

Unit: US$/day

Table XI: Profitability of a 120,000 dwt bulk carrier in 1992

6.2.3 Container ship service

A shipowner of three medium sized container ships of 780 TEU each, had the intention of employing the ships in a new liner service. Therefore he had to select a trade route and calculate the revenues and costs (1985). This section shows the simplified results of that exercise. **Table XII** shows the ship's particulars and **Figure 13** the general arrangement.
The shipowner decided on a niche market route: Northwest Europe to the North American Westcoast via the Panama Canal. In Europe four ports of call were selected and on the Westcoast three. The round-trip schedule is schematically shown in **Figure 14**. The distances between the ports can be found in distance tables, either in book form or as a software programme. **Table XIII** gives an example from Reed's Marine Distance Tables with the distance between Los Angeles and San Francisco/Oakland and Seattle.
On this basis a round-trip calculation in days can be made, allowing for sailing, port handling times, Panama Canal passages and a (bad weather) reserve. It is important to arrive at a multiple of 7 days for one round voyage, as this results in a fixed day sailing from each port. Shippers of containers and terminal operators prefer fixed day calls for their planning. The calculation is shown in **Table XIV**.
The revenues calculation is thus based on a service with three ships of 780 TEU, which make a round-trip of 63 days and call on 7 ports. The number of round-trips is 17 per year and the sailing frequency is 21 days. The revenues per round-trip are based on certain volumes and revenues for westbound and eastbound containers and amount to US$ 1,365,360 per round-trip and US$ 23.7 million for 17 trips per annum. This is summarised in **Table XV** and **Table XVI**.

Type of ship	Single screw diesel propelled, cellular container vessel with bow propeller	
Classification	Lloyd's register of shipping + 100A1 + LMC UMS container vessel	
Length o.a.	139.90	m
Breadth	21.50	m
Depth	10.90	m
Draught (design)	6.80	m
Draught (scantlings)	7.00	m
Deadweight at 6.80 m	10,000	tonnes
Deadweight at 7.00 m	10,500	tonnes
Container capacity	780	TEU (4 tiers 918 TEU)
- in hold	340	TEU
- on deck	440	TEU (4 tiers 578)
Gross tonnage	8,850	
Speed	15.0	knots at 6.8 draught
Fuel consumption at sea		
- Without reefers	18.3	tonnes/day (HFO)
- With reefers	20.3	tonnes/day (HFO)
Fuel consumption harbour	1	tonne /day (MDO)
V_{max}	16.3	knots at 6.8 m
Main engine	Stork Werkspoor Diesel Type 9TM410	
Output	5,580	kW at 600 rpm

Table XII: Particulars container ship

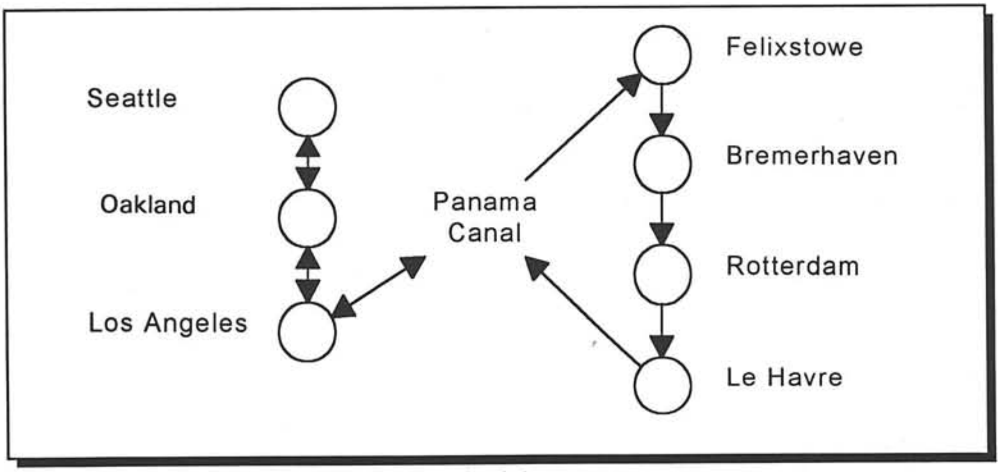


Figure 14: Container ship round-trip schedule

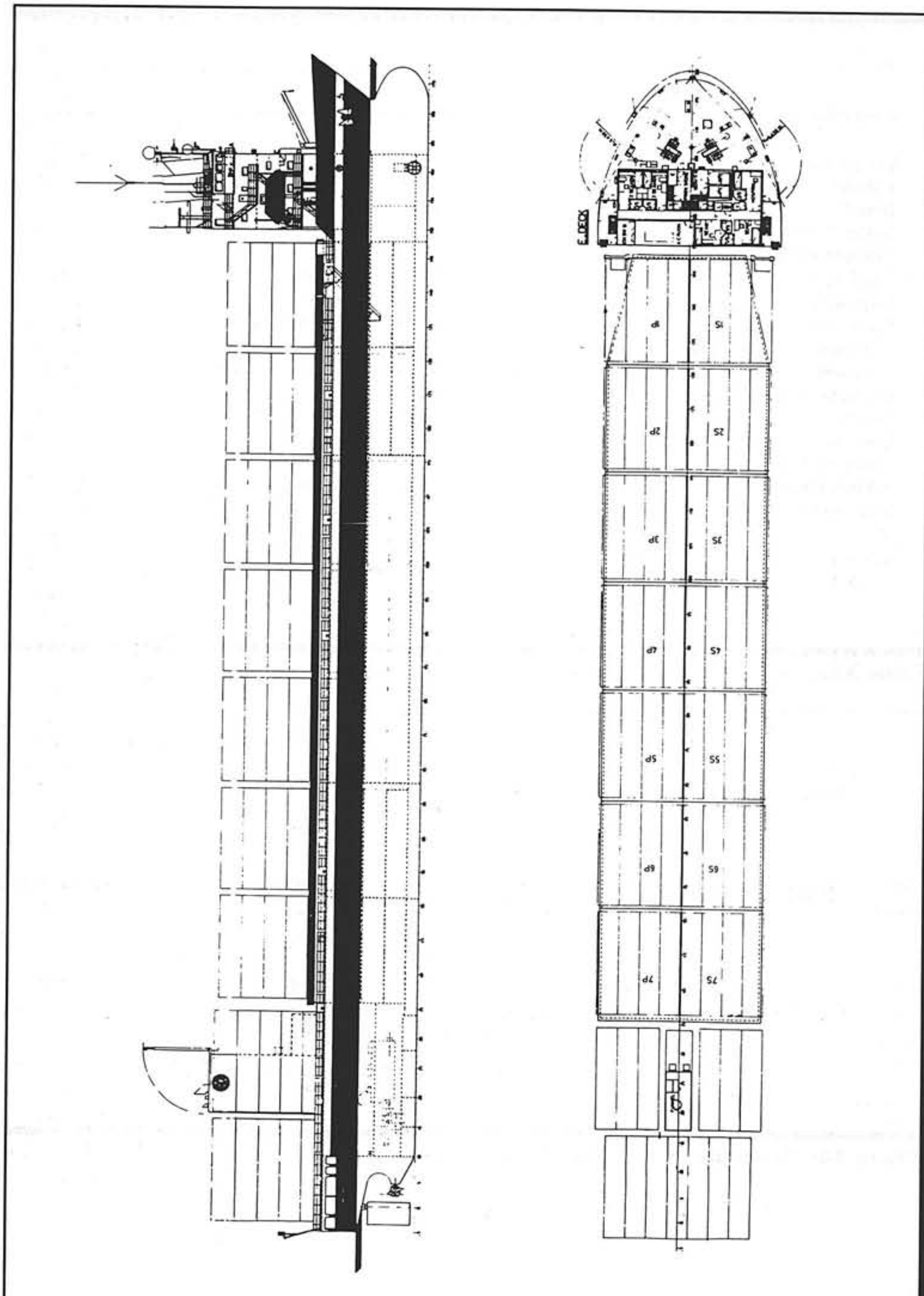


Figure 13: General arrangement container ship

	Guaymas	Honolulu	Iquique	Longview	Los Angeles	Mazatian	Portland	Punta Arenas
Antofagasta	3895	5777	234	5333	4433	3533	5375	1979
Balboa	2369	4688	1980	3814	2912	2010	3856	3937
Buenaventura	2501	4808	1764	3951	3047	2138	3993	3716
Cabo Bianco	2603	4731	1196	4050	3148	2240	4092	3148
Callao	3113	5157	650	4556	3654	2750	4598	2655
Cape Horn	5539	6477	2345	6926	6010	5206	6958	417
Coquimbo	4157	5871	598	5578	4680	3790	5620	1612
Corinto	1730	4070	2245	3175	2275	1367	3217	4170
Corral	4576	5975	1200	4920	5075	4215	4962	1006
Guayaquil	2683	5865	1346	4130	3228	2323	4172	3298
Guaymas	-	2999	3750	2048	1150	385	2090	5400
Honolulu	2999	-	5720	2287	2231	2859	2329	6370
Huasco	4180	6060	519	5618	4718	3818	5660	1694
Iquique	3750	5720	-	5188	4288	3388	5230	2191
Longview	2048	2287	5188	-	937	1910	42	6781
Los Angeles	1150	2231	4288	937	-	1006	979	5865
Mazatlan	385	2859	3388	1910	1006	-	1952	5051
Monterey	1399	2099	4540	670	286	1259	712	6108
Portland	2090	2329	5230	42	979	1952	-	6823
Punta Arenas	5400	6370	2191	6781	5865	5051	6823	-
Salaverry	2868	4910	895	4311	3369	2505	4353	2900
San Diego	1075	2275	4213	1020	95	935	1062	5792
San Francisco	1480	2095	4623	603	369	1345	645	6201
San Jose	1501	3845	2405	2950	2047	1140	2992	4290
Seattle	2242	2403	5384	305	1128	2099	374	6988
Tacoma	2262	2423	5404	325	1148	2119	367	7008
Tocopilla	3830	5757	130	5268	4368	3468	5310	2067
Valparaiso	4290	5917	783	5708	4806	3930	5750	1427
Vancouver	2258	2419	5400	321	1144	2115	363	7004
Victoria	2182	2343	5324	245	1068	2039	287	6928

Table XIII: Distances between ports of West Coast of North and South America

The costs can be divided into the direct costs, such as agency commission, stevedoring costs, container lease, and other costs and daily running costs. The direct costs per round-trip are US$ 665,604 and US$ 11.56 million per year. The other costs are related to the port costs, the Panama Canal charges, bunkers, and overhead/management and are US$ 225,000 per round-trip or US$ 3.9 million per annum. The daily running costs, which is equivalent to the sum of capital costs and operating costs of the ship is US$ 7,500 per day, which is US$ 8.2 million per annum. The balance of revenues minus costs is US$ 39,211 or barely break-even. This is clearly not a solid basis for the start of such service.

	Distance (NM)	Time (days)
Sailing - Le Havre - Los Angeles - Los Angeles - Oakland - Oakland - Seattle - Seattle - Oakland - Oakland - Los Angeles - Los Angeles - Felixtowe - Felixstowe - Bremerhaven - Bremerhaven - Rotterdam - Rotterdam - Le Havre	 7557 369 796 7680 255 250	 21 1 2.2 2.2 1 21.3 0.9 0.7 0.7
	Total sailing	**51**
Panama Canal		**2**
Port time		**8**
Reserve		**2**
	Total	**63**

Table XIV: Example round-trip calculation

Voyage calculation				
Container capacity per ship		780		
Number of ships		3		
Roundtrip time (days)		63		
Number of round-trips per annum		17		
Sailing frequency (days)		21		
Revenue calculation	**Westbound**	**Westbound**	**Eastbound**	**Eastbound**
Capacity utilisation	*Boxes*	*TEU*	*Boxes*	*TEU*
20 ft	234	234	150	150
40 ft	234	468	150	300
total	**468**	**702**	**300**	**450**
Revenue per box (US$)	**Westbound**	**Westbound**	**Eastbound**	**Eastbound**
	20 ft	*40 ft*	*20 ft*	*40 ft*
Ocean freight	1300	1800	1000	1500
Terminal handling charges	290	400	290	400
Revenue per box	**1590**	**2200**	**1290**	**1900**
Total gross revenues (US$)	**Westbound**	**Westbound**	**Eastbound**	**Eastbound**
(Total per round-trip 1,365,360)	*Boxes*	*US$*	*Boxes*	*US$*
20 ft	234	372,060	150	193,500
40 ft	234	514,800	150	285,000
Total	**468**	**886,860**	**300**	**478,500**
Total gross revenues per annum (US$)				**2,371,257**
Direct costs				
Agency commission		15 % of ocean freight rate		
Stevedoring cost				
- Europe		100 US$ per box		
- West Coast		250 US$ per box		
Container lease				
- 20 ft		200 US$ per one-way trip		
- 40 ft		300 US$ per one-way trip		
Total direct costs per container (US$)	**Westbound**	**Westbound**	**Eastbound**	**Eastbound**
	20 ft	*40 ft*	*20 ft*	*40 ft*
Agency fees	239	330	194	285
Stevedoring	350	350	350	350
Container lease	200	300	200	300
Total	**789**	**980**	**744**	**935**
Total direct costs (US$)	**Westbound**	**Westbound**	**Eastbound**	**Eastbound**
(Total per round-trip 665,604)	*Boxes*	*US$*	*Boxes*	*US$*
20 ft	234	184,509	150	111,525
40 ft	234	229,320	300	140,250
Total	**468**	**413,829**	**300**	**251775**
Total direct costs per annum (US$)				**11,568,831**

Continued in **Table XVI**

Table XV: Container service Northwest Europe - West coast North America

Continued

Other costs (per round-trip) (US$)		
Port costs Europe + US$	60,000	
Panama Canal charges	40,000	
Bunkers	60,000	
Selling, general + administration	56,000	
Miscellaneous	9,000	
Other costs (US$ per annum)		**3,910,714**
Charter hire		
Per ship of 780 TEU per day (US$)	7,500	
Per ship per annum	2,737,500	
3 vessels per annum	8,212,500	
Operating profit per annum (US$)		
Gross revenues	23,731,257	
Direct costs	11,568831	
Other costs	3,910714	
Charter hire	8,212500	
Operating profit	**39,211**	

Table XVI: Container service Northwest Europe - West coast North America

CHAPTER 7: FREIGHT RATES AND SHIP PRICES

7.1 Freight rates

Shipowners run their ships in order to make a return on investment. For this to happen, in the long term, they have to earn more money than they spend. This chapter explores the revenue side of the shipping equation, which is determined by the level of the world freight rates.
Freight rates depend on a number of factors, many of which will be discussed in the next chapter. There is no one single answer to this question. A lot depends on the type of shipping services the owners provide with their ships. E.g., a container shipping company charges a rate per container. The rate depends on the transport distance, the type of container (reefer containers are more expensive), and of course the competition. Container ships can also be chartered or hired to an operator. The revenue level can also be captured in several indexes, depending on the size class of the vessel.
Reefer ship operators may charter their ships on the basis of a financial compensation expressed in USdollarcents per cubic foot per 30 days. In crude oil tanker shipping, the revenues may be expressed in USdollars per day and/or in a generally accepted index, like Worldscale, or it may be specifically linked to a ship size category, such as the Howard Houlder Aframax tanker index. In dry bulk shipping there are other indexes, such as the Baltic Freight Index, the SS&Y Atlantic Capesize Index or JE Hyde Handysize and Handymax Index. In this chapter some of the most well-known freight rates indicators are briefly described.

7.1.1 Dry bulk shipping

Baltic Freight Index (BFI)

The Baltic Freight Index (BFI) is a weighted index figure based on the daily charter fixtures concluded in a number of sub-markets, such as Panamax and Capesize vessels; trade routes, such as US Gulf to Japan; commodity, such as grain or ore; and finally type of charter, such as spot or time charter.
Table I shows the details of the weighting of the index. **Figure 1** shows the development of the BFI over the period 1985-1995. This graph clearly demonstrates the volatility of the freight rates. The underlying freight rate developments by route, ship size and commodity are illustrated in **Figure 2**, which contains four series:

- Grain in Panamax vessels on the route US Gulf to Japan;
- Grain in Panamax vessels on the route US Gulf to the European Continent;

Route		CMDY	Weighting	Today's US$/tonne	Previous US$/tonne
1	US Gulf-N Cont	Grain	10%	15,400	15.394
1a	Transatlantic round	T/c	10%	11,807.000	11,781.000
2	US Gulf - Japan	Grain	10%	28.5236	28.531
2a	US Gulf - FE timecharter	Grain	10%	15,843.000	15,900.000
3	US N Pacific -Japan	Grain	10%	15.743	15.750
3a	Transpacific round	T/C	10%	10,343.000	10,481.000
6	H Roads - R Bay - Japan	Coal	7.5%	11.994	12.017
7	H Roads - Rotterdam	Coal	7.5%	5.844	5.844
8	Queensland - Rotterdam	Coal	7.5%	8.844	8.928
9	F East to Nopac-Cont	T/c	10%	7,936.000	7,950.000
10	Tubarao-Rotterdam	Iron ore	7.5%	5.581	5.583

Table I: Baltic freight index

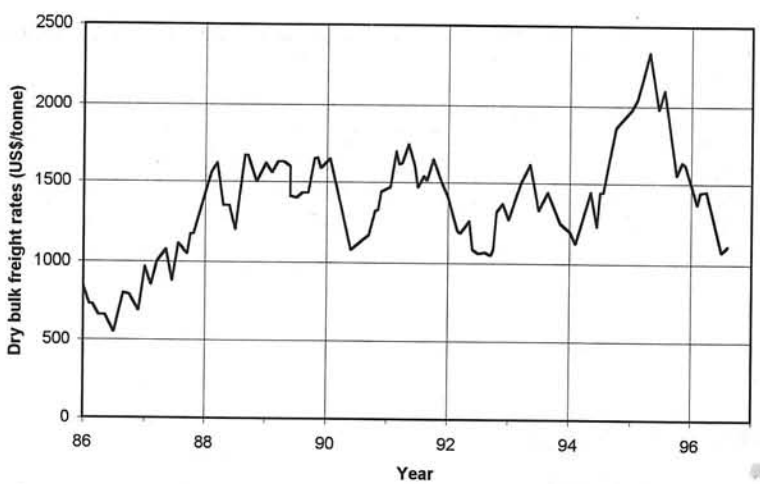


Figure 1: Development of the BFI over the period 1985-1995. (wordt aangeleverd)

- Coal in Capesize vessels from Hampton Roads (East Coast USA) and Richards Bay (South Africa) to Japan;
- Iron ore in Capesize vessels from Tubarao (Brazil) to the European Continent.

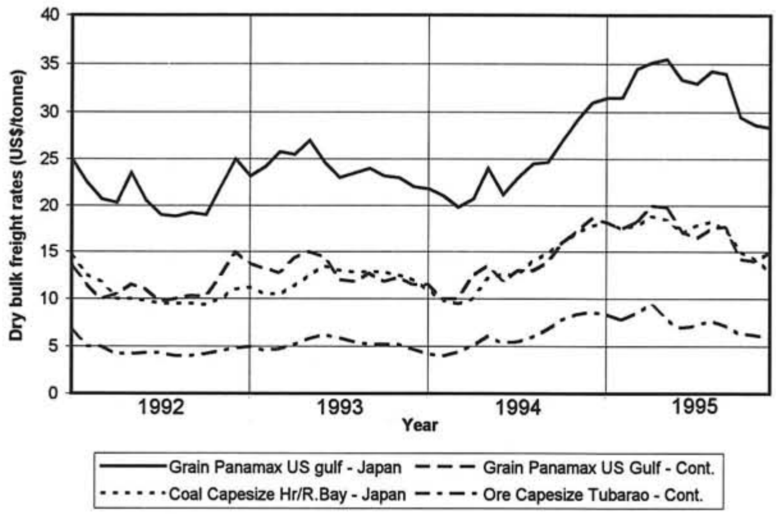


Figure 2: Dry bulk freight rate development, (source: Fearnleys)

These graphs of sub-segments demonstrate that the movements in freight rates are far from homogeneous and depend on many factors. The graphs are based on the actual sea freight expressed in US$ per tonne. These can also be translated into time charter equivalents, which are expressed in US$ per day for the entire ship.

Panamax, Capesize, Handysize/Handymax

Figure 3 shows the development of the time (period) charter rates for three dry bulk vessel types: Capesize, Panamax and Handysize. Although the direction of the changes in all three graphs are similar, the extent of the fluctuations varies widely. The graphs are made up of hundreds of charter fixtures, see **Figure 4**, which shows the period time charters for Panamax vessels. Within the category of some 850 Panamax vessels in the world fleet, different ships achieve higher freight rates than other ships, depending on the size and fuel economy. Modern, large and fuel efficient ships command a higher charter rate.

The shipbroker Simpson, Spence & Young is specialised in Capesize vessels and publishes an index of a segment of the Capesize market, the Atlantic routes. **Figure 5** shows the development of this index for the years 1993-1995. The index began on October 2, 1989 at 5,000.

The shipbroker J.E. Hyde & Co. has developed an index for the Handysize and Handymax bulk carriers, based on a weighting of 11 routes. These routes and their relative weight are shown in **Table II**, while **Figure 6** shows the graphical representation.

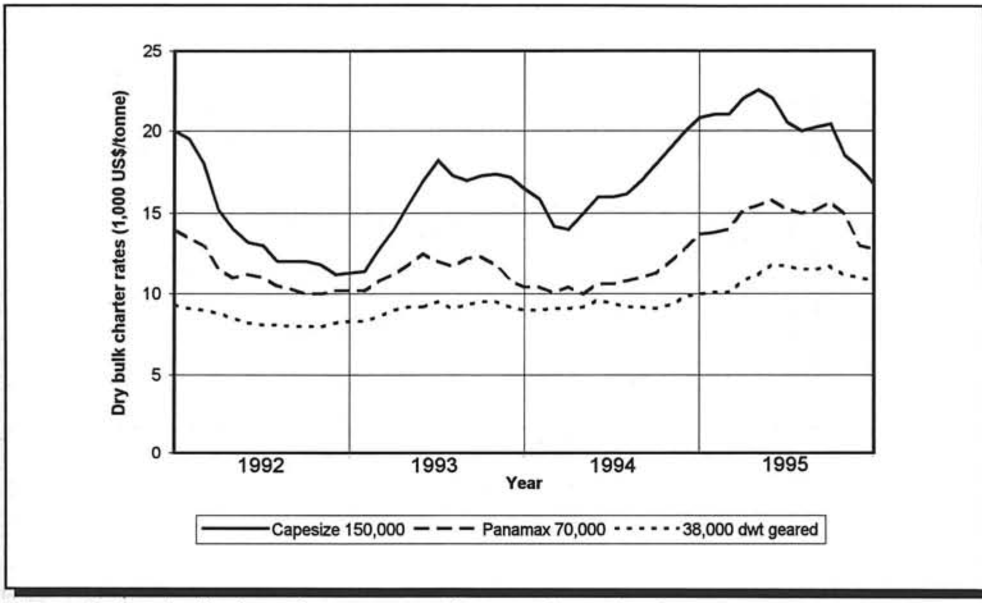


Figure 3: Dry bulk time charter rates (source: Fearnleys)

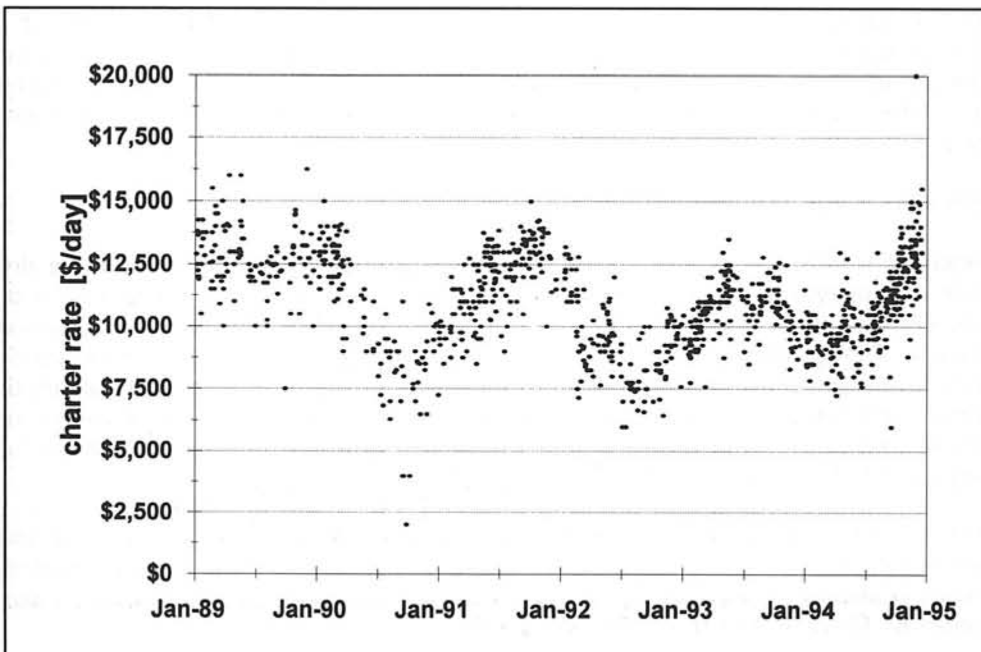


Figure 4: Panamax dry bulk carrier time charter rates

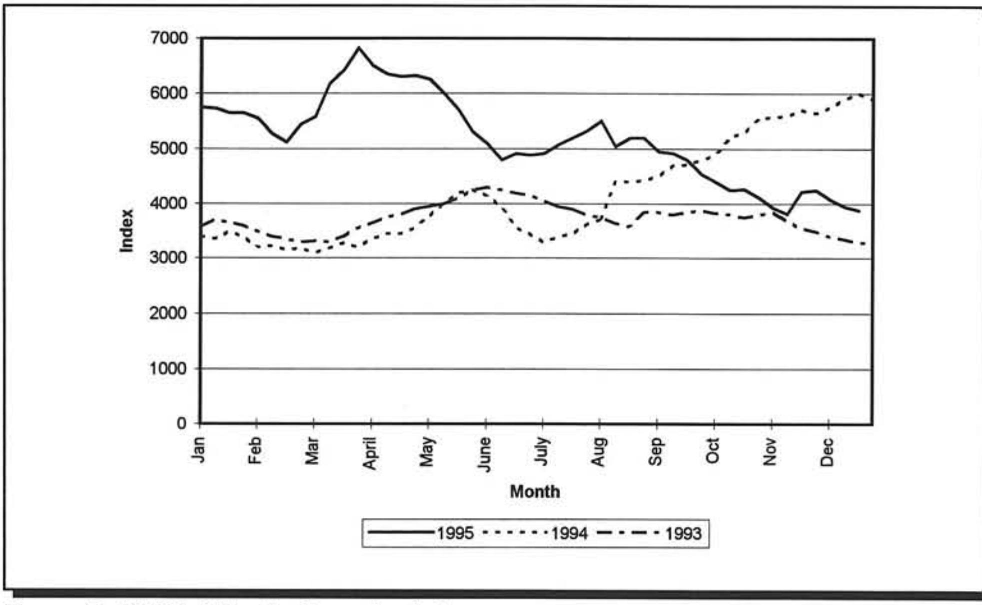


Figure 5: SS&Y Atlantic Capesize index

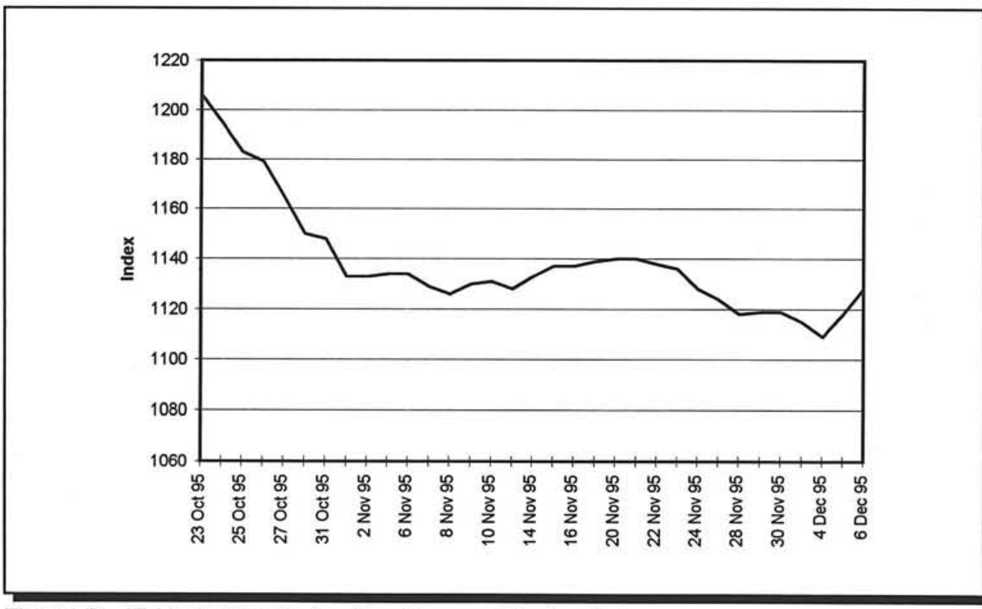


Figure 6: JE Hyde Handysize/Handymax shipping index

Nov 93 ($)	Oct 95 ($)	Weight (%)	Description
12,250	15,250	15	35/40,000 dwt Antwerp-Hamburg range tct Far East
22.75	26.50	10	25,000 5% HSS, USG/Algeria 5 days, 1,000 FIO
9,750	12,400	15	40/45,000 dwt Singapore-Japan, one Austrialian round voyage
8,000	8,750	15	26/30,000 dwt Skaw/Passero, one Trans-Atlantic round voy.
5,500	7,750	7.5	30/35,000 dwt South Africa tct Lisbon/Hamburg
13.25	19.00	5	20,000, 10% HSS, 1 USG/1 Venezuela
32.00	42.00	7.5	30/35,000 scrap, USNH/South Korea
6,000	7,250	7.5	35/40,000 dwt, Singapore tct Boston-Galveston
38.00	40.00	5	20/25,000 mt steels, Black Sea/China
16.00	17.50	7.5	25/35,000 dwt, grain, 1 Brazil/1 Antwerp-Hamburg range
21.00	24.50	5	20/23,000 dwt bulk sugar, 1 Queensland/1 Japan

Table II: Relative weighting of the Handysize/Handymax index

7.1.2 Crude oil and oil products tanker shipping

Tanker freight rates used to be negotiated between the shipowner and the shipper in terms of US$ per tonne. This meant that a different freight rate had to be calculated between all the ports of export and import. This cumbersome procedure was eliminated by the establishment of a reference index, which is called the New Worldscale. A special industry body, called the Worldscale Association publishes the Worldwide Tanker Nominal Freight Scale, which enables the shipowners and shippers to translate the Worldscale index into all the existing routes and ports in the world. The tens of thousands of rates are every year updated and form the basis of many simple charter parties.

The Worldscale is based on a standard vessel of 75,000 dwt, based on a round voyage, with a service speed of 14.5 knots, and a bunker consumption of 55 tonnes per day. Worldscale 100 is defined to be the freight rate where this standard ship is earning a 'reasonable' profit. Larger ships need less worldscale points to earn the same profit and smaller ships need more worldscale points. One should note that the farther away from the standard ship size a vessel is and the farther away from a 'normal' market situation one is, the poorer the worldscale is as a direct measurement of earnings.

The Worldscale is published daily for different ship sizes, such as the VLCC and the Suezmax. **Figure 7** shows the Worldscale development over the period from 23 October up to and including 6 December 1995.

The Worldscale rates can also be recalculated into time charter equivalents, expressed in US$ per day. **Figure 8** shows the monthly averages of the time charter rates of Very Large Crude Carriers, Suezmax tankers, and Aframax tankers.In spite of the large difference in size of these vessels, the time charter rates in US$/day are quite similar.

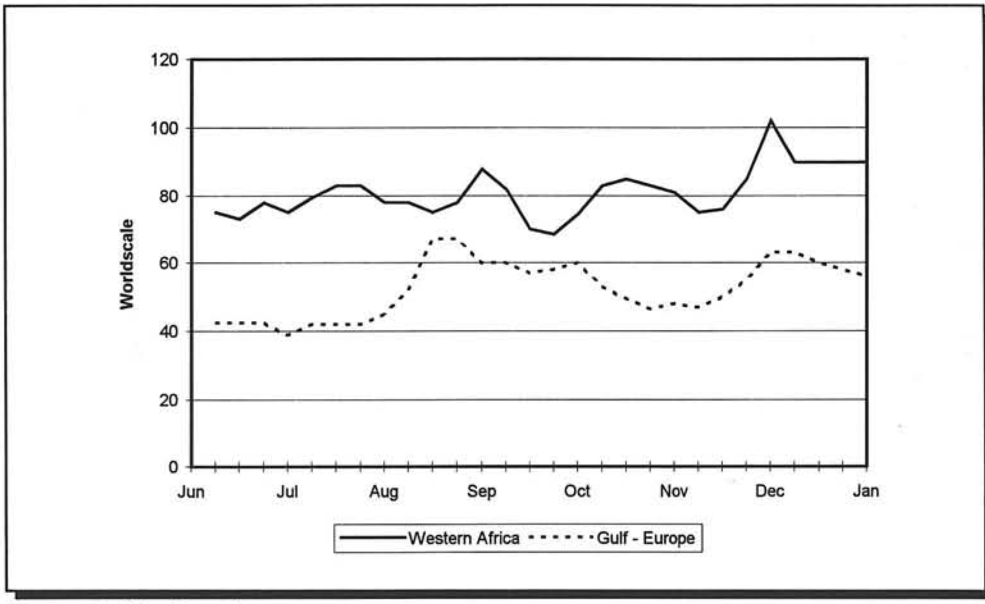


Figure 7: Worldscale

The oil tanker market is segmented into two major components: Crude oil (dirty) and oil products (clean). **Figure 9** shows the development of 32,000 dwt and 70,000 dwt oil products tankers. Again, the difference between the ship sizes is not quite reflected in the level of the freight rates.

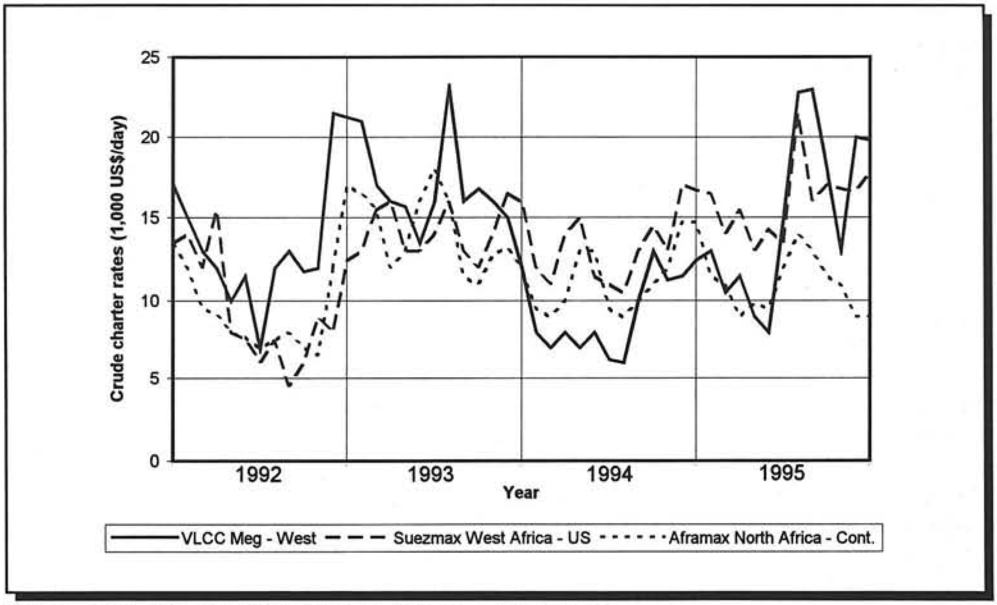


Figure 8: Crude oil charter rates (source: Fearnleys)

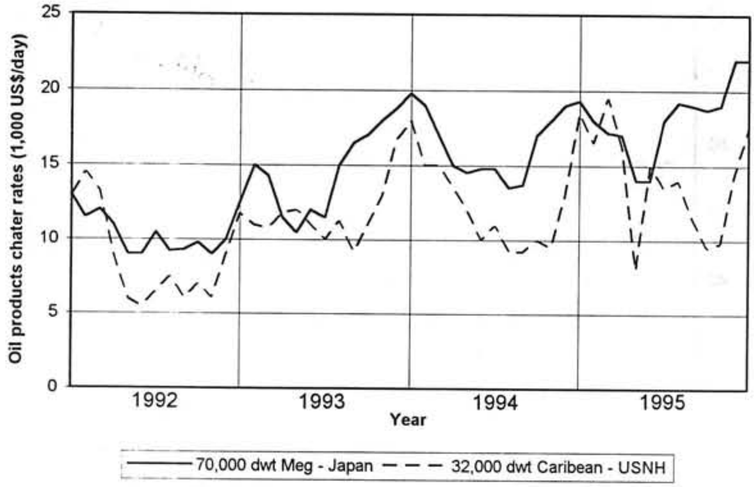


Figure 9: Oil products charter rates

7.1.3 Chemical tankers

The chemical tankers market is a specialised niche market, which is made up of a relatively small number of shipowners, which perform voyages between many ports of the world. The charter rates are not as extensively published as in the bulk markets, and consequently no indexes are published on a regular basis.
Nevertheless, *"Chemical Week"* published a long term rate development graph (1977-1992) for two parcel sizes (1,000 and 3,000 tonnes), two types of products (easy chemicals and stainless steel tanks required), and two routes (Houston-Rotterdam and Houston-Far East). **Figure 10** shows the freight rate in US$ per tonne.

7.1.4 Gas carriers

The gas (LPG) carriers can be segmented into a number of size categories, expressed in cubic metres. The largest category of around 75,000 m^3 is of the fully refrigerated type (FR), and the smallest category around 3,200 m^3 is of fully-pressurised or semi-refrigerated type. **Figure 11** shows the rate development in US$ per month for the different categories. These rates are weekly published by specialised shipbrokers, such as Fearnleys.

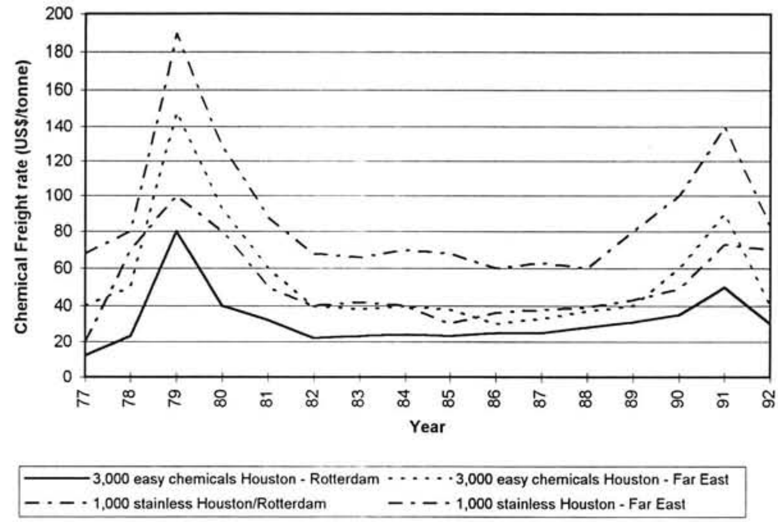


Figure 10: Chemicals freight rates

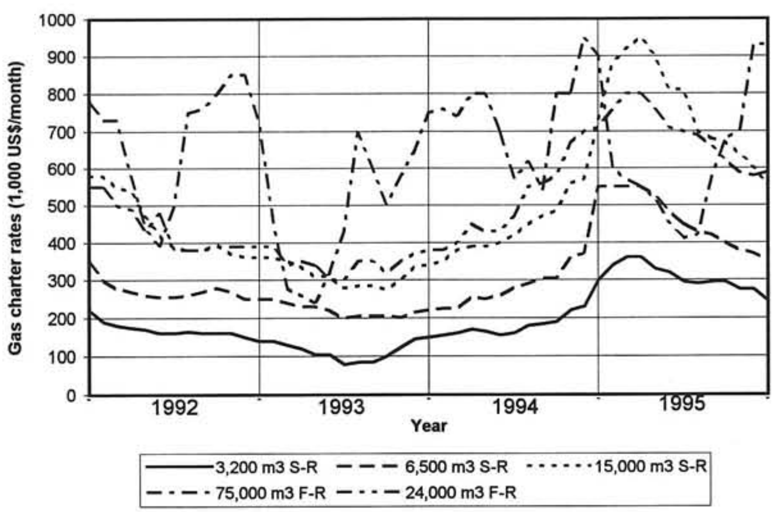


Figure 11: Gas charter rates (Source: Fearnleys)

7.1.5 Reefer ships

Reefer ships freight rates are expressed in the charter hire in dollarcents per cubic foot (cu.ft.) per 30 days. Specialised shipbrokers such as Klaveness publish the rate development regularly. **Figure 12** shows the development over a more than thirty year period of reefer ships between 350,000 and 500,000 cu.ft. In the early 1980s, the distinction became visible between breakbulk ships and pallet friendly ships. The latter category commands a premium, as the stevedoring costs are substantially lower.

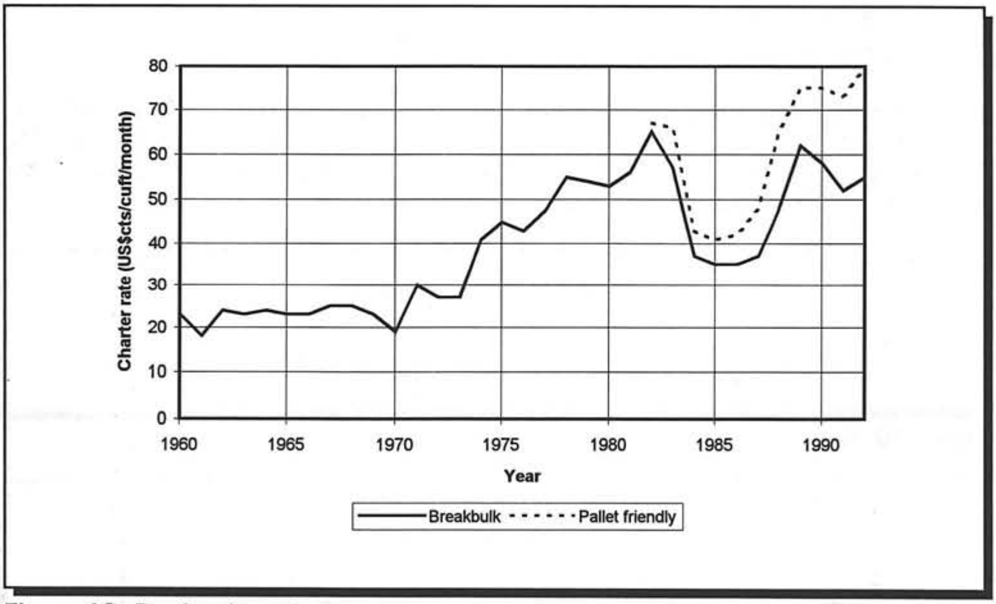


Figure 12: Reefer time charter rates

7.1.6 Container shipping

In spite of the fact that the container ship charter market has become a very important part of world shipping, no freight indexes exist that are generally accepted by the shipping professionals. There are several attempts to translate the market dynamics into a single index-figure, such as from the New York broker Commonwealth Shipping. This monthly index is based on the spot and time charter fixtures of four size categories: 250 TEU, 550 TEU, 1000 TEU and 1500 TEU. Each time charter equivalent can be translated into a value in US$ per TEU. On the basis of relative importance of each category in the total charter fleet, the index is calculated. This is shown for November 1995.

Container ship index 1,200.19 (-19.97), Report November 1995

Index data

250 TEU - US$ 22.35 per TEU (unchanged Index 187.05)
550 TEU - US$ 16.14 per TEU (US$ 0.12 Index 283.01 - 2.10)

1000 TEU - US$ 11.25 per TEU (US$ 0.61 Index 315.56 - 17.11)
1500 TEU - US$ 10.99 per TEU (US$ 0.02 Index 414.58 - 0.76)

***Comparative indices** (3, 6, 12 months previous)*

AUG 1995 1181.38
MAY 1995 1143.81
NOV 1994 1069.36

In the study *"Analysis of the Container Ship Charter Market 1983-1992"*, ten years of charter fixtures have been analysed for four ship size categories. The charter hire expressed in US$/TEU/day is shown in **Figure 13**. **Figure 14** shows the spread of the underlying data for the size category 400-600 TEU.

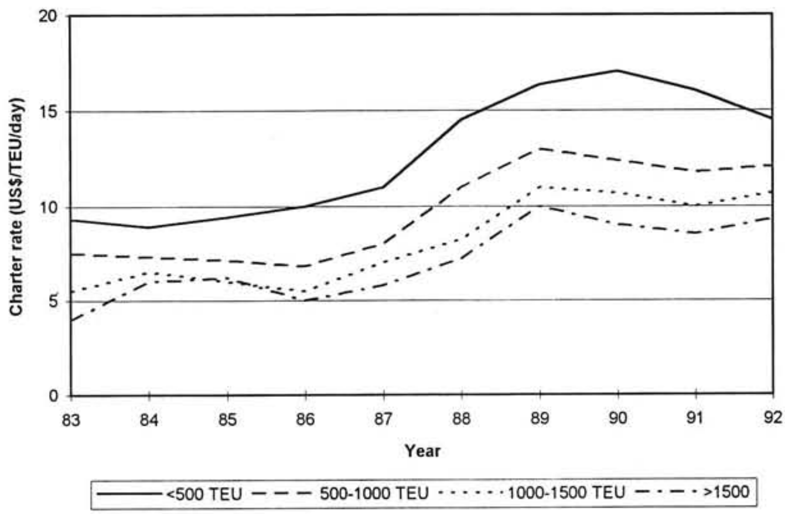


Figure 13: Container ship charter rates

7.2 Newbuilding, secondhand and demolition prices

The prices of ships determine to a large extent the potential for shipowners to make a return on investment. If newbuilding prices are low, even a low freight rate can bring profit to the owner. The prices of ships can be segmented into three categories: Newbuilding, secondhand and demolition.

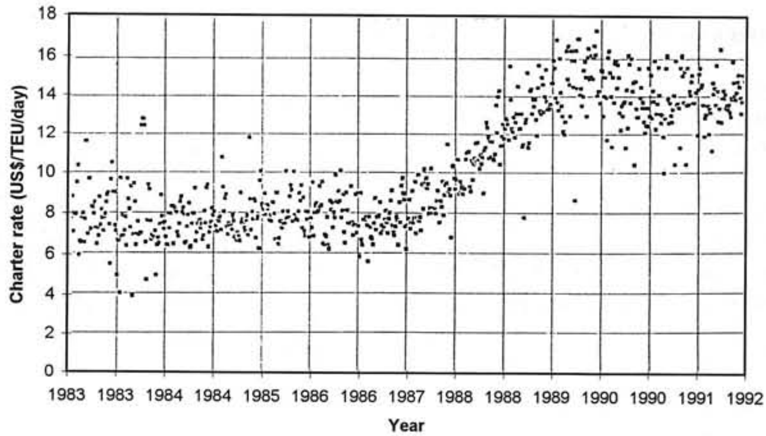


Figure 14: Spread of charter rates of container ships

7.2.1 Newbuilding prices

Newbuilding prices of ships are not necessarily linked to the actual shipbuilding costs for the yards. The prices of newbuildings are determined by the forces of supply and demand. This is illustrated by a number of graphs.

Figure 15 shows the newbuilding price development of three types of dry bulk carriers over the period 1980-1994. A Panamax bulk carrier could be bought in 1985/86, one of the most dramatic shipping periods, for US$ 14 million, while four years later the price was doubled.

Figure 16 shows the newbuilding price development of tankers over the period 1992-1995. Imagine a shipowner who bought early 1992 a double-hull VLCC for US$ 110 million and found himself confronted three years later with newbuilding prices of US$ 80 million. He had already lost on paper US$ 30 million.

Ocean Shipping Consultant's study *"World Shipbuilding: Demand & Prices 1996-2005"*, contains an illustrative graph with the indexed newbuilding price developments over the period 1981-1995, see **Figure 17**. This graph demonstrates that not all ship types follow the same price pattern, which can be explained by the building capacity available at the various yards around the world. With the exception of tankers, the relative prices of dry bulk carriers, LPG carriers, and container ships have declined over the fifteen year period.

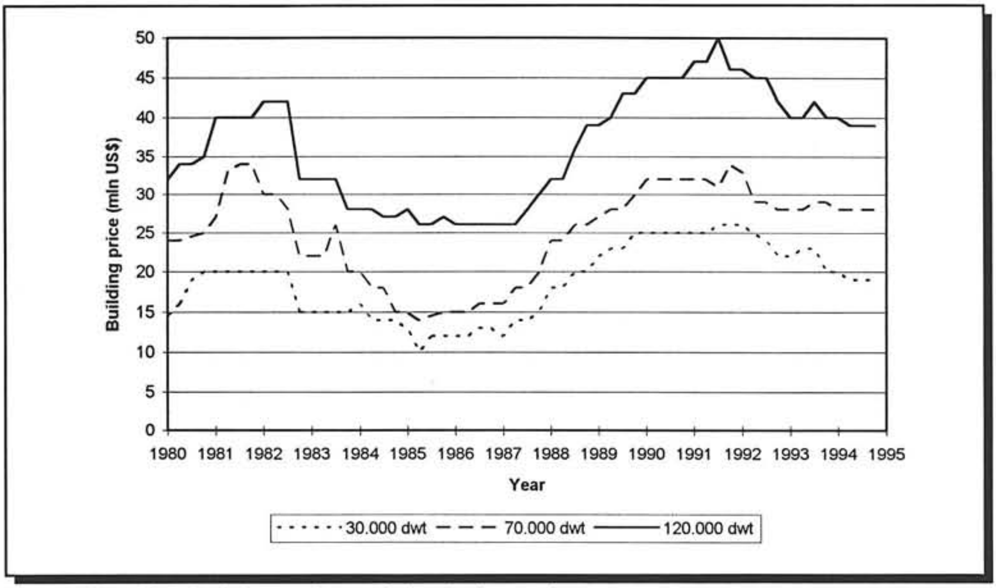


Figure 15: Newbuilding prices of dry bulk carriers

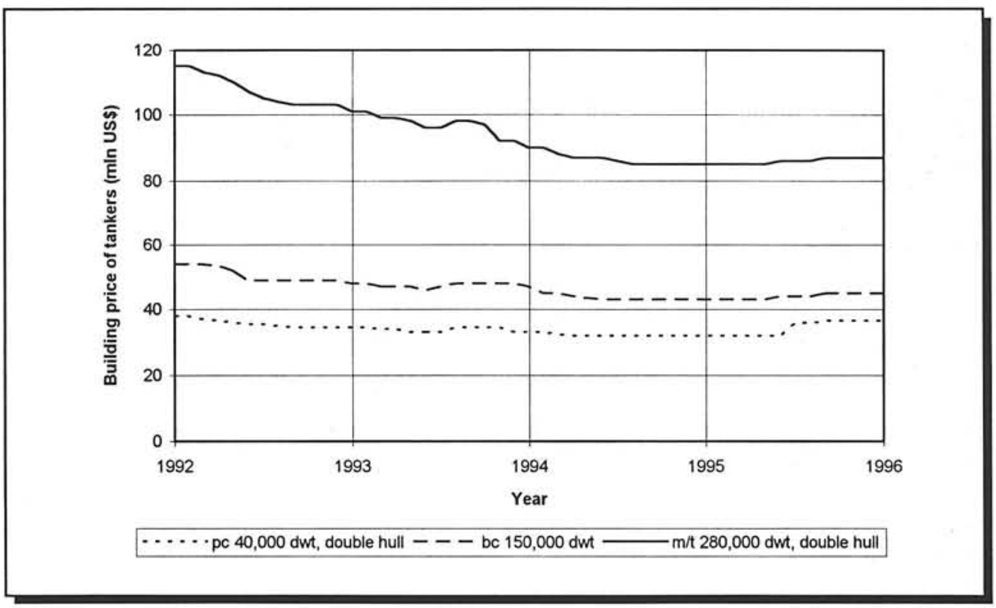


Figure 16: Newbuilding prices of tankers

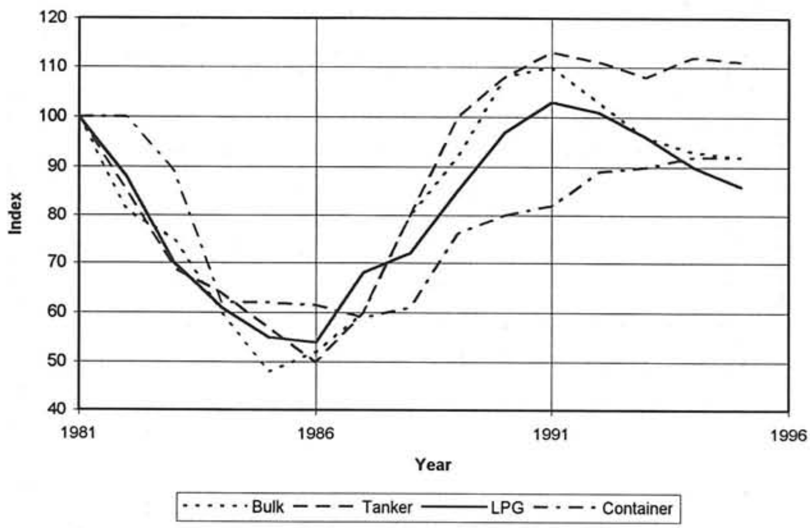


Figure 17: Indexed price developments 1981-1995

7.2.2 Secondhand prices

In December 1995 there were 2342 ships on order[1]. The activity in the secondhand ship market, in particular the dry bulk and tanker markets, amounted in the first ten months of 1995 to 168 tankers and 410 bulk carriers. The volume of secondhand sales depends on the price ratio between newbuilding prices and secondhand prices. Clarkson Research studies World Shipyard Monitors tracks the ratio over time. This is illustrated by **Figure 18** and **Table III** for the various ship types.
The price gap between newbuilding prices and secondhand prices depends on a number of factors such as the freight rate level and the occupancy rate of the shipyards. It is never a straightforward answer, as is illustrated by the case of the Capesize bulk carriers[2].

Figure 19 shows the average time charter rate of Capesizes over the period 1980-August 1995 (right-hand axis). The two other lines illustrate the value of 5 year old ships and the newbuilding premium over secondhand ships. The shipowner has to weigh the investment costs in new ships against the purchase of secondhand tonnage; a decision that will be influenced by the earning potential (freight rate) in the near future, and the price ratio development in the longer term.

[1] *"Fairplay"*, Newbuildings

[2] *"Lloyd's Shipping Economist"*, Sept. 1995, p 16-17

		1986	1987	1988	1989	1990	1991	1992	1993
Tanker ratios									
VLCC	5 yr old	67	67	71	77	77	71	71	59
Suezmax	5 yr old	67	71	77	77	59	59	53	53
Aframax	5 yr old	56	50	71	91	63	63	48	68
Handy	5 yr old	77	63	67	71	67	56	48	53
VLCC	'75 blt	21	26	30	34	25	22	11	12
Suezmax	'75 blt	32	32	36	42	23	21	8	10
Aframax	'75 blt	-	-	9	6	8	9	25	11
Handy	'74 blt	43	32	34	31	22	18	11	9
Tanker average		80	71	54	58	43	41	32	37
Bulk carrier ratios									
Capesize	5 yr old	53	67	83	77	56	77	77	73
Panamax	5 yr old	48	63	67	83	63	71	67	68
Handymax	5 yr old	43	63	67	77	63	71	71	74
Handysize	5 yr old	28	48	67	71	50	63	71	73
Capesize	'74/75 blt	19	41	33	31	19	31	12	14
Panamax	'74/75 blt	14	28	31	30	13	25	20	21
Handymax	'77 blt	24	40	48	50	29	32	31	71
Handysize	'81 blt	36	45	59	56	40	45	43	49
Bulk carrier average		34	51	62	65	45	50	48	51

Unit: %

Table III: Price ratios (Secondhand/Newbuilding)

Figure 20 illustrates the price development of the secondhand bulk carriers. It is peculiar that the secondhand values of Panamax and Handymax bulk carriers are more or less equal, in spite of the fact that the ships have quite different deadweight capacities: 70,000 dwt versus 45,000 dwt.

7.2.3 Demolition prices

Ships are demolished or scrapped when they fail to obtain the certificates from the classification societies or flag states for technical reasons, when the freight rates are too low to make a return on investment, or when the scrap prices are high. The demolition sales price is calculated on the basis of the ship's steel weight and the price per tonne (US$/LDT). This price fluctuates with the supply and demand for scrap, but also depends on the ship type. Large tankers achieve higher rates than small general cargo ships, as a lot more labour input is required to demolish the latter ship type, and is therefore more expensive.

The price per tonne hovers around US$ 180, as is illustrated in **Figure 21** (right-hand axis), while the lefthand axis shows the three months moving average of the volume of ships scrapped, expressed in deadweight tonnes.

Figure 22 shows the long-term scrap activity and price development. Poor shipping markets result in relatively large scrap volumes and low prices and vice versa.

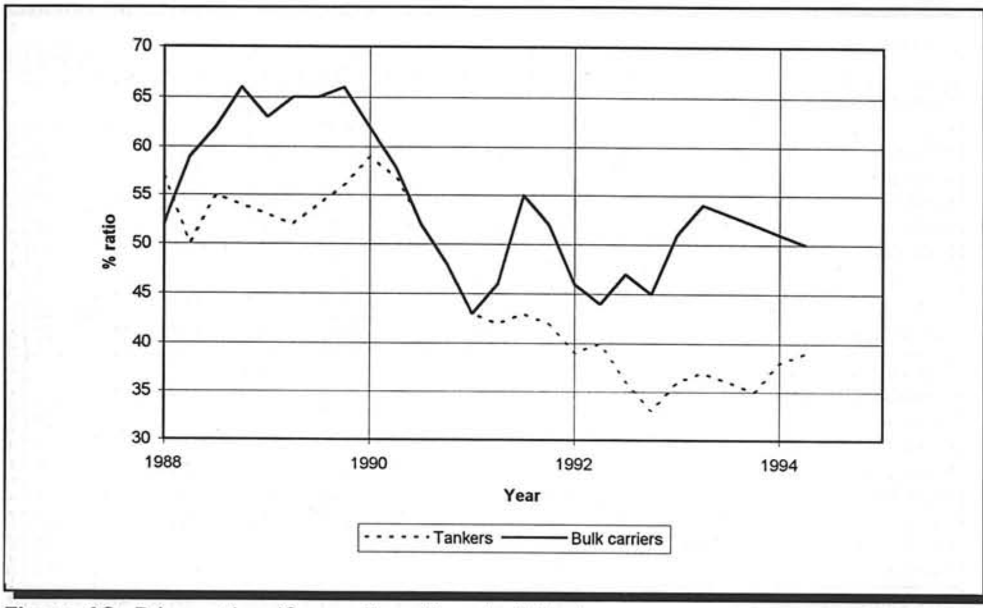


Figure 18: Price ratios (Secondhand/newbuilding)

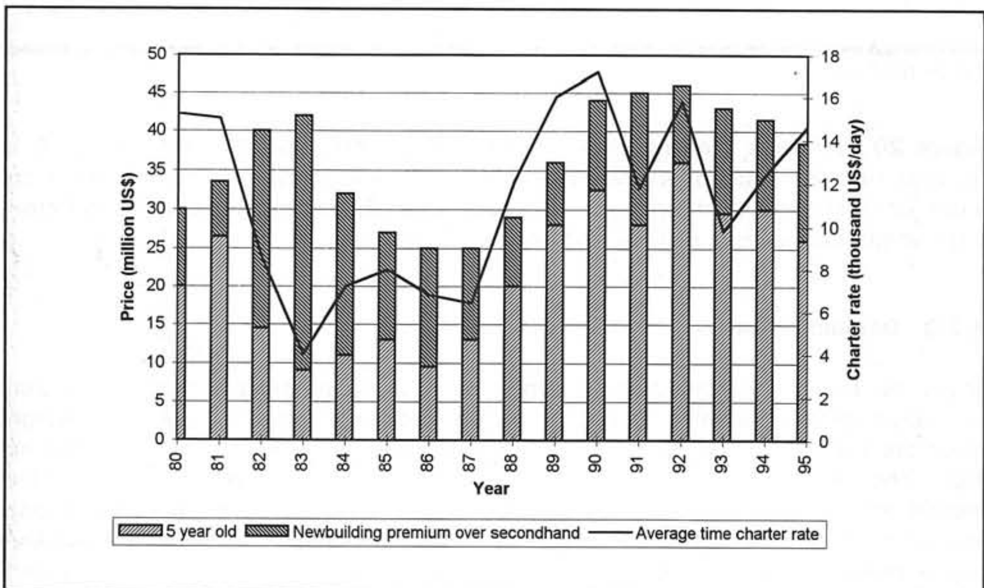


Figure 19: Charter rates Capesizes

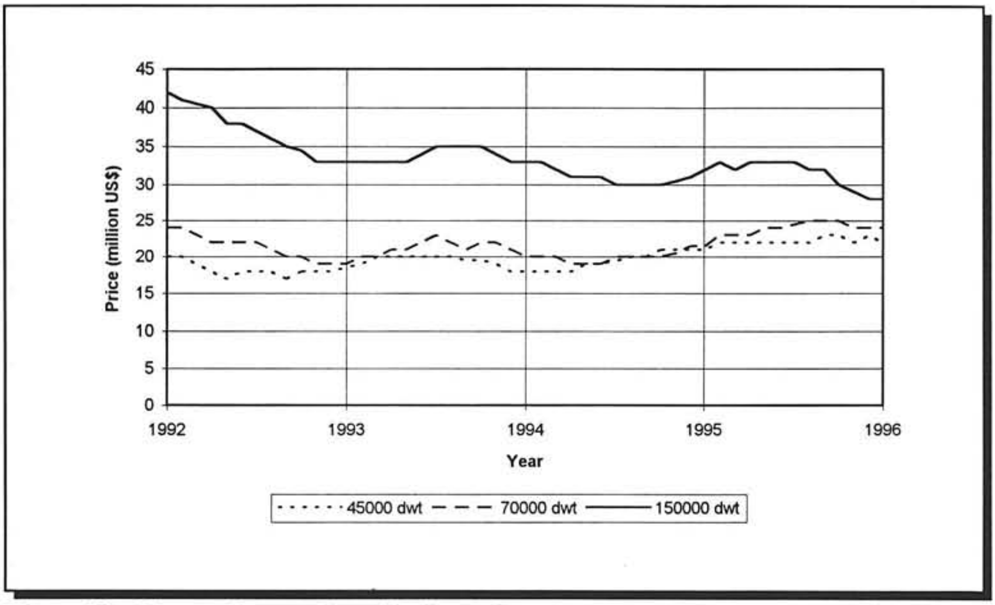


Figure 20: Prices of secondhand bulk carriers

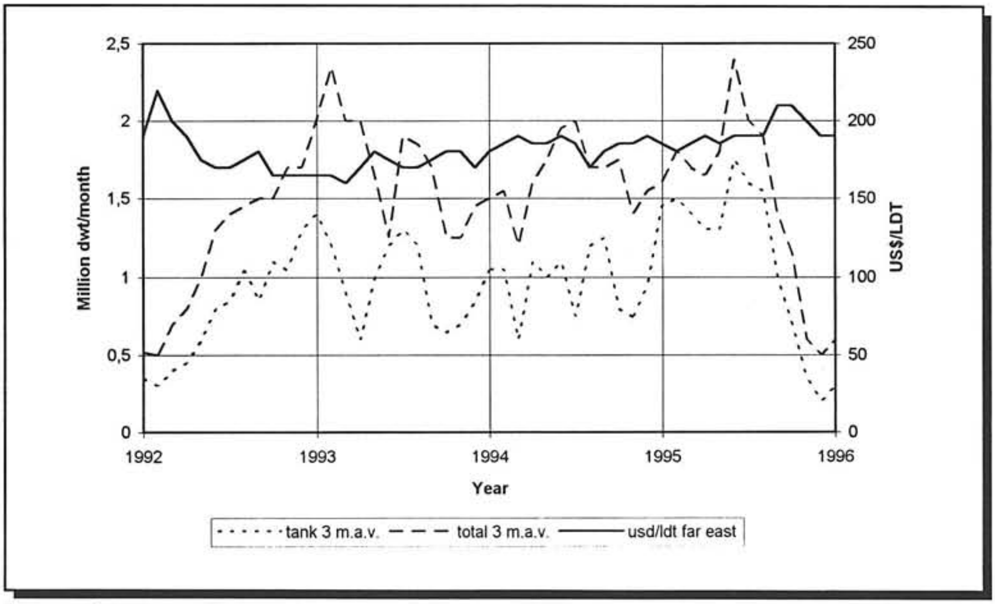


Figure 21: Demolition sales and prices

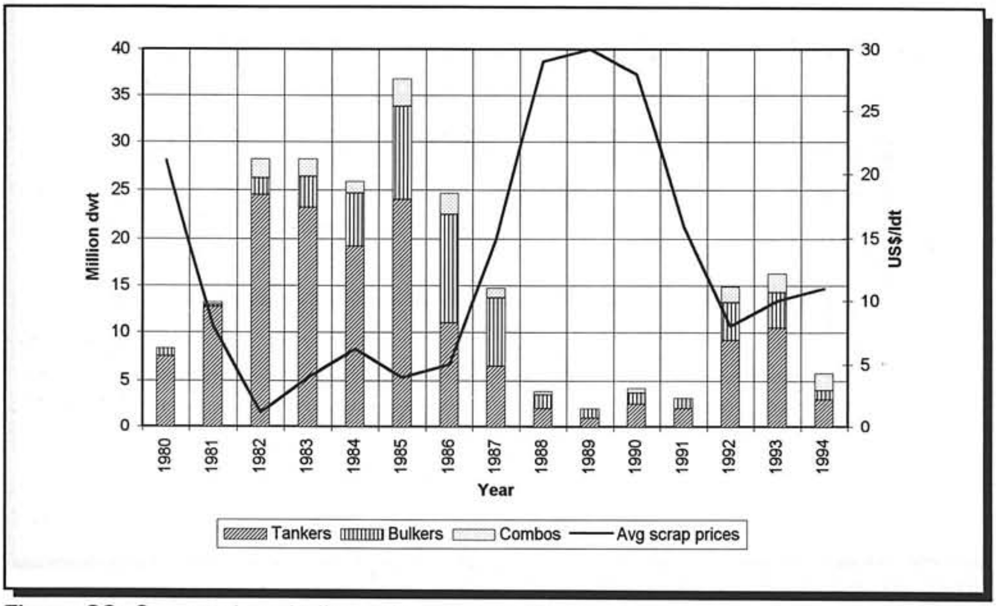


Figure 22: Scrap prices bulk carriers and tankers

CHAPTER 8: MARKETS AND MARKET STRUCTURES IN SHIPPING

After discussing some fundamentals, both on the demand and supply side of international shipping, this chapter aims at bringing it together to form a basis for a detailed market analysis (see the next chapter) and to introduce some terms and definitions which are necessary in understanding shipping economics.

Figure 1 attempts to give a broad overview of what shipping is all about. As discussed in chapter 1, international shipping can broadly be divided into two main parts: Bulk shipping and liner shipping. Most of the transportation work (78%) is bulk shipping, but most of the value of trade is liner shipping. The shipping markets have the role of bringing together the ones who require transport and the ones that can perform the job.

On the demand side cargo owners mainly have three possibilities when they want to ship commodities:

- Contacting a shipowner directly;
- Contacting one or more brokers;
- Contacting a freight forwarder or shipper.

The shipowner on the other hand has some of the same possibilities:

- Contacting a cargo owner directly;
- Contacting one or more brokers;
- Creating alliances with freight forwarders or shippers or setting up his own agency.

The freight forwarders or shippers are mostly found in general cargo markets or liner trades. They specialise in advising or handling the physical transportation of almost any type and size of cargo. They have an extensive network towards all types of transportation (ship, rail, truck, air) and can handle multi-modal door to door transportation as well as single voyages by sea. Often the liner shipping operators have special arrangements with shippers, giving them rebates on transport in exchange for their loyalty towards the line. They normally operate in markets where transport tariffs exist, so they are seldomly involved in negotiating prices.

The role of a broker is different and quite essential for the bulk markets. His function is to bring together the cargo owner and the shipowner and make them agree on a price for the freight. This role is vital to make the market function. The brokers get a commission for every contract they can conclude. The broker not only deals with freight, but also sales of secondhand vessels or contracting of newbuildings. In that case the broker brings together investors and shipbuilders.

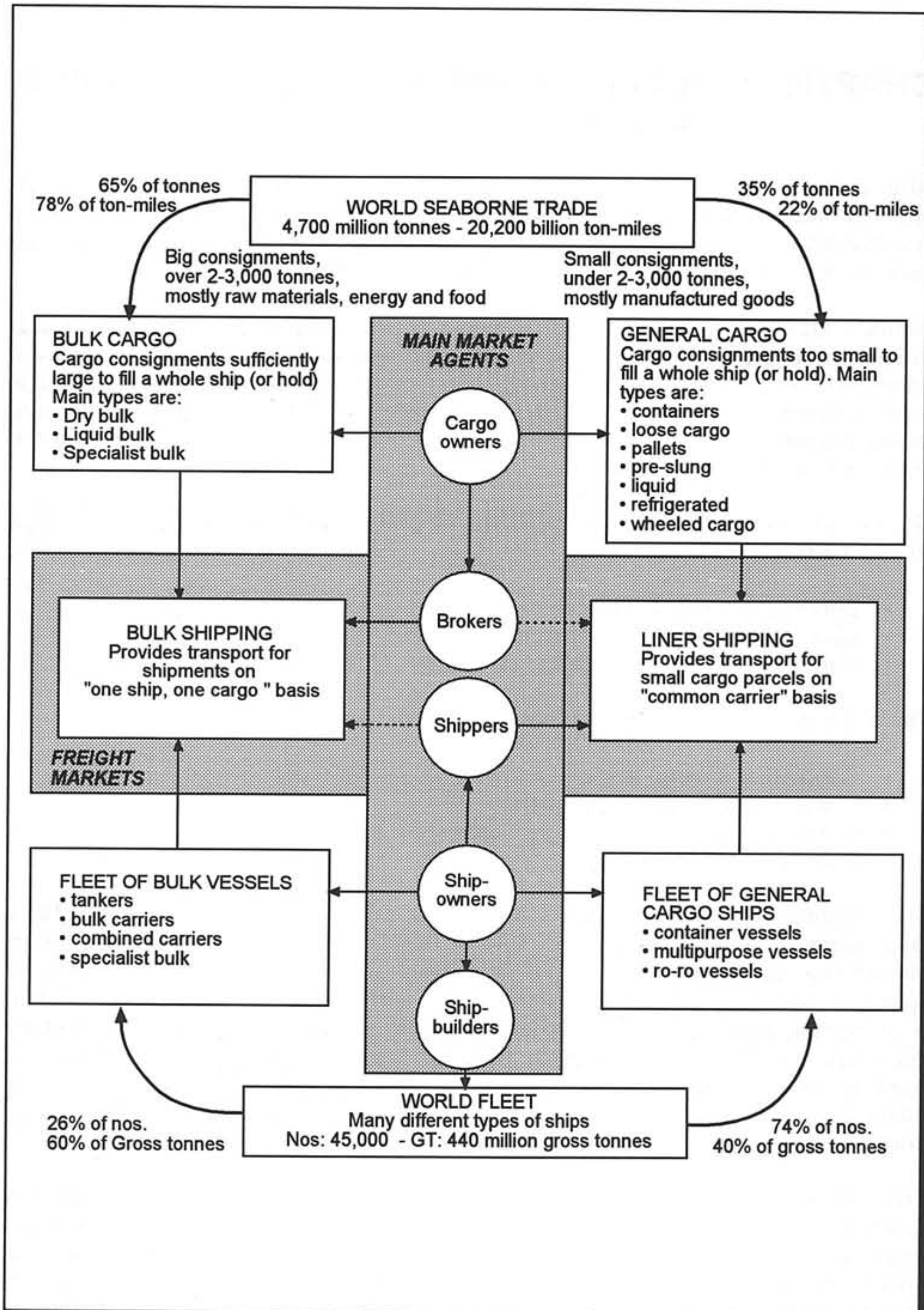


Figure 1: An overview of the global shipping industry

8.1 Freight contracts and rewards

A number of different contracts have been developed for bulk freight markets. The one that hires transport is called the charterer, and contracts are called a charter party (C/P[1]). A main distinction must be made between the *spot* contract and the *forward* contract. The spot contract (normally the voyage charter) is for one single trip only and is normally rewarded in US$ per tonne carried. This income is supposed to cover all the costs of the shipowner. The forward contract, normally a time-charter contract (T/C), is a contract for hiring the ship for a specified period of time. This contract is rewarded in US$/day or sometimes US$/dwt/month. Under this contract the charterer is responsible for all voyage dependent costs (i.e. port and canal fees and fuel oil). The income for the shipowner is thus his contribution to the coverage of fixed costs (operating costs, capital costs and eventual profit).

Knowing a spot rate in US$/tonne does not give much information. How much this will give the shipowner net after the trip is over, depends mainly on the length of the trip. All shipowners, therefore, need to calculate the so-called *time-charter equivalent of the spot rate*. Today most such calculations are handled by simple computer programmes, but the principles of the calculation are straight forward. An example for an oil tanker is show.

The following symbols are used:

DWT	=	Deadweight of the ship
R	=	Spot freight rate in US$/tonne
L	=	Load factor for the trip (i.e. cargo tonnes per dwt)
P	=	Port charges and canal fees in US$ per trip
Q_1	=	Price of heavy marine fuel in US$/tonne
Q_2	=	Price of diesel oil in US$/tonne
D	=	Days in port per trip for loading and unloading
W	=	Other waiting days
M	=	Transport distance (length of haul)
B	=	Ballast share (ballast leg/length of haul)
C_0	=	Consumption of fuel (diesel oil) per day in loading/unloading
C_1	=	Consumption of fuel (diesel oil) per day in waiting condition
C(S)	=	Consumption of fuel (heavy fuel) at sea at speed S
S	=	Speed in knots (nautical miles per hour)
V	=	Voyage results in US$ for the trip
T	=	Time-charter equivalent of R

[1] More details about this in chapter 10.

The voyage result is simply the total income (freight rate times tonnes carried), minus port charges and bunker costs, which have three components[1]:

$$V = R*DWT*L - P - Q_2*C_0*D - Q_2*C_1*W - Q_1*C(S)*[\frac{(1+B)*M}{(24*S)}]$$

The last term [((1 + B)*M)/(24*S)] is simply the number of days at sea, because the numerator is the length of the total round-trip[2] and the denominator is the number of miles covered per day.

V is thus the total income on the trip. To get this as a US$/day-income, the total income on the trip is divided by the total number of days on the round-trip:

$$T = \frac{V}{D + W + [\frac{(1+B)*M}{(24*S)}]}$$

T could also be expressed in US$/dwt/month:

$$T = \frac{V}{DWT}*\frac{30,417}{D + W + [\frac{(1+B)*M}{(24*S)}]}$$

where the last term is the number of round-trips per month (number of days in one month divided by the total number of days per trip).

Whenever the term TC-equivalent of the spot rate is used, it is the above transformation from a gross income measure in US$/tonne to a trip-independent contribution figure for the shipowner in US$/day that one has in mind. It should be noted that often when a rate is given in US$/day it is not clear whether this is a TC-equivalent of a spot rate or actually a TC-rate. In many contexts it is vital to be able to make this distinction.

8.2 Classification of markets

The shipping industry consists of a series of different markets. An obvious distinction is the one between the markets for the transportation services on the one hand and the markets for the ships themselves on the other. Another important distinction is the role that the markets have. Shipping has well-developed markets for future contracts - the time charter markets. These are essentially markets for dealing with uncertainty about the future. This is in contrast to the spot markets, which are markets where the balance between demand and supply as they are

[1]We simplify by assuming that only auxiliary engines using diesel oil is used when not trading at sea.

[2]If the ballast leg is equal to the length of haul, the roundtrip is (2*M)

known today, is reflected. The spot market thus has the important function of clearing the market in the short run, making supply equal to the actual demand. The TC-markets (Time Charter markets), on the other hand are dealing with expectations about the future and are thus an auxiliary market relative to the spot market. A similar distinction is between the newbuilding market on the one hand and the secondhand markets for ships on the other. The role of the newbuilding market is to make the supply of new ships equal to the demand for ships. By building new ships, the supply side of shipping is directly influenced and this will in turn influence the freight market. The secondhand markets, however, have a similar function as the TC-markets, they handle uncertainty about future expectations and whatever happens in the secondhand market will not directly influence freight markets as a sale of an existing ship does not affect the supply side of the freight market, only ownership to existing assets. **Figure 2** is made to illustrate this.

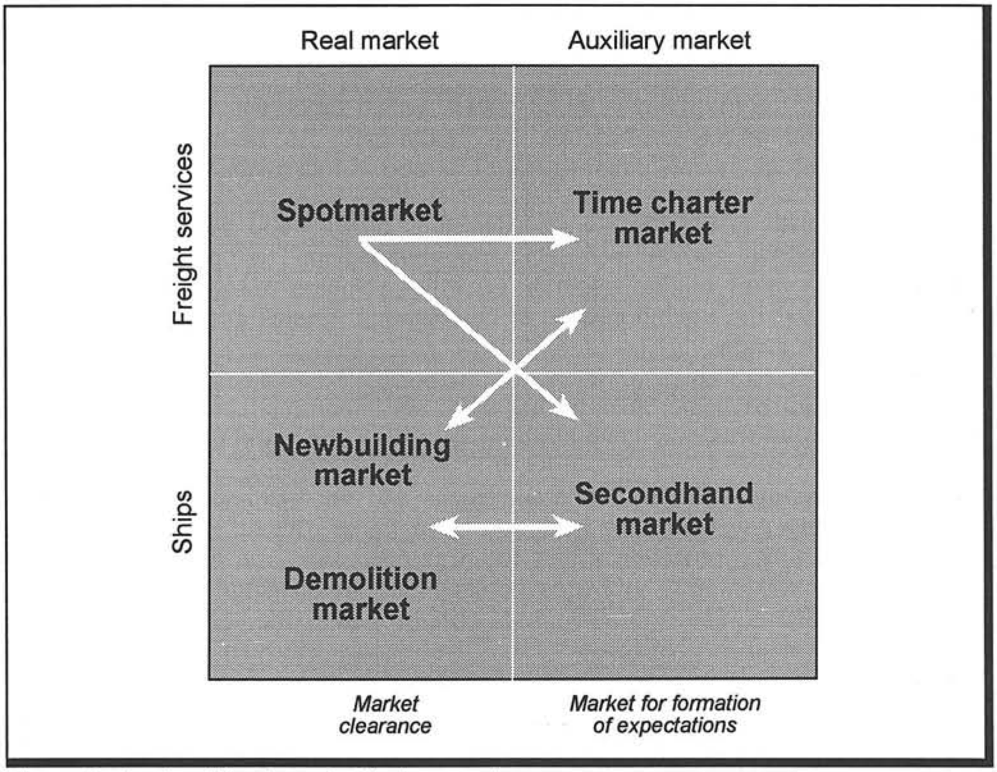


Figure 2: A classification of shipping markets

The spot market for freight services and the newbuilding market for new ships (as well as the demolition market for old ships) are real markets, in the sense that the main role of the market is to make demand equal to supply in the short run. The TC- and secondhand markets are auxiliary markets that basically deal with expectations about the future.

A very important point is that these markets are not independent of each other. In a static sense, leaving dynamics over time aside for the moments, the spot market for freight services is the main market. By signaling through the spot freight rate, the balance between demand and supply, important information is going to all the other markets.

Using the market for transportation of oil as an example, **Figure 3** has been constructed to partly give an overview of all the main elements of that market and the interrelations that exist. Several important points can be made on the basis of this figure.

First, the role of the spot market is to make supply equal to demand. This is reflected in the actual productivity of the fleet, and the freight rate is directly dependent on the relative scarceness of supply. The closer to maximum productivity, which is the same as the maximum transportation capacity one comes, the higher the freight rates. The tanker market is characterised by a rapidly falling freight rate as the utilisation rate decreases.

Productivity is affected directly by oil prices, which determine fuel prices, which affect the speed of the vessels and the freight rate. As we will see later, the speed of the vessels is only dependent on the ratio of fuel prices to freight rates.

The spot-rate affects the shipowners' decisions directly and this has a dynamic effect on the market, through scrapping and newbuilding. The figure also indicates that the oil transport market depends on other shipping markets. The dry bulk market will affect the trading pattern of combination vessels and this has a direct effect on tanker supply.

The hexagons in the figure indicate that there are important factors outside of the shipowners control that may have a strong impact on the market.

The figure does not include the time-charter and secondhand markets, simply because they do not affect the balance of the freight market directly. The spot market situation will, however, affect future expectations and be reflected in the TC-rates. This will directly influence demand for newbuildings or the supply of ships for demolition. The prices in these markets will at the same time influence future expectations, so there is a mutual relationship between the two types of markets. The same mechanism exists for the relationship between secondhand prices and the market for demolition. If secondhand prices increase due to expectations of improved freight markets, this will directly influence the supply of ships for demolition, and the relative price between secondhand prices and demolition prices will determine the volume of scrapping. Again the relationship is mutual.

One could argue that there is a direct mutual relationship between spot rates on the one hand and the newbuilding (and demolition) markets on the other, as the building of new ships (or scrapping of old ones) influences the supply side.

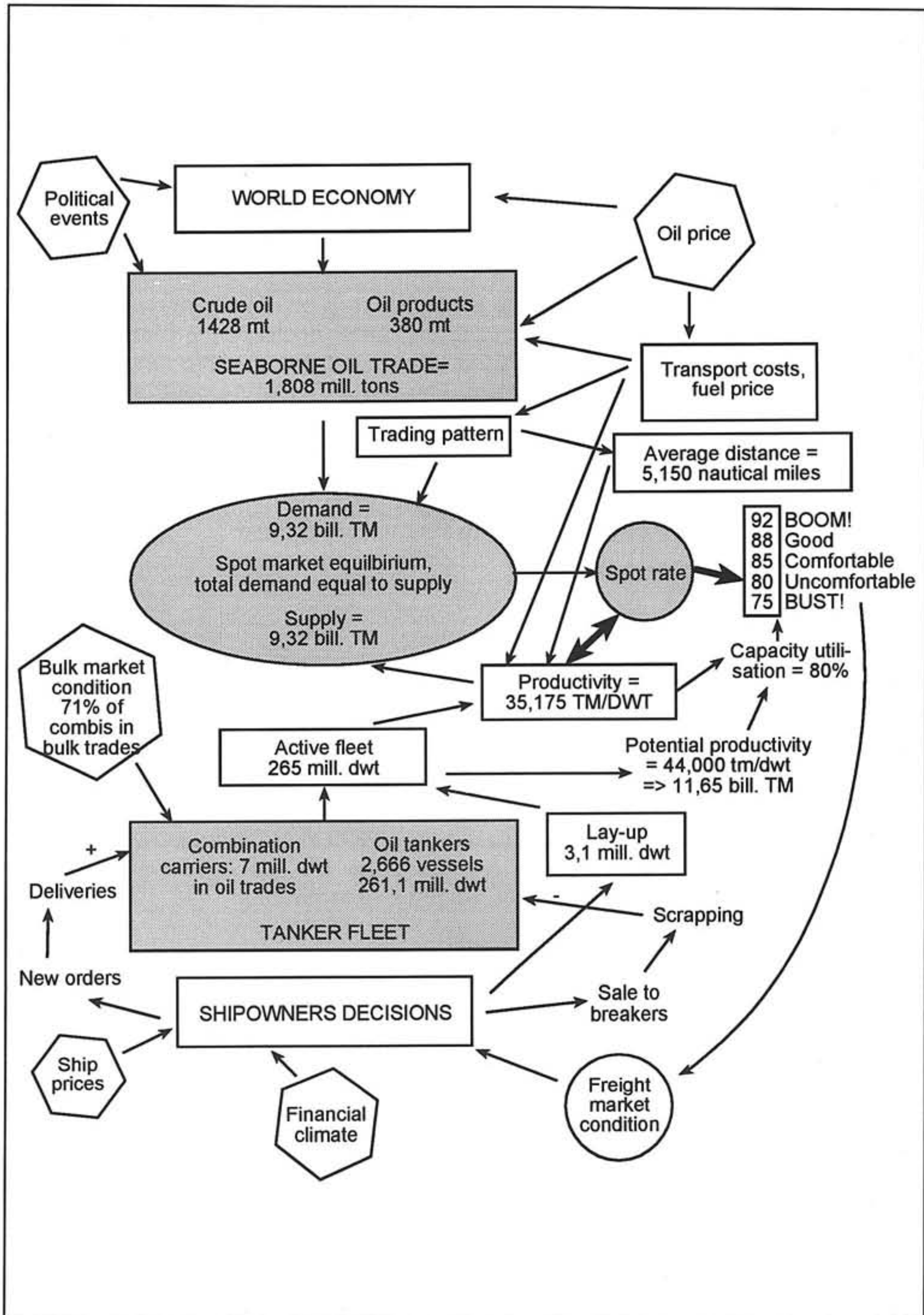


Figure 3: A structural model of the oil tanker freight market

There is, however, a time lag between the moment a decision of ordering a new ship is made until this decision is actually affecting the spot markets. It may take 2 years (and sometimes even longer) before a ship is delivered. It seems more natural, therefore, to argue that the relationship between spot markets and newbuilding markets works through the auxiliary markets for time charters and secondhand ships.

8.3 Formation of expectations in shipping

A seller who expects prices to increase in the future is obviously interested in very short term contracts as he would expect to get better prices in the future. A buyer with the same expectations would on the other hand like to have long term contracts as he would save money that way. The prices for future contracts are thus very dependent on buyers' and sellers' expectations. Unfortunately one cannot observe how expectations are formed in a market, but one can form hypotheses about how they are formed and try to test this by analysing market data.

There are two extreme views on how expectations are formed:

- Myopic expectations;
- Perfect rational expectations.

Myopic expectations mean that only the current market situation matters for the formation of expectations about the future (Myopic means short-sighted). Perfect rational expectations mean that the agents in the market have a well-founded understanding (or model) of how markets will develop in the future and they base their assessment on this.

Expectations of the myopic type are based on historical information. Extrapolative expectations imply that expectations for the future are based on extrapolating a current trend. This is also referred to as adaptive expectations.

Between the two extremes one could think of a situation where market agents have some idea about the future expected equilibrium level of the market, but no accurate insight into the convergence process towards this future equilibrium. This is referred to as semi-rational expectations. In shipping this means that all market agents have some idea of where shipping is heading in the longer run. The break-even rates for newbuildings will indicate where the long term trend lies, as one would not get sufficient newbuildings if the investors did not believe that at least break even will be reached sometime in the future. Comparing this to the current spot market, will then form the expectations in bulk shipping. The further away from the long run break-even rate the current market is, the stronger are the expectations of a change in the market towards long run equilibrium.

In chapter 9, some empirical studies on formation of expectations will be addressed.

8.4 Market forms

In the basic microeconomics theory, the market regime prevailing in any given market, will depend on a number of different factors:

- The nature of the product;
- The number of producers;
- Barriers to entry or exit to the market;
- The number of consumers.

The two extreme market types in the microeconomics literature are on the one hand pure competition and on the other monopoly. In the monopoly case there is no competition, only one producer controls the entire production. In the case of pure competition there are many, small producers that sell the same, homogeneous product at the same price. It is generally assumed that all producers are profit maximisers. To get maximum profit, the general rule is to produce and sell so that the marginal cost is equal to marginal revenue. The two extreme market solutions are illustrated in **Figure 4**.

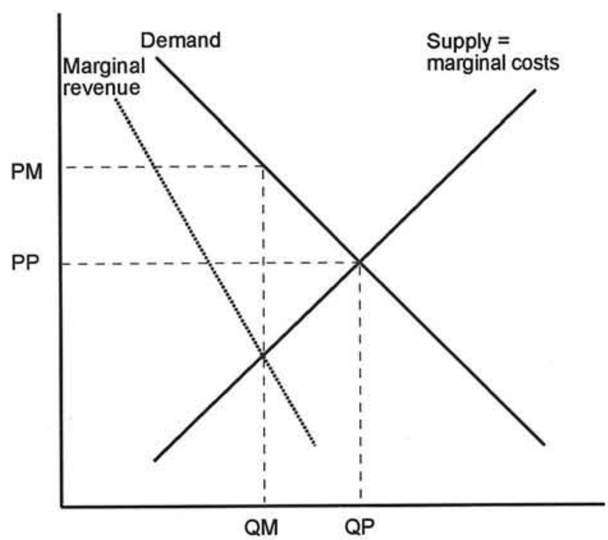


Figure 4: Prices and quantities under perfect competition and monopoly

A monopolist will restrict his output (QM) so that marginal cost equals marginal revenue and this will give a much higher price (PM) to consumers. Pure competition will give the lowest possible price to consumers (PP) and the highest output (QP), and the market solution is characterised by the price being equal to marginal costs. In such a situation no super profit will be earned, for then new entrants will just come in and push down prices again.

In between the two extremes one can find a number of intermediate market forms, all presenting market solutions with prices and quantities between pure competition and monopoly, like:

- Duopoly;
- Oligopoly;
- Monopolistic competition.

There are many special solutions to the three intermediate forms mentioned. Names like Cournot, Nash, Bertrand, Stackelberger and Spencer have all presented solutions to the intermediate market forms, and lately a vast literature on game theoretical solutions have emerged. It is beyond the scope of this book to discuss all these market forms, but some general comments to what distinguishes a market could be useful.

It is obvious that from a producer's point of view, the monopoly situation is to be preferred to any other situation. That requires, however, the possibility to keep competitors completely out of the market. Producing a unique product is often not enough, as copies or close substitutes may be produced without any possibility to prevent it. A patent is also no guarantee for protection.
Sometimes the production technology is such that one needs a large plant to make production economically interesting. If there are sufficient economies of scale in production, this will normally restrict competition. In such cases the size itself could be a barrier to entry. In general, therefore, the existence of economies of scale and/or unique features with the product or service offered, may create market forms of the intermediate type.

If there are only a few producers in a market segment, the relationship between the competitors can give rise to various market forms. If they are closely cooperating, they may collectively act as if they were a monopoly. In such cases we talk about collusion. If they are generally accepting each others presence, and adjust their production to keep prices up, a Cournot solution might be a good description, but if one of the producers has an advantage (often lower production costs), a slightly more aggressive market regime like Stackelberger's price leadership might be relevant. Sometimes the competitors know each other well and try to figure out what the others will do in response to his own actions. In such cases one will often have to turn to the game theory to find a market description that fits.

To identify and to be able to analyse a specific market, one should ask some fundamental questions:

- What is the nature of the product, to which degree is it special?
- Are there large economies of scale in production?
- Are there other barriers to entry?
- Are there close customer contacts?
- Are there many or few competitors and customers?

- Are there any barriers to exit?
- How well do the competitors know each other?

8.5 Main types of freight markets and shipping segments

As discussed in chapter 2, there are numerous different ship types trading in a variety of different market segments. As indicated in the previous section, a number of questions must be asked in order to understand the nature of a specific segment thoroughly. As a first step towards this understanding, the following classification of shipping segments may prove useful. First we make the obvious observation that we are not talking of a physical product here, but a service.

Two of the main dimensions mentioned are:

- To which degree is the service unique and different from that of competitors?
- To which degree do economies of scale exist in providing the service?

Using these two dimensions, it is possible to divide shipping into 4 main groups as indicated in **Figure 5.**

In the bottom left corner we have a situation where there are no economies of scale and a very homogeneous service. In such cases a pure competitive competition situation will normally be the result. This could be given many different names, like auction shipping, tramp shipping or commodity shipping, but we will use the latter. It is typical for this type of market that there is hardly any direct customer contact - all market contact is through a broker.

If economies of scale exist, one might move from commodity shipping to contract shipping. The main difference lies in the customer relation. Even if there is little, if anything to be gained in terms of lower average costs from having a large fleet, size might be an advantage simply because one can offer customers security of delivery and reliability and one can gain from increased flexibility of size. This might form the basis for successful contract relations with customers.

Moving along the other axis, the degree of specialisation increases. Again this implies that customer relations change, as one needs to offer the specialised service directly to the customers. Note that because of increased specialisation, the secondhand markets are less likely to offer an easy exit solution.

The final box, where both economies of scale as well as specialisation exist, could be called industry shipping. In this type of market the relationship between customer and service provider is even closer and the service is tailor-made to suit the customer. If customer loyalty can be build up to a high level, this is as close to a monopoly situation as one can come.

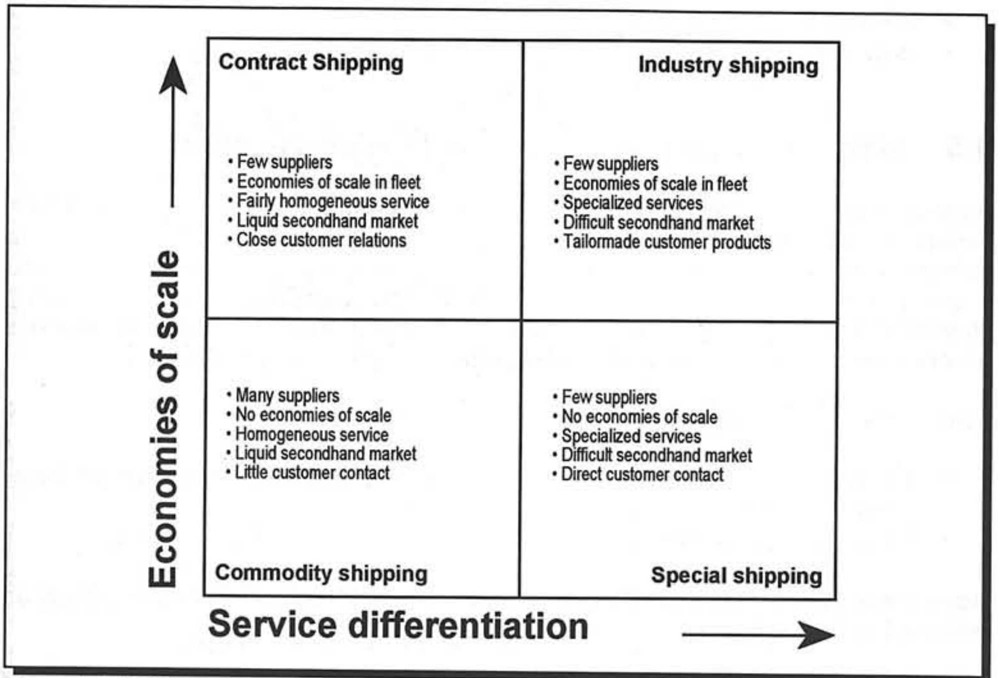


Figure 5: Main types of shipping segments

It may be instructive to see how some of the ship types and shipping segments fit into the classification scheme offered here. This is attempted in **Figure 6.** It is difficult to find an exact spot to place most segments, simply because they can be very complex and span over several subtypes.

Large tank and large bulk operations are the 'purest' form of commodity shipping. The service offered is very homogeneous, there is no economies of scale in operations and the number of competitors is very large, indeed.

In Handysize bulk carrier operations, pools are quite popular and the idea is to make the fleet more marketable when the size increases, because one can offer cargo owners more security and reliability and thus get contracts with more stable, and somewhat higher income. Norwegian bulk operators like Jebsen, Western Bulk Carriers, Bulk handling have formed large pools. This is partly to be able to meet the competition from large operators like Sanko and Pan Ocean in the Far East, but also because other pools, like the French Unitramp are becoming large and active in the market.

Chemical carriers used to be a rather special shipping operation. Over the years both the ships and the operations have been more and more standardised, but there are still economies of scale in the operations. This is due to the fact that the customers are large, chemical plants that put a lot of emphasis on reliability both with respect to time and safety. Only the very large operators will be able to

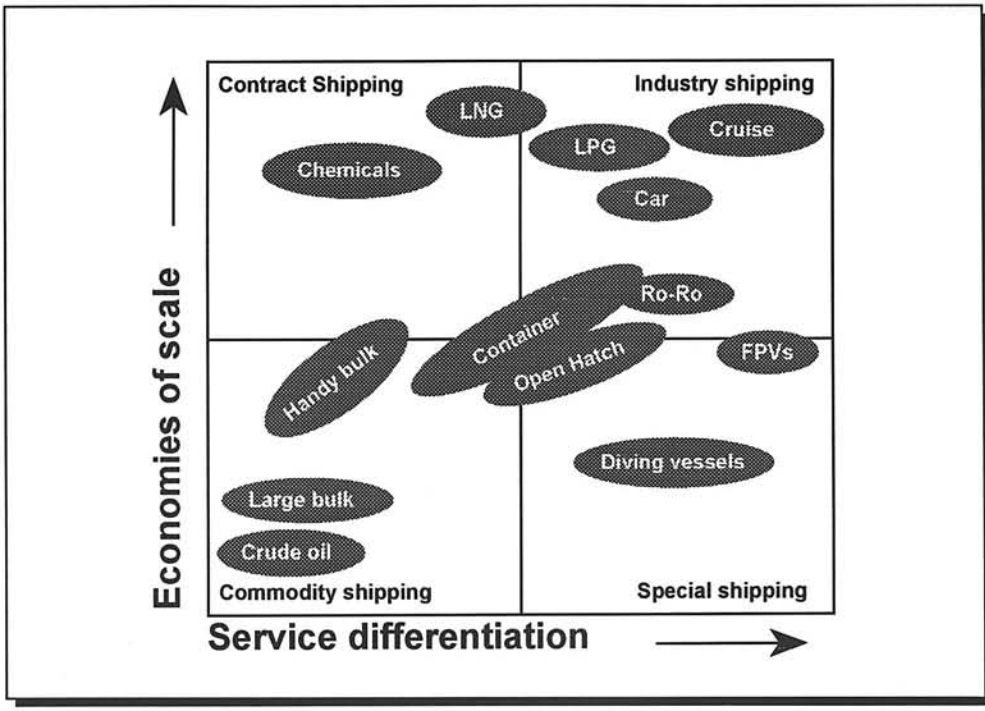


Figure 6: Examples of shipping segments

negotiate contracts with the big customers in this market, and chemical shipping is one of the best examples of pure contract shipping.

The best example is LNG, however. Each of the largest LNG ships, carrying some 125,000 cubic meter of natural gas is a very expensive ship to build, around 350 million US$. This activity is therefore, dominated by fixed costs and no one would dare basing a LNG newbuilding on pure speculation. Almost the entire trade is based on long term contracts with large customers (often governments), and although the ships are rather specialised, LNG is mainly a contract shipping activity.

There are few examples of pure special shipping. Diving vessels and some other types like research vessels and livestock carriers are some examples here, but there are not so many. In the latest years a lot of focus has been on the Floating Production Vessel (FPV), that used to be highly specialised, but that already is becoming more and more standardised and many shipyards are currently offering this ship type.

Roll-on roll-off-vessels (ro-ros) are often employed in very close contact with the customer to offer special logistical solutions, so at least some part of the ro-ro business is industry shipping. To a greater extent this is true for pure car carriers, as their employment is completely integrated with the logistics of the car manufacturers.

Liquid Petroleum Gas carriers (LPG) is rather specialised in many size and type categories, often employed in close cooperation with customers. This places LPG also in the industry shipping type.

The cruise business has been placed in the upper right hand corner of the box, indicating both an extreme degree of economies of scale (both in relation to hotel purchases, but also from a marketing point of view) as well as having a most differentiated product. Some might argue that cruise business is not really shipping, but simply floating hotels. Cruise vessels are still ships, though.

One sector that is difficult to place is container shipping. On the one hand it is clear that enormous economies of scale exist, because of the very high fixed costs involved in the operation. On the other hand the level of competition and the standardisation offered by the container itself, drives it towards commodity shipping. Some operators do offer very specialised services, so it really spans several segment types.

8.6 The dynamics of competition

Shipping is not a static industry. Enormous changes take place over time. One aspect of the dynamics of shipping worth emphasising, is the speed with which competition is brought into any new innovation in shipping. One should not really underestimate this. **Figure 7** illustrates this point.
Historically most innovations in shipping (like the chemical tanker, the combination carrier, the gas carrier, the reefer ship, etc.) have their origin in the commodity shipping segment. Some developments were a result of depressed bulk markets, other came because bulk operators actively wanted to try something else.

If an innovation is successful, a special shipping market is created, normally with a super profit. This however, immediately attract newcomers. Then, several things might happen. By a process of copying a concept and overcontracting, the industry profit might quickly be eroded and the competition level so hard that the special shipping segment becomes a commodity market. This happened with the heavy lift vessels, where it took less than a year from when the first semi-submersible solution was created until the market was crowded by similar solutions. It has happened also with the combination carrier and several other special ships. Sometimes, however, an innovation remains a profitable business, like many of the segments in **Figure 6**. To maintain profitability, however, a consolidation process must take place. This will normally be a process of some operators leaving the business and an active merger and acquisition activity. It is then quite clear that only a few could remain and stay profitable. The markets in shipping are, therefore, highly dynamic by nature and shipping company strategies should take this into account. Many companies have experienced heavy losses because they underestimated how quickly the technology diffusion process is in shipping.

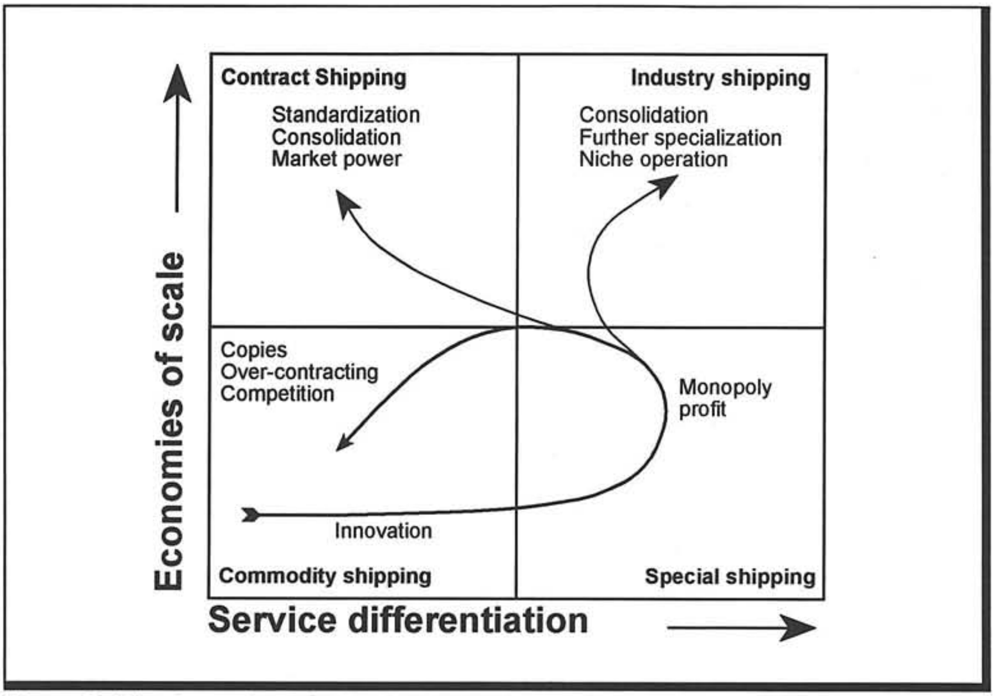


Figure 7: The dynamics of shipping segments

CHAPTER 9: MODELLING FREIGHT MARKETS

9.1 The simultaneity problem

There are many ways in which one can conduct market analyses in shipping. The choice of method depends both on the exact market segment and the purpose of the analysis. In this chapter the main focus shall be on the bulk markets with particular emphasis on the market for large crude oil carriers.

A traditional way of analysing bulk markets would involve the following steps:

- Identify the main commodities and the main areas of export and import;
- Quantify the demand for the various commodities and the distribution for the various trade routes;
- Calculate the required tonnage needed to cover the demand;
- Compare the demand requirements with the existing fleet capacity and make judgements on the market prospects.

For many purposes this could work well, but the method has some weaknesses. The two main drawbacks are that demand and supply are treated as if they were totally independent phenomena, and that the conversion of demand into a tonnage requirement figure involves an estimate of the productivity of the fleet, which is normally assumed to be constant. In a well functioning market, demand and supply are both influenced by the price level of the market, but this price level is precisely reflecting the balance of demand and supply. The productivity of the fleet is also influenced by this market level. This simultaneity problem is often poorly handled or is just ignored. The solution is to employ the tools offered by microeconomics - the simple partial equilibrium model.

The markets for bulk shipping come remarkably close to the standard assumptions made in the microeconomic theory about the conditions for a purely competitive market:

- The market agents are numerous and small relative to the market size and cannot influence the market price;
- The product is homogeneous;
- There is full information in the market;
- There are no barriers to entry or exit.

All of these assumptions are fulfilled in the bulk market. **Table I** lists the 30 largest tanker owners in 1995 according to Lloyd's *"World Shipowning Groups"*.

From this table it is clear that even the largest shipping companies in the world have a market share of less than 3% of the total market, and although the 30 companies together control almost half of the world tonnage measured in dwt,

Company	Total fleet deadweight	Market share	No of ships	Market share	Av. ship size deadweight
World-Wide Shipping Agency Ltd	8007443	2.7%	36	0.4%	222429
Mitsui OSK Lines Ltd	7339548	2.5%	57	0.7%	128764
Vela International Marine	7146482	2.4%	27	0.3%	264685
Bergesen. D.Y. A/S	6454790	2.2%	21	0.2%	307371
Ceres Hellenic Shipping Enterprises (Livanos.G)	5758792	2.0%	40	0.5%	143970
Petroleo Brasiliero Sa (Petrobras)	5656269	1.9%	77	0.9%	73458
Novorossiysk Shipping Co.	5545063	1.9%	101	1.2%	54902
Navix Line	5485805	1.9%	30	0.3%	182860
Nippo Unyu Shokai Co. Ltd	5385894	1.8%	32	0.4%	168309
National Iranian Tanker Company (NITC)	5338511	1.8%	29	0.3%	184087
Maritime Overseas Corporation	5268831	1.8%	47	0.5%	112103
Exxon Corporation	5008635	1.7%	50	0.6%	100173
Chevron Corporation	5006521	1.7%	37	0.4%	135311
China Ocean Shipping Company (COSCO)	4729833	1.6%	111	1.3%	42611
Shell Royal Dutch Group	4668474	1.6%	37	0.4%	126175
Mobil Oil Corporation	4256512	1.5%	32	0.4%	133016
Teekay Shipping Co. Inc.	4232053	1.4%	43	0.5%	98420
Kuwait Oil Tanker Co. S.A.K. (KOTC)	4073555	1.4%	29	0.3%	140467
Ofer. S	3908798	1.3%	33	0.4%	118448
Latsis. John S	3618210	1.2%	15	0.2%	241214
Shipping Corporation Of India Ltd (Sci)	3560411	1.2%	46	0.5%	77400
A.P. Moeller	3470187	1.2%	26	0.3%	133469
Troodos Shipping & Trading Ltd (Hajiioannou. L&P)	3417911	1.2%	27	0.3%	126589
Andros Maritime Agencies Ltd (Embiricos)	3250236	1.1%	19	0.2%	171065
Kawasaki Kisen K.K. (K Line)	3235627	1.1%	21	0.2%	154077
Hong Kong Ming Wah	2902687	1.0%	14	0.2%	207335
Papachristidis (UK) Ltd (Seatramp)	2870473	1.0%	13	0.1%	220806
Thenamaris Maritime Inc.	2851519	1.0%	31	0.4%	91984
Texaco Inc.	2777655	0.9%	20	0.2%	138883
ICB Stockholm	2771413	0.9%	14	0.2%	197958
Sum 30 Largest Tanker Owners	137998138	47.1%	1115	12.8%	123765
World Tanker Fleet 1995	292801000	100.0%	8692	100.0%	33686

Source: Lloyd's World Shipowning Groups

Table I: The largest tanker shipping companies 1995 they only control 12.8% of all ships. There are, therefore, a large number of very small operators in the market besides these 30.

Shipping offers a service, which is to carry goods from point A to point B. For the bulk commodities the services provided are very similar, indeed so similar that it seems quite reasonable to claim that the product (or more precisely: service) is homogeneous[1].

full information also seems to be satisfied. The shipping industry has developed a network of brokers that handles almost all information about where the cargoes are and what prices are quoted. Within a few minutes any cargo owner in the world will have almost full information on available ships and prices quoted by simply calling two or three brokers. It does not really matter if he calls to Oslo, London, New York or Hong Kong - the brokers are all part of an international network of information.

Any person with sufficient money can become a bulk shipowner. Bulk shipping has well-developed markets for secondhand tonnage and the industry is crowded with companies offering to handle all aspects of both technical and commercial management of ships. The entry barriers to the industry are, therefore, very low and so are the exit barriers. It is very easy to get rid of a bulk carrier in the secondhand market.
This means that bulk shipping exhibits all the main features of a market characterised by free competition. From the microeconomic theory a typical illustration of an equilibrium situation in such a market is indicated in **Figure 1**.

The theory simply says that prices (P*) are determined by that equilibrium quantity (X*) that makes demand equal to supply. The illustration is a snapshot of the market conditions in one particular situation. In order to use this simple framework as basis for the analysis of bulk markets one needs to decide on the appropriate measurement units of X and P and determine the shapes of the demand and supply curves and how they respond to changes in market conditions.

9.2 Measurements of prices and quantities in bulk shipping

As shipping is a transportation service - carrying goods between various ports of the world - an adequate measurement of transportation work is tonne-miles. One tonne-mile (TM)[2] is defined as:

$$TM = tonne * mile$$

[1] In tanker shipping the term substandard operators have emerged in later years and it is clear that some cargo owners avoid using certain service providers in the industry. Although this is the case, there are enough other competitors to make the assumption of a homogeneous service valid.

[2] Tonne-miles are abbreviated as both TM and T/M and very often in shipping statistics one will see MMM T/M, which means billion T/M, as each M indicate 1000.

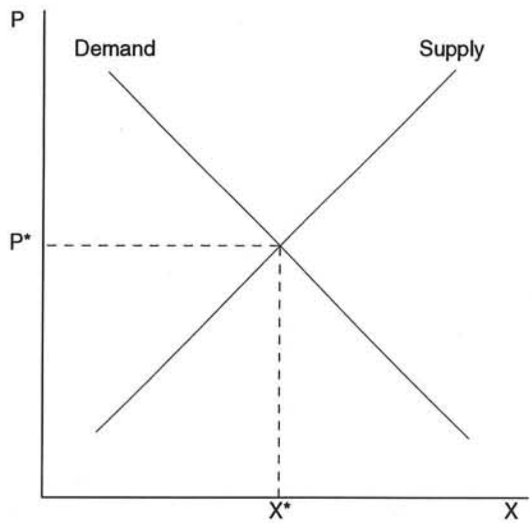


Figure 1: Equilibrium in a market with perfect competition

where:

Tonne = One metric tonne of cargo
Mile = One nautical mile (1852 meter[1]).

The quantity of shipping services should thus be measured in tonne-miles.

The freight rate can be measured in many different ways. As indicated in chapter 8, what matters to the shipowner is what is left after all voyage-dependent costs have been deducted. It is, therefore, the time charter equivalent of the spot rate that is of most interest to the suppliers. This can best be measured in US$/day.

The relevant units of measurement are, therefore, simple. The shapes of the demand and supply curves are not as straight forward, however. In principle the shapes are determined by the elasticity of demand and elasticity of supply with respect to the freight rate. A number of factors influence these relationships.

9.3 The elasticity of bulk shipping demand

Demand for transportation may be affected by changes in the freight rate for several reasons. As seen in chapter 6, the freight rate is an income for shipowners, but a cost element for cargo owners. If the underlying demand for a specific commodity is elastic and the freight element in the CIF price is high, the implicit, derived elasticity for transportation may be substantial. For the majority

[1]The international nautical mile is equivalent to the average length of a minute of latitude, and corresponds to a latitude of 45°.

of bulk commodities, however, the transportation cost share in the CIF price that low that it does not have a major effect for transportation demand in general.

Another possibility is that when freight rates increase, the importer may try to find an exporter that is closer, in order to reduce transportation costs. This effect has been analysed years ago in a study by Strandenes and Wergeland (1982) who examined the pattern of trade for major bulk commodities. The idea behind the study was to conduct an experiment. By examining the actual trade pattern of iron ore, coal and oil, the hypothetical question was asked: With a different mix of importers and exporters to carry exactly the same world trade, what is the mix that minimises the transportation work needed to carry this trade? Such a transport-minimising trade pattern would never occur in practice, for a number of reasons:

- There may be quality differences in the raw materials, making some combinations of importer and exporter unlikely;
- There may be long term contracts binding some importers to specific exporters;
- There may be physical port restrictions also making some trading combinations less likely.

All of these objections are to some extent true, but as they are long term by nature, one would expect each of them to affect the *level* of deviation from the minimum and should not vary too much from year to year. The experiment was, therefore, carried out on a series of years from 1967-1979 to study variations over time and not the level of deviations as such.

To see more clearly what is involved, **Table III** shows the trade pattern for coal in 1979. Table A shows the actual trade flows are given in million tonnes per year. By assuming that total exports and total imports should be kept constant, the minimisation is solved by linear programming to give the theoretical minimum trade pattern as in table B. In the minimisation, the average distances as given in table C were employed to give the transportation work as indicated in table D and E. For 1979 the deviation was 137 billion tonne-miles (581-444), or 30.8% from the theoretical minimum. This is thus a potential measurement of demand inefficiency. One should note that the way this experiment is conducted, the supply of shipping do not enter into the picture at all.

The results for coal for the entire period, are given in **Table II**. The table shows the the percentage inefficiency for each year. The final column shows the deflated freight rate for the coal trade Hampton Roads - Japan in 1975-US$/tonne. One can see that the inefficiency is negatively correlated with the freight rate[1]. This is as one should expect - when freight rates go up, the inefficiency goes down.This seems to indicate that importers are more concerned about finding a transport efficient solution when transportation is expensive.

[1]The partial correlation coefficient is in this case -0.6.

Year	Actual TM	Minimum TM	% Inefficiency	Freight rate
1967	293	271	8.2%	13.88
1968	340	313	8.7%	12.47
1969	416	385	8.1%	11.37
1970	496	461	7.6%	18.81
1971	452	393	15.0%	8.47
1972	478	414	15.5%	6.25
1973	498	447	11.4%	19.19
1974	565	508	11.2%	20.87
1975	613	506	21.2%	7.40
1976	551	471	16.9%	6.63
1977	551	439	25.4%	5.81
1978	446	344	29.6%	6.43
1979	581	444	31.0%	10.97

Table II: Demand inefficiency in coal trades 1967-79

Similarly when freight rates are very low, it does not really matter where the imports come from. Then the cost of planning the transportation exceeds the potential savings in the transportation bill.

Figure 2 illustrates the relationship between the measure of inefficiency and the deflated freight rate.

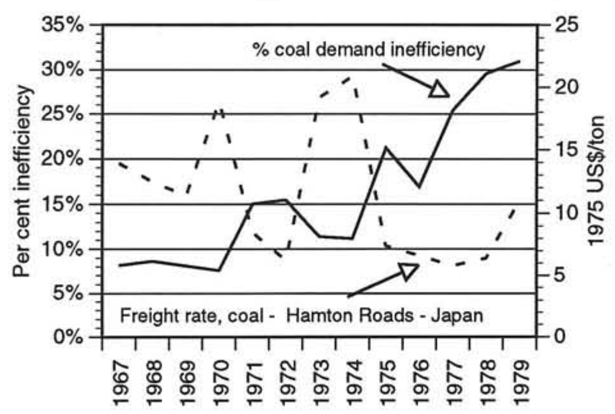


Figure 2: Relationship between demand inefficiency and freight rate

Table A: Actual trade pattern in coal, 1979 - million tonnes

From/to	Europe	South America	Japan	Total exports
Europe	32.8	1.3	1.1	35.2
USAC	23.1	4.6	10.9	38.6
Can-WC	0.0	0.0	13.9	13.9
Australia	9.3	0.1	27.0	36.4
Total imports	**65.2**	**6.0**	**52.9**	**124.1**

Table B: Theoretical. distance-minimising trade pattern, 1979 - million tonnes

From/to	Europe	South America	Japan	Total exports
Europe	35.2	0.0	0.0	35.2
USAC	30.0	6.0	2.6	38.6
Can-WC	0.0	0.0	13.9	13.9
Australia	0.0	0.0	36.4	36.4
Total imports	**65.2**	**6.0**	**52.9**	**124.1**

Table C: Average length of hauls

From/to	Europe	South America	Japan	
Europe	2000	6000	15000	
USAC	3500	4700	9500	
Can-WC	8900	8300	4500	
Australia	11700	7400	4200	

Table D: Actual trade pattern in coal, 1979 - billion tonne-miles

From/to	Europe	South America	Japan	Total exports
Europe	65.5	7.9	16.2	90
USAC	80.9	21.5	103.5	206
Can-WC	0.0	0.0	62.6	63
Australia	108.7	0.7	113.5	223
Total imports	**255**	**30**	**296**	**581**

Table D: Theoretical. distance-minimising trade pattern, 1979 - billion tonne-miles

From/to	Europe	South-Am	Japan	Total exports
Europe	70.3	0.0	0.0	70
USAC	105.1	28.1	24.6	158
Can-WC	0.0	0.0	62.6	63
Australia	0.0	0.0	153.0	153
Total imports	**175**	**28**	**240**	**444**

Source: Strandenes and Wergeland (1982)

Table III: Actual and hypothetical trade patterns in coal 1979

The relationship between the inefficiency and the freight rate can be estimated by a simple regression model. From the calculations it was concluded that in coal trades an elasticity of -0,4 is the order of magnitude between the inefficiency measure and the freight rate, i.e. if the freight rate doubles (+100%), the inefficiency is reduced by 40%. If this is translated into a tonne-mile demand elasticity, it corresponds to -0.06, i.e. if the coal freight rate increases by some 10%, demand will be reduced by -0.6.

Similar studies were made for iron ore and crude oil, and generally the same relationship seems to exist, although the order of magnitude is smaller for both iron ore and crude oil. The inefficiency elasticity was in both cases around -0.13, which corresponds to a tonne-mile demand elasticity with respect to the freight rate of about -0.03 for iron ore and as small as -0.005 for crude oil.

For crude oil, this result makes sense, as one would expect oil transport demand to be very inelastic. This is partly due to the fact that transportation costs constitute a small part of the CIF price, and partly because oil has a very low final price elasticity as well. In addition to this, the number of exporting areas for oil is fairly limited and the trade pattern is generally very efficient. In crude oil transport analyses one will have to assume that the demand for transportation is very inelastic with respect to the freight rate. This does not mean, however, that demand is fairly constant. This will be discussed later.

The general conclusion must be that for dry bulk commodities there is a significant elasticity of demand that affects the shape of the demand curve and will have an impact in market analyses. For crude oil, transport demand is very inelastic.

To see why the elasticity is important, **Figure 3** could be instructive. Assume that price P0 is the starting point at the intersection of supply curve S0 and the two demand curves. The horizontal demand curve is completely inelastic - demand remains unchanged whatever the freight rate. The other curve is a demand curve with constant elasticity and it has been drawn for an elasticity of -0.4. Assume that supply shifts to the left for some reason (scrapping of tonnage is one possibility). If one assumes an inelastic demand curve, the freight rate estimate of the shift in supply would be P2, but with an elastic demand curve it will only be P1. Similarly, if supply shifts to the right (because of new deliveries, perhaps), assuming an inelastic demand would give P4 as a forecast of freight rate, but with elastic demand P3 would be the result. Assuming inelastic demand is, therefore, the same as underestimating price increases and overestimating rate decreases. For dry bulk trades this demand effect should be taken into account.

9.4 The elasticity of bulk shipping supply

Supply of transportation capacity depends both on cargo capacity and how efficient this capacity could be used to cover the distances necessary to meet transport demand.

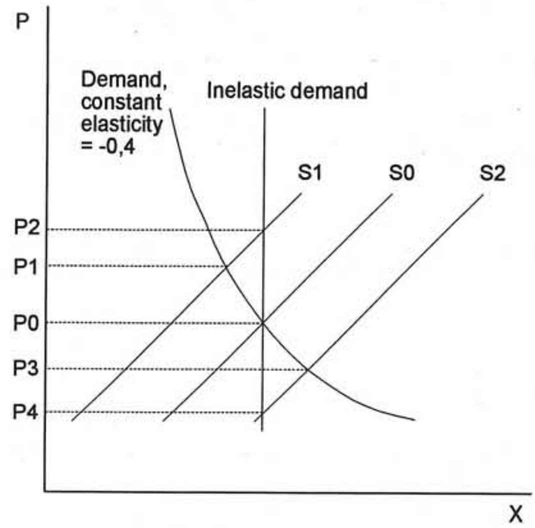


Figure 3: The effect of elastic demand

To show the various factors that influence supply, the following breakdown of tonne-miles per year could be instructive. The following symbols are used.

TM	=	Tonne-miles per year
D	=	Total available deadweight of cargo capacity
sh	=	Share of total fleet in lay-up or idle
L	=	Load factor, defined as total cargo tonne per dwt[1]
O	=	Months off hire per year, so (12-O) is the active trading months
S	=	Average speed in knots
B	=	Ballast factor, defined as the average number of miles in ballast relative to miles in loaded condition
W	=	Waiting days per trip inside and outside ports, including time for loading and unloading
T	=	Trips per month
M	=	Average length of haul, i.e. the average number of miles in loaded condition

[1]The deadweight is the total carrying capacity of a cargo ship. Some of this capacity must be used to carry the required fuel oil (bunkers) for the engines. For larger tankers a rule of thumb is that at least 2.5% of the total carrying capacity must be reserved for bunkers. The maximum L is therefore 0.975, but it could be much lower due to part loading and multi-porting.

The total supply TM can then be broken down as follows:

$$TM = D*(1-sh)*L*T*(12-O)*M$$

where the number of trips per month can be written as:

$$T = \frac{\text{Number of days per month}}{\text{Number of days per roundtrip}}$$

$$T = \frac{30.417}{\text{Number of days in port} + \text{Number of days at sea}} = \frac{30.417}{W + \frac{(1+B)*M}{24*S}}$$

where (1 + B)*M is the total miles per round-trip and 24*S is the number of nautical miles per day at speed S.

This means, however, that the fleet productivity, which is normally measured as tonne-miles per dwt, can be written as

$$\frac{TM}{DWT} = (1-sh)*L*T*(12-O)*M = \frac{(1-sh)*L*30.417*M*(12-O)}{W + \frac{(1+B)*M}{24*S}}$$

Instead of calculating the components in terms of trips per month and months actively trading, one could have calculated trips per year and used days per year off-hire instead. Let d be days off-hire per year (d = O*30.417), then an alternative expression for productivity is:

$$\frac{TM}{DWT} = \frac{(1-sh)*L*(365-d)*M}{W + \frac{(1+B)*M}{24*S}}$$

Fleet productivity is thus dependent on all the terms, L, W, B, M, S, O and sh, and the productivity will increase if[1]:

- The load factor goes up;
- The off-hire is reduced;
- The waiting days are reduced;
- The ballast factor decreases;
- The average length of haul increases;
- The speed increases

Fleet productivity is perhaps the most important term to understand shipping economics, but still it is interesting to see that in many analyses the term is assumed constant over time. This is clearly not the case, as **Figure 4** shows. Here the total number of tonne-miles for crude oil and oil products has been divided by

[1] Ceteris paribus

the deadweight of oil tankers plus an estimate of the deadweight of combination carriers that traded in oil[1] in the various years.

Unfortunately, good historical data do not exist for all the parameters of fleet productivity. It is also difficult to precisely specify the normal range of variation for the various factors.

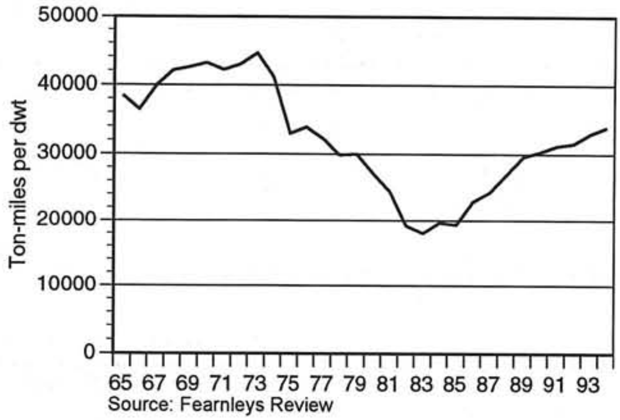


Figure 4: Tanker fleet productivity

In the following, an attempt has been made to discuss the nature of the various factors and a possible 'normal' range of variation.

9.4.1 Lay-up and storage

The share of the fleet in lay-up or storage can in principle become zero, and has historically varied a lot, but was never lower than 2-3% during the last twenty years. In recent years the share of tankers used for storage has been fairly stable around 4-5 million dwt, as can be seen from **Table IV**.

9.4.2 The load factor

The load factor can theoretically become as high as 0.975, but will in practice hardly ever be higher than 0.95, but may come as low as perhaps 0.65 if demand

[1]The estimate is based on the amount oil and dry bulk products carried, as this has been reported by Fearnleys Review over the years. This may impose a small inaccuracy, as it it would have been more appropriate to use the share of tonne-miles in oil and dry bulk, but such figures were not available for all years.

Year	Fleet	Lay-up	Storage	Total idle	% of fleet
1984	272.4	46.0	9.6	55.6	20.4%
1985	251.9	36.1	9.0	45.1	17.9%
1986	236.2	13.8	13.6	27.4	11.6%
1987	231.0	9.7	11.2	20.9	9.0%
1988	230.5	2.7	9.6	12.3	5.3%
1989	235.8	2.3	7.2	9.5	4.0%
1990	242.9	2.3	11.7	14.0	5.8%
1991	251.0	2.2	5.4	7.6	3.0%
1992	258.0	5.8	4.5	10.3	4.0%
1993	263.0	4.5	5.2	9.7	3.7%
1994	263.7	3.5	3.6	7.1	2.7%
1995	261.5	3.1	5.6	8.7	3.3%

unit: million dwt

Table IV: Tanker fleet in lay-up or storage 1984-1995

is very low and part loading and multi porting[1] are common phenomena. The load factor can also be affected by regulations, as e.g. the IMO requirement of segregated ballast tanks for all tankers. Older tankers will thus have to reserve some tank capacity just for ballast water and the load factor on average is reduced for these ships.

9.4.3 Off-hire

The number of months off-hire is a parameter that the shipowner to some extent can influence, as it is possible to reduce drydocking off-hire, by having a lot of repair and maintenance handled by sailing personnel. During a year of operation, a large tanker will on average be off-hire for a minimum of 10 days ($O=0.329$), but for an ageing fleet an average of more than a month, say 40 days, is not at all unrealistic, particularly in a poor market where the alternative cost of off-hire days is low.

9.4.4 Waiting days

The number of waiting days per round-trip is a parameter mainly determined by the conditions of the market, but a number of different factors can influence waiting times, such as strikes, war, weather conditions or port facilities. The waiting days as defined above, includes both port days as well as waiting days outside of port. It is fairly common in the large tanker market that an owner chooses to wait outside of a port area with a ship ready to load in the hope of an

[1]Multi-porting is a term used to describe a situation where a vessel is visiting several ports for loading of cargo. Even if the ship ends fully loaded, for part of the trip the loadfactor is less than maximum.

improvement of the freight market (speculative waiting) and this may have an effect on the market in certain periods. In some periods congestion problems in certain ports have had a significant impact on the market, and waiting times have been known to go up to months, rather than days.

Port days will mainly consist of loading and unloading times. A large tanker normally requires 2 full days of both loading and unloading, but it is rare that a ship can go straight to the point of loading or unloading. 5-6 days are, therefore, on average the minimum waiting days per round-trip. As for a maximum 'normal' range of variation, this is very difficult to assess, but it would be extreme if the number of waiting days per round-trip goes beyond 30 days on average.

9.4.5 Average length of haul and ballast factor

The time a ship spends in loaded and ballast condition is determined by the pattern of trade and is thus fundamentally a demand side aspect of shipping. By engaging in particular trades, the ballast factor may be affected. For large tankers on the Arabian Gulf - Western Europe trade it is common to use the Suez Canal when in ballast and go around the Cape of Good Hope when laden. The distance from Ras Tanura to Rotterdam is 11,170 nautical miles when going around the African continent, but only 6,350 when using the Suez Canal. In this case the ballast factor is 0.5685.

Combination carriers have the advantage that they can carry both dry bulk and liquid bulk. The economics of combination carrier operations is to a large extent a question of positioning the ship for backhaul cargo to minimise the ballast leg. The Norwegian shipping company Wilh. Wilhelmsen has purpose-built large combination carriers to carry iron ore from Brazil to Japan on a contract with the Brazilian company Docenave. On the return leg to Brazil, Wilh. Wilhelmsen e.g. has the right to let the *Docefjord*, with a deadweight of more than 310,000 tonnes, carry oil from the Arabian Gulf to South America, which makes this round-trip profitable.

In periods, Aframax tankers have been able to almost eliminate the ballast leg by carrying crude oil from the North Sea to the USA, picking up heavy fuel oil in Venezuela for the return trip to Europe.

In general, however, most bulk trades are shuttle business, where the carrier goes laden one way and in ballast on the same return leg. In such cases, the ballast factor is of course 1. For the large tanker market the number of ships using the Suez Canal in ballast is sufficient to make the average ballast factor less than 1. It is not very likely that the average ballast factor will be less than 0.8, which is the most efficient one can expect the tanker market to be. It will hardly ever be the case either that the ballast factor will exceed 1.

The average length of haul is determined from the demand side and is reflecting the variations in trading patterns. As seen in chapter 1, average trading distances have been varying a lot for tankers over the years. For the tanker market the average distance was about 4,300 miles in 1966 and as much as 7,200 in 1986, falling to 4,600 again in 1985 and is currently around 5,400 miles. These variations are mainly due to changes in the balance between OPEC and non-OPEC production as a reflection of changes in the oil prices, as discussed in chapter 1. It seems reasonable to assume a 'normal' range of variation for average length of hauls from 4,500 to 7,000 nautical miles for the whole tanker market. For the very large tankers, average length of hauls will be about 3,000 miles longer.

9.4.6 Speed

The speed of the vessel (S) is the one parameter that a shipowner can more or less control completely. In some contracts the loaded speed of a vessel may be specified, but generally speed is decided upon through optimisation. By varying the speed of the vessel, the cost of fuel will be affected. As a rule of thumb, the Admirality formula indicates that fuel consumption decreases approximately with the cube of the deviation from the design speed of the vessel. If S is actual speed, S' is design speed, C is actual fuel consumption and C' is design fuel consumption, the following estimate can be used[1]:

$$C = C' * (\frac{S}{S'})^3$$

or simply:

$$C = a * S^3, \text{ where } a = \frac{C'}{S'^3}$$

As an example, assume that a VLCC uses 165 tonnes of heavy fuel oil per day when the speed is 15 knots. If the formula is applicable, then:

$$165 = a * 15^3, \text{ so that } a = 0.0488889$$

Assume furthermore that the price of heavy fuel oil is 120 US$/tonne. The fuel costs and fuel cost saving of slow steaming at varying speeds is indicated in **Table V**.

This must be weighed against the loss of income that will occur because the ship spends more time on the round-trip. This loss is of course dependent on the actual (or expected) freight rate. **Table VI** calculates the alternative cost of time, i.e. the loss of income due to a longer trip for three different freight rate levels - 8,000, 24,000 and 45,000 US$/day and also the total nett gains from slow steaming.

[1] In Norman and Wergeland (1981) this parameter was estimated for large crude oil carriers, based on data from shipping companies for different ships. For diesel powered tankers the exponential coefficient was found to be close to 3 (2.87), but for turbine tankers, the coefficient was substantially lower and even lower than 2 - 1.81.

I	II	III	IV	V	VI	VII
Speed	Fuel consumption (tonnes)	Costs per day 120US$*II	Days used for 24,000 miles round-trip 24,000/(24*I)	Extra days relative to design speed	Round-trip fuel costs V*III (US$)	Cost savings relative to design speed (US$)
9	36	4,277	111	44	475,200	844,800
10	49	5,867	100	33	586,667	733,333
11	65	7,809	91	24	709,867	610,133
12	84	10,138	83	17	844,800	475,200
13	107	12,889	77	10	991,467	328,533
14	134	16,098	71	5	1149,867	170,133
15	165	19,800	67	0	1320,000	0

Table V: Cost savings from slowsteaming

VIII	IX	X	XI	XII	XIII	XIV
Speed (knots)	Loss of in-come at freight rate 8000US$/d 8000US$•V	Loss of in-come at freight rate 24000US$/d 24000US$•V	Loss of in-come at freight rate 45000US$/d 45000US$•V	Nett gains at freight rate 8000US$/d VII-IX	Nett gains at freight rate 24000US$/d VII-X	Nett gains at freight rate 45000US$/d VII-XI
9	355,556	1,066,667	2,000,000	489,244	-221,867	-1,155,200
10	266,667	800,000	1,500,000	466,667	-66,667	-766,667
11	193,939	581,818	1,090,909	416,194	28,315	-480,776
12	133,333	400,000	750,000	341,867	75,200	-274,800
13	82,051	246,154	461,538	246,482	82,379	-133,005
14	38,095	114,286	214,286	132,038	55,848	-44,152
15	0	0	0	0	0	0

Table VI: The cost of time and total savings from slowsteaming

As can be seen from this table, when freight rates are low, it is very economical to reduce the speed of the vessel. Actually, it would even have been beneficial to reduce the speed to less than 9 knots (the optimum speed is in this case 8.84 knots). In practice, this rarely happens, however. This is partly due to the fact that large vessels like VLCCs need at least 7-8 knots to have steering control, and partly because at low speeds the engine will start to foul. When freight rates are high, slow steaming is not an actual policy, simply because the alternative cost of time becomes too high. In such cases ships will go as fast as possible to get on to the next contract. This is the case in column XIV, where the nett gains of slow steaming are negative (the optimum speed would have been 15.66, which may not be obtainable). At intermediate freight rate intervals, the optimum speed is the one that balances the cost savings of burning less fuel against the alternative cost of time. The highest total savings in column XIII are for a speed of 13 knots. A more detailed analysis would give 12.7 knots as the optimum speed with a total nett savings of 84,000 US$.

It is obvious that the optimum speed for a specific ship depends both on the fuel price, which determines the order of magnitude of fuel cost savings, and the freight rate, which determines the order of magnitude of the alternative cost of time. If, in the example, the fuel price increased to 200 US$ per tonne, the optimum speed at freight rates of 45,000 US$/d would have been 13.2 knots and at freight rates of 24,000 US$/d it would have been 10.67 knots. In fact the optimum speed is dependent only on the *relative* relationship between the freight rate and the fuel price.

Speed optimisation of course depends on a number of other factors as well, like weather and sea conditions, wind, currents, hull fouling, etc., but the main principles still remains as previously described.

The 'normal' range of variation for the average speed of tankers would be 9-15.5 knots, downwards limited by the slowest advisable speed and upwards limited by the maximum service speed of the vessel.

9.4.7 Summary of productivity factors

By using the 'normal' ranges for all the productivity factors above, and dividing each range into 10 intervals, it is possible to construct a diagram as **Figure 5**, that partly shows the relative importance of the various factors and partly can be used to calculate the productivity of the total fleet, if individual estimates of the various factors can be obtained.

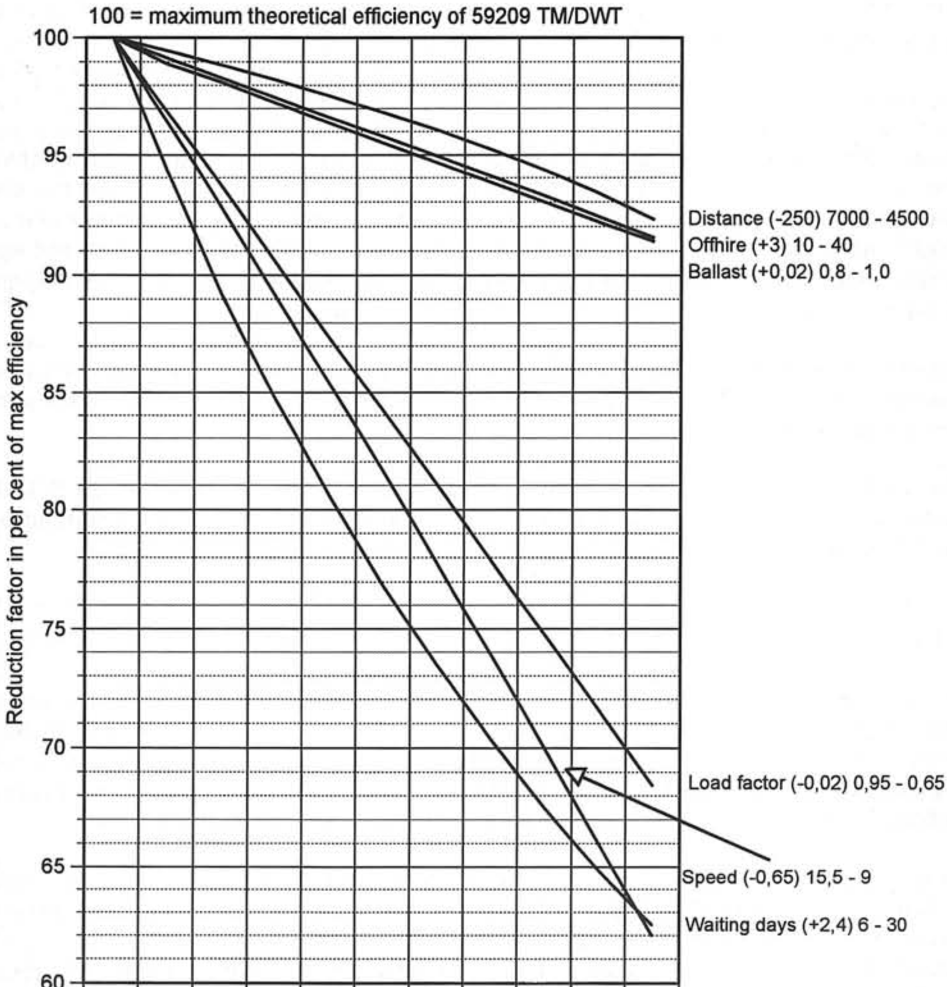
With given data for each of the six factors, the table below the graph can be used to find the interpolated values for each, then read off each corresponding curve a percentage factor. These factors are then multiplied by each other to get an overall adjustment factor, that finally is multiplied by the maximum theoretical efficiency of 59,209 TM/dwt.

An example might illustrate this, as it is a little elaborate.

In their large tracking study of VLCCs, Clarkson Research Studies Ltd. presented in 1993 very detailed data for the entire VLCC market for parts of 1991.

The average speed in the tracking period in 1991 was 11 knots, but the variations were substantial, ranging from 10 to 13.6 knots. 11 knots is close to the middle of the 7th interval for speed, and reading off the speed curve 74% is obtained.

The ballast factor can be estimated from the data of average days per vessel in ballast conditions (111.3 days) and loaded days (137 days). This gives a ballast



	0	1	2	3	4	5	6	7	8	9	10
Dist.	7000	6750	6500	6250	6000	5750	5500	5250	5000	4750	4500
Offhire	10	13	16	19	22	25	28	31	34	37	40
Ballast	0,80	0,82	0,84	0,86	0,88	0,90	0,92	0,94	0,96	0,98	1,00
Loadf.	0,95	0,93	0,89	0,86	0,83	0,80	0,77	0,74	0,71	0,68	0,65
Speed	15,5	14,85	14,2	13,55	12,9	12,25	11,6	10,95	10,3	9,65	9,0
Wait d.	6,0	8,4	10,8	13,2	15,6	18,0	20,4	22,8	25,2	27,6	30,0

For each interval 1-10 the "best" value is reduced by 1/10 of the range of variation

Figure 5: A summary of tanker fleet productivity factors

factor of 0.812, which is between interval 0 and 1. This gives a correction percentage for this factor of about 99%.

The average length of haul for the large tanker market exceeded the 'normal' maximum of 7,000 by about 1000 miles (8,037). This would give a correction factor over 100%. An ALH of 8,037 would imply a correction factor of 102%.

The load factor was not directly estimated in the Clarkson study, but 453 vessels were tracked, representing 124.5 million dwt. A total of 2,273 loaded calls were tracked, which is an average of 5 per ship. That should represent a total of 625 million potential tonnes for the tracking period, but only 76.5% of the total time tracked was engaged in actual trading. The 124.5 million dwt must, therefore, be reduced to 95.2 million dwt, so the relevant maximum number of tonnes is 478 million. Only 323 million tonnes of cargo were delivered, which gives a load factor as low as 0.676. In that case we are around interval 9 in **Figure 5**, which gives a correction factor of 71%. The low load factor is partly due to a very high level of multi-porting in Europe.

The remaining two factors, off-hire and waiting days are part of the non-trading days. The tracking study gives an account of all days not at sea, which is summarised in **Figure 6**.

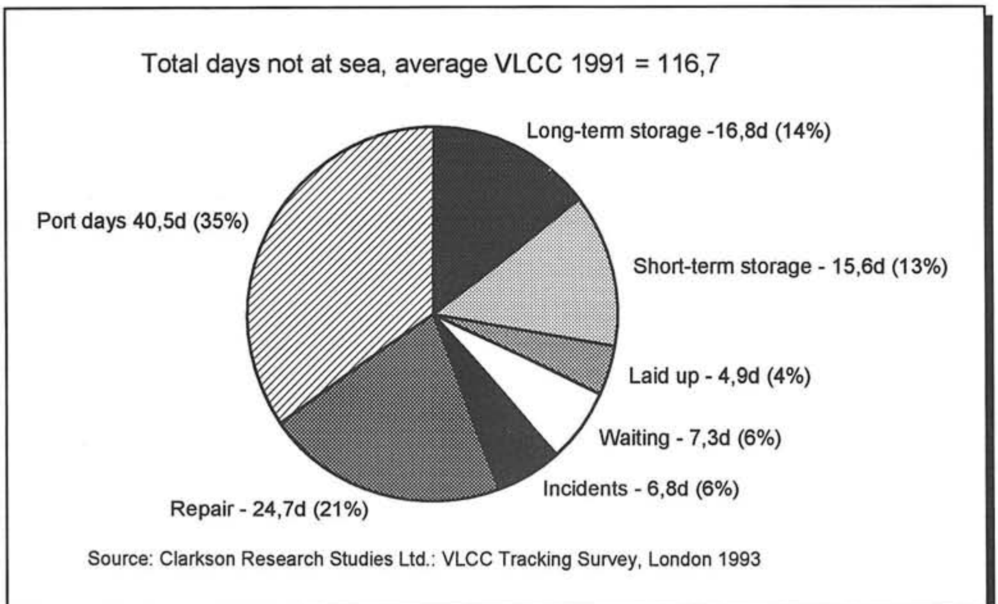


Figure 6: Days not at sea for an average VLCC 1991

When a ship is used for storage or is actively laid-up by the owner, the ships are not active in the market. In total 37.5 days were on average spent on this non-trading activity. This corresponds to 10% of a year, so the correction factor for lay-up is 90%.

The port days of 40.5 for a year corresponded to 1.9 days for loading, 2.9 days for discharging and 0.2 days for bunkering, i.e. a total of 5 days in port per trip. In addition comes 7.3 days of other waiting time, i.e. a total of 12.3 days waiting, which in **Figure 6** is between interval 2 and 3, so the correction factor for waiting days is about 86%.

Finally, days off-hire comprises the repair days and incidence days, which totalled 31.5 days in 1991. In **Figure 5** this is around interval 7, which gives a correction factor of 94% for off-hire.

In sum we get a calculation of productivity for this example as given in **Table VII**.

Factor	Correction
Load factor	71%
Speed	74%
Waiting days	86%
Distance	102%
Offhire	94%
Ballast	99%
Laid up	90%
Total	**38.6%**
TM/dwt	22,855

Table VII: VLCC productivity 1991

By multiplying all the 7 coefficients with each other, a total correction factor of 38.6% is given. This can be multiplied by the maximum productivity of 59,209 to arrive at an estimate of 22,855. This is fairly close to the estimate of Clarkson of 20,902 for the sampled tracked. The reason for the deviation is that the number of days non-trading used in the example were the full year estimate, while speed and load factor were based on the sample only. Clarkson estimated that the tracking sample corresponded to a full year estimate of 36,084 and from **Figure 4** we can see that the total tanker productivity for 1991 was about 32,000.

It is not very easy to measure the components of productivity precisely, but one should be aware of the fairly dramatic variations that exist in practice. Some components quite clearly vary directly with the freight rates. If freight rates go up, so does speed, and normally both the load factor will increase and waiting days go down, because high freight rates indicate a relative high demand. This should be taken into account when the tanker market is analysed, and one should always be suspicious to studies that assume a constant productivity factor for tankers.

Another obvious conclusion is that it is mainly load factor, speed and waiting days per trip that constitute the most important elements of fleet productivity.

9.5 Types of market models

There are several ways in which market models can be classified. One important distinction is between the comparative static[1] models on the one hand and the dynamic models on the other. A second distinction depends on the tools used for operationalisation of the model. One can use econometric methods to estimate relationships using time series data or one can construct models directly on the basis of microeconomic data. A third distinction is the way that models are solved. One can solve them analytically, by using mathematical expressions that allow a manual solution. One can use some form of computer algorithm for solving simultaneous systems, or one could use tools like a spreadsheet in combination with a user dialogue. The latter types of models cannot normally handle simultaneity problems because of their recursive nature.

A number of models exists both in research institutes and in private commercial companies. The models referred to below are just a sample of the many models available, and the choice is made primarily to explain the different types of models that exist, there are no value judgements in this at all.

Recursive, spreadsheet-like models with econometric relations

The BDSS system (Bulk Decision Support System) provided by Marsoft has a number of users world wide. The same is true for the models of Maritime Strategies Ltd., which has developed large econometrical models with a lot of detailed modelling of trade flows and fleet productivity. The models are very empirical of nature, with little or no economic theory built into the models. They are large in structure with a lot of parameters that users can change, which makes it complex to make consistent scenarios, as it is easy to forget that if you change some parameters, others should be adjusted as well. For experienced analysts with a good overview and practical insight into the shipping markets, the models can be good support tools.

Theory-based models with econometrically estimated relations

A static version is the NORBULK[2] model from the Centre for International Economics and Shipping in Bergen from 1979. This is a model attempting to combine aggregation with estimation to make a fairly simple, but useful tool in understanding the dry bulk market. The main advantage of the model is its simplicity

[1] This term is used for models that do not have a specific time dimension, but where the model gives a 'snapshot' of the market situation at one specific point in time.

[2] This is described in Wergeland (1981).

and the fact that it calculates an equilibrium freight rate based on elastic demand and supply curves.

A dynamic model is the City University econometric model of the world dry cargo and tanker markets[1]. This is a much larger model system that in addition to the freight market also analyses newbuilding, secondhand and demolition markets for total dry bulk trades, for the VLCC segment and for medium size tankers. The main advantage of the model is the formal theories on which it is based. This makes it easier to understand what is going on within the model. The main two disadvantages are that the results of the model depend on the relevance of historically estimated equations and the underlying hypothesis of perfect rational expectations.

Theory-based models, constructed from microeconomic data

There are three models worth mentioning, all developed at the Centre for International Economics and Shipping.

The first model was NORTANK[2] from 1981, which is a model for large tankers only. This is a model that can be solved analytically, based on a detailed description of the economics of large tanker supply. The main advantage is that the model is not dependent on estimated relations. The main disadvantage is a very simplistic treatment of oil the tanker demand.

The second model is NORSHIP from 1986, which is a model inspired by NORTANK on the supply side and NORBULK on the demand side. It is a model system for both dry bulk carriers and tankers, with an explicit modelling of the combination carriers. The model solves the simultaneous equilibrium in freight markets, secondhand markets, newbuilding markets and demolition markets. Although the model can be used to solve a sequence of years, it is not truly intertemporal. The main advantage of the model is that it clearly demonstrates the interdependency of the various shipping markets. The main disadvantage is that for dynamic simulations, the user must specify a number of exogenous parameters, which is difficult without risking logical inconsistencies.

The third model is a tanker model without a specific name[3], developed as a long term, truly intertemporal and stochastic dynamic model of the tanker market. The model is designed to calculate theoretically correct prices for the various markets (spot, secondhand, newbuilding and demolition) given an underlying hypothesis of rational investors, but with an explicit treatment of uncertainty. The main advantage of the model is the way that uncertainty is brought into the theory of

[1]This model is described in Vergottis (1990), but the theory behind is described in detail in Beenstock (1985). and Beenstock and Vergottis (1989).

[2]This is described in Norman and Wergeland (1981).

[3]It is described in Lensberg and Rasmussen (1992).

investment behaviour. The main disadvantage is the complexity in running the model, which makes it cumbersome to make scenarios.

The more simplistic of the non-commercial models described above, NORTANK and NORBULK, will be described in detail below. The purpose is twofold: partly to show how one can go from the general framework as described above to a concrete market model, secondly, through some examples, to show how models can be used to better understand how shipping markets work.

For the more complex models, readers are referred to the references in the chapter notes.

9.5.1 NORTANK - constructing supply from micro data

The breakdown of tonne-miles per year, as previously given, can be used to construct a partial equilibrium model of the tanker market. The model described below was constructed in 1981 and will be explained using the data from the original version (Norman and Wergeland, 1981). At the end of the section the model will be applied to the 1994 situation.

The same notation is used as in section 9.4, but the equations are now written with a subscript *i* to denote individual ships (or representative ship types). The supply of transport work from a ship of type *i* can be written (assuming that the ship is not laid up):

$$TM_i = D_i * L_i * T_i * (12-0_i) * M_i$$

Where:

- TM_i = Supply in tonne-miles per year from ship type i
- D_i = Total deadweight of ship type i
- L_i = Load factor (cargo tonne per dwt) for ship type i
- T_i = Number of trips per month for ship type i
- O_i = Months off-hire for ship type i
- M_i = Average length of haul for ship type i

The number of trips per month is defined as in section 9.4:

$$T = \frac{30.417}{W_i + \frac{2*M_i}{24*S_i}}$$

Where:

- W_i = Number of waiting days per trip for ship type i
- S_i = Average speed for ship type i

It is assumed that the vessel sails in ballast 50% of the time, so that the ballast factor B = 1. Therefore the factor (1+B) * M = 2*M.

The optimum speed problem involves balancing costs savings for fuel against loss of income by reducing speed. The income must be measured as the TC-equivalent of the spot rate. This is done as indicated in chapter 8. The following symbols are used.

P = Freight rate in US$ per tonne carried
Q = Price of heavy fuel in US$ per tonne
H = Port charges and canal fees in US$ per dwt per month
BP_i = Consumption of fuel in port - tonnes per dwt per day
$B_i(S_i)$ = Consumption of fuel at sea - tonnes per dwt per day
V_i = Voyage result for ship type i in US$ per dwt
R_i = Time charter equivalent of P

The voyage result is:

$$V_i = P*L_i - H - Q*BP_i*W_i - Q*B_i(S_i)*\frac{2*M_i}{24*S_i}$$

The TC-equivalent is the voyage result multiplied by the number of trips per month:

$$R_i = V_i*T_i$$

As long as R exceeds the variable operating costs, the ship will trade and the optimum speed is the speed which maximises R.

In practise, there are many routes and many different types of ships, so calculating optimal speed for all routes is cumbersome. It can be argued, however, using the notion of equilibrium, that in an equilibrium situation the optimum speed must be independent on the specific route. This is because, if the maximum TC-equivalent is higher on one route, ships will be directed towards this route and the rate will decrease there and increase in other routes. Eventually, in equilibrium, the TC-equivalent must be the same for all routes. If the TC-equivalent is identical, it follows that optimum speed also is identical for all routes. It is, therefore, possible to use one representative route to calculate optimum speed.

There are two expressions in the equation that represent a problem if one wishes to obtain a solution for optimum speed in closed form. First the function $B_i(S_i)$ needs to be solved. The denominator in the expression of T_i is a problem, because it contains both W and S and there is no way W can be eliminated in a simple manner. Both functions can be approximated by functions of the following type, however:

$$B_i(S_1) \approx k * S_i^{\beta}$$

$$T_i \approx A(W_i) * S_i^{\mu(W_i)}$$

The coefficients A and μ can be estimated for a given value of W_i, but since the waiting days will vary a lot over time, A and μ must be adjusted accordingly. This is done in the model by a special subroutine that selects that approximation which is consistent with W. **Table VIII** shows the values for A and μ for 4 values of W. The approximation is a very good one, with an adjusted R^2 of 0.99998.

W	A(W)	μ(W)
6	0.9280	0.0362
10	0.8856	0.0384
15	0.8377	0.0409
20	0.7949	0.0432

Table VIII: Coefficients for the trips per month function

For the fuel consumption function, four representative ships were chosen and data were collected from Norwegian shipping companies as to the fuel consumption for various speeds. Again the approximation gave a very good fit to the data. **Table IX** summarises some of the ship type specific data used in the original version of NORTANK.

	250.000 TT	280.000 MT	280.000 TT	405.000 TT
Size range in '000 dwt	200-250	200-300	250-300	300+
% of 1979 fleet	31.7%	7%	39.5%	21.8%
Parameter k * 10^{-6}	3.86785	0.21488	3.76041	3.65297
Parameter ß	1.81	2.87	1.85	1.78
Relevant speed range	9-16	10-16	10-15.75	10-16
Variable operating costs US$/dwt/month	0.45	0.40	0.40	0.25

Table IX: Data for representative ships in NORTANK

The optimum speed can be found by substituting the approximated functions into the TC-equivalent expression. To further simplify the problem, one representative trade will be used, i.e. Ras Tanura - Rotterdam via Cape, which is a distance of 11,169 miles and a round-trip is twice this distance. It will further be assumed that the waiting days per trip are the same for all four ship types. The TC-equivalent can now be written

$$R_i = A(W)*[P*L_i-H*Q*BP_i*W)*S_i^{\mu(W)}-Q*k*S_i^{\beta}*\frac{2*M}{24*S_i}*S_i^{\mu(W_i)}]$$

$$R_i = A(W)*[P*L_i-H*Q*BP_i*W)*S_i^{\mu(W)}-Q*B*S_i^{(\mu(W)+\beta-1)}]$$

Where:

$$B = k*\frac{M}{12} = k*\frac{11,169}{12}$$

Optimum speed is found by maximising R_i and this requires that the first order derivative of R_i with respect to S_i must be 0. In addition we must remember that the ships have minimum and maximum speed restrictions as indicated in table II. If we now let

$$P_i' = P*L_i-H-Q*BP_i*W_i$$

then optimum speed S_i' is found by

S_i' = S_i min for $G'(W) < S_i$ min
$G'(W)$ for intermediate values of S_i
S_i max for $G'(W) > S_i$ max,

where:

$$G'(W) = G(W)*(\frac{P'}{Q})^{\omega}$$

$$\omega = \frac{1}{\beta-1}$$

$$G(W) = [\frac{\mu(W)}{\mu(W)+\beta-1}]^{\omega}$$

The procedure is then to calculate G'(W) and check if minimum or maximum speed limits apply. This value for optimum speed is then substituted into the formula for the TC-equivalent. If the TC-equivalent is greater than the variable cost, the ship will trade at speed S_i', otherwise it will be laid up.

Let now E_i be a vessel activity variable, defined as

E = 1 if the TC-equivalent is greater than variable cost
0 if the TC-equivalent is less than variable cost

If, for simplicity, it is assumed that the load factor, the days off-hire and the average trading distance is the same for the various ship types, market supply can be found by summarising the individual ship type supplies:

$$TM = L*(12-O)*M*\Sigma(D_i*E_i*T_i)$$

In 1979, the large tanker fleet constituted some 184 million dwt. The fuel price in that year was around US$ 200. With an estimate of port costs and bunker costs while waiting of about US$ 1.25 per tonne carried, and assuming that the overall load factor was 0.95, the number of months off-hire was 1 and the average trading distance 7,000 nautical miles. The 1979 supply curve for the large tanker market would look like **Figure 7.**

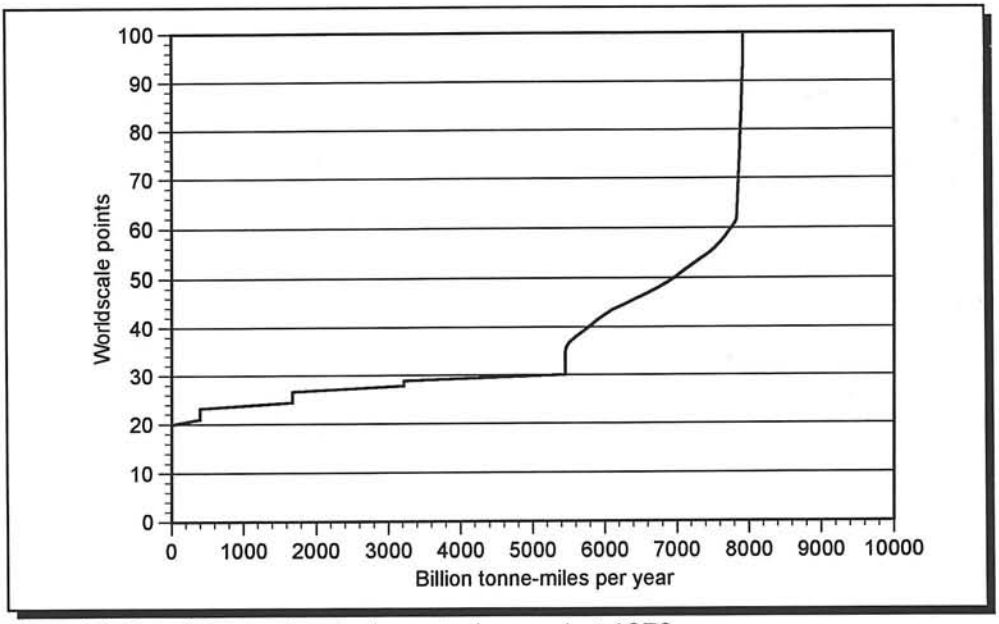


Figure 7: Supply curve for the large tanker market 1979

The reference freight rate used is the spot rate for the trip Ras Tanura - Rotterdam measured by Worldscale, which for that year had a reference point of WS 100 = US$ 27.33.

The lay-up level of WS 20 is determined by the ship type with the lowest variable costs. The step-wise and elastic part of the curve from 0 to around 5,500 billion TM, reflects differences in variable costs and the dwt of each ship type. At the point where all ships are trading, the supply curve becomes inelastic (WS30-WS37), reflecting that ships are trading at minimum speed. If no lower limit to speed had been specified, the curve would have looked much smoother at this point. The fairly elastic segment from WS37 to WS60 reflects that all ship types are increasing speed from the minimum up to the point where all ships are sailing as fast as they can.

The demand side of NORTANK is rather simplistic, and can for all practical purposes be regarded as exogenous to the model. The demand level for large tankers was in 1979 estimated on 6,100 billion TM, so the total demand/supply picture would look like **Figure 8**.

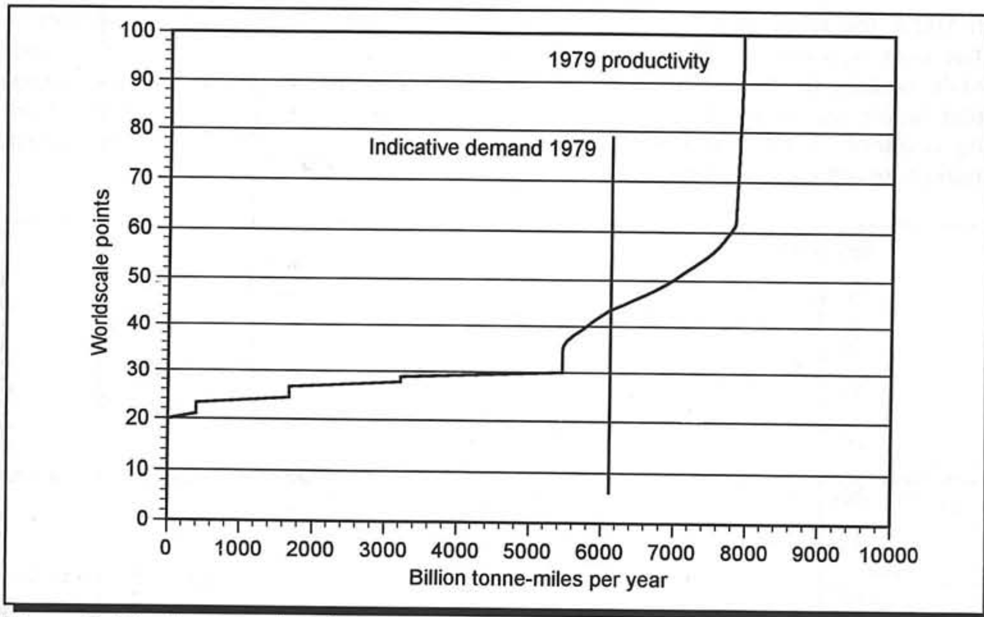


Figure 8: The large tanker demand and supply 1979

The equilibrium freight rate was WS 43.5, or US$ 11.89. *"Fearnleys Review"* reported an average freight rate for 1979 of WS 47, so the simulation seems to be consistent with this.

The supply curve in NORTANK is static, and a number of parameters affects how the curve looks like. When the market level changes, so will the efficiency parameters as argued previously. NORTANK must, therefore, be used with caution and insight.

There is one variable that has a particularly dramatic impact on the supply curve for large tankers and that is the bunker price. Consider the 1979 situation again, but instead of a bunker price of US$ 200, three alternative bunker prices are simulated: US$ 50, US$ 150 and US$ 250. This is illustrated in **Figure 9**.

When bunker prices get very low, the phenomenon of slow steaming disappears, simply because the cost savings of slowing down become very small. If a ship is sailing, it will do so with full speed. This causes the freight market to be in one of two conditions: A low freight rate may reflect the reservation price level for lay-up for the marginally poorest ship, or a freight rate may reflect being close to the capacity limit. The latter case will normally lead to highly fluctuating freight rates,

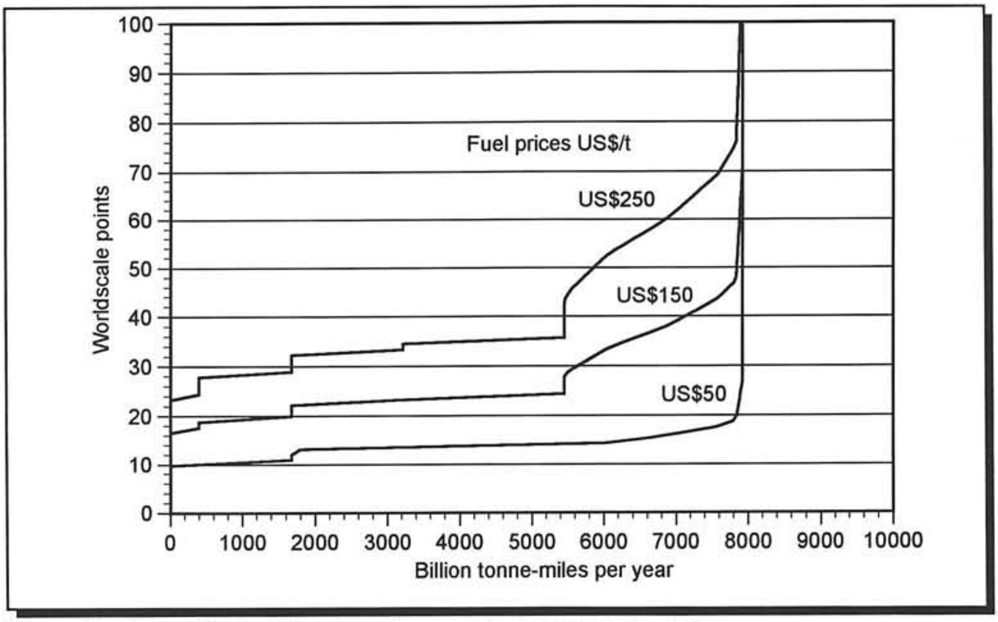


Figure 9: The effect of bunker prices on large tanker supply

where the high levels can become very high, indeed, because both demand and supply will be almost inelastic at this point.

The higher the oil price becomes, the more elastic will the supply curve be. Since higher oil prices affect the variable costs of shipping, the reservation price for lay-up will increase. This does not necessarily mean that TC-equivalents will increase, but that may very well be the case, as the effect of a higher oil price is to make the supply curve much more elastic and thus responsive to the freight rate.

To illustrate this point the development from 1985 to 1986 is used. In 1985 the crude oil price was around 27-28 US$, with a corresponding fuel price of about US$ 180. In 1986 the oil price dropped to a level close to US$ 10 and the bunker price was around US$ 48. In the shipping markets at that time, many 'experts' indicated that with the lower price level for oil, oil demand would increase and this would be very good news for shipping.

The VLCC fleet was 131.5 million dwt in 1985, and decreased to 114.3 million dwt in 1986. This should also have a positive effect on the large tanker market. Total oil demand rose from 871 million tonnes in 1985 to 957.8 million tonnes in 1986 - an increase of about 10%. The number of tonne-miles increased even more, almost 16% from a total level of 4,007 billion TM in 1985 to 4,640 in 1986. The VLCC fleet carried about 35% of all oil shipments in 1985, and increased this share to about 36% in 1986. With slightly longer hauls in 1986 compared to 1985, the total VLCC demand increased from a level of about 1,900 to about 2,200 billion TM. Without further analysis, this should imply market improvements for large tankers. *"Fearnleys Review"* reports a WS26 situation in 1985 and a WS29 in 1986, so in nominal terms no improvement at all.

A simulation, using NORTANK can illuminate why. Assuming a poor productivity in 1985 with a load factor of around 0.85, almost 18 days waiting per trip (much of it speculative) and an average distance of 6,400 nm together with the previous estimates on fleet and fuel price, give the supply curve as indicated in **Figure 10.**

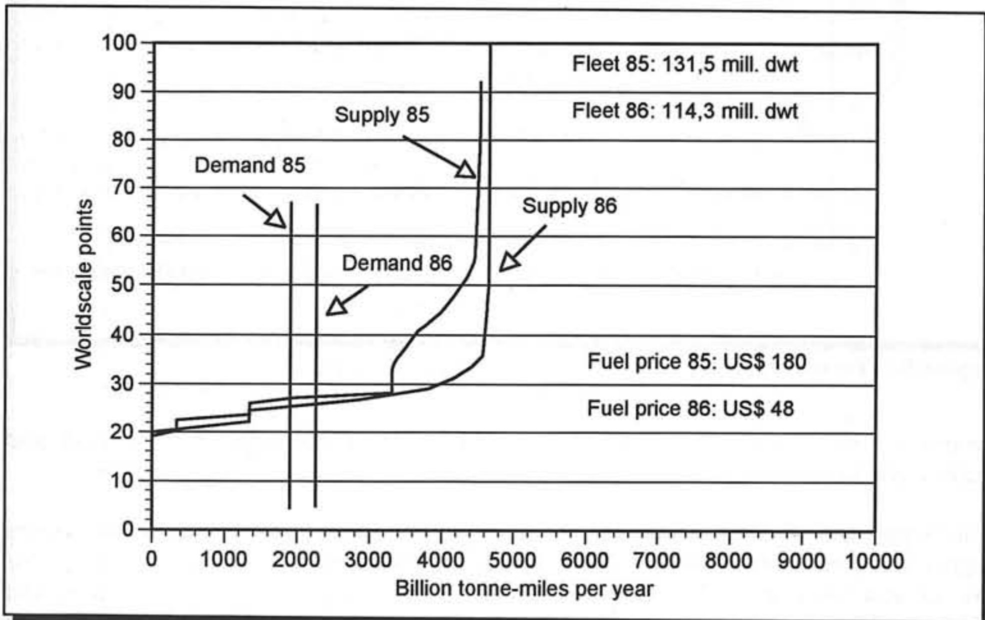


Figure 10: The effect of the oil price drop 1985-86 for the large tanker market

Although the fleet was reduced from 1985 to 1986, supply did not shift inwards, simply because some of the other productivity parameters improved due to the higher demand. The load factor increased to some 0.88 and waiting days per trip were reduced to some 12-13 days per trip. The falling oil price removes all elasticity in the supply curve and despite the increased demand, nominal freight rates do not improve. Looking at TC-equivalents for the ULCC, the level in the NORTANK simulations was around US$ 8,300 per day in 1985 and this actually decreased to US$ 7,500 in 1986, basically due to a revision in the WS100 basis downwards to reflect lower fuel costs.

The figure also illustrates a very basic fact for the 1985 situation. The demand level, even at the poor productivity of 1985, was far away from a level that would give a decent TC rate (around WS 40). Actually, demand was required to shift some 90% to achieve this. After the oil price reduction, demand needed to shift more than 100% to get close to a freight level where money is earned (and this even after the actual 20% increase). This shift would probably not even be enough, as productivity improvement would have shifted the supply curve even further to the right, if such an unlikely situation had happened.

It is, therefore, quite essential to have a good understanding of the supply side of the large tanker market in order to assess how various developments can affect this complicated market.

In 1995, freight markets for large tankers on average showed some improvement and again many analysts indicated that we now very soon will have a booming tanker market. This may well happen, as the underlying demand growth is fairly good, the oil prices fairly stable and the supply side is slowly shrinking. Again NORTANK may give some insight into the market situation.

In **Figure 11** an attempt has been made to visualise the 1994 market situation in the large tanker market. The fleet was 121.6 million dwt, the fuel price fluctuated around US$ 75, so the supply curve looked something like the one in the figure marked with 1994 productivity.

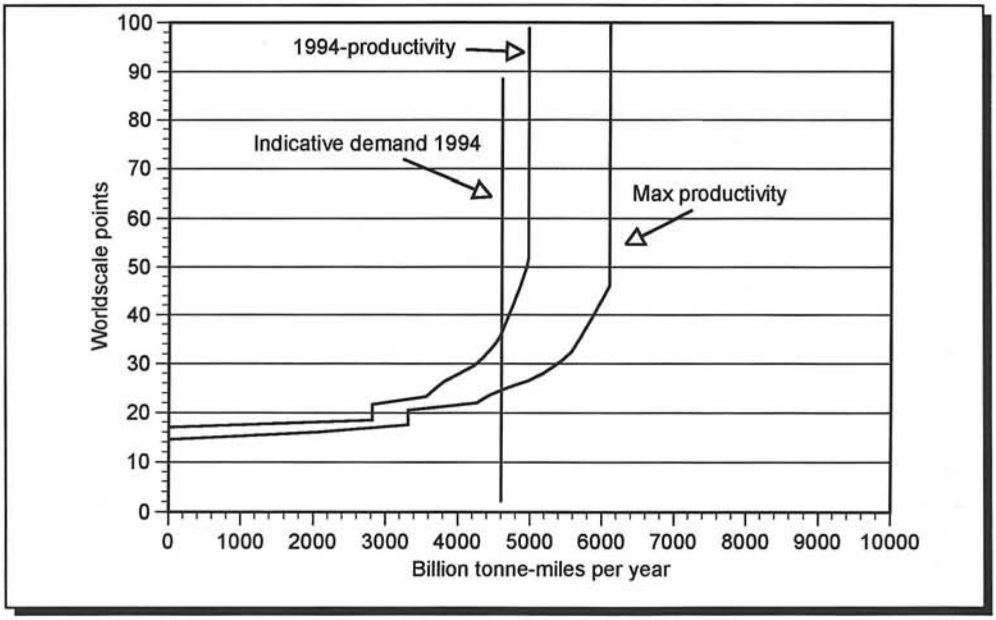


Figure 11: An indicative status in the 1994 large tanker market

The shape of the curve has changed somewhat to reflect the fact that almost 50% of the fleet today consist of motor tankers. Total oil shipments in 1994 amounted to some 1,403 million tonnes, of which the large tankers had a share of 44%, or some 617 million tonnes. The large tankers had a share of tonne-miles somewhat higher than that, so the demand level for large tankers must be something like 4,600 billion tonne-miles, as indicated, with a freight rate level of WS

36-38. This seems fairly consistent with *"Fearnleys Review"* reporting WS 39 for 1994. As indicated, this equilibrium is very close to the short term supply maximum. This may partly explain why there has been a clear lift in the large tanker market in 1995 and 1996. Again many analysts conclude that the market soon is in 'balance' and again it could be instructive to emphasise the main message in this section: Large tanker supply is affected by a number of elements influencing total productivity. The other curve indicated in **Figure 11** estimates the maximum productivity possible if the total dwt are kept constant. As can be seen, the maximum carrying capacity is at a level of demand about 30% above current demand. In the current market situation, where one is getting close to short term capacity, is a situation where one should expect temporary price increases, maybe even substantial increases. Traditionally, high spot rates immediately sets off new orders for newbuildings. If that happens again, the good market may be very temporary, indeed and the large tanker market will again be depressed for a long time.

9.5.2 NORBULK - the power of aggregation

As discussed in chapter 1, the dry bulk markets are quite closely correlated with the general economic development. To avoid the many problems of analysing each and every dry bulk commodity in detail, the idea behind NORBULK is to use aggregated relationships. It is known from economic modelling that it is generally easier to model an aggregated variable (i.e. GDP) than the components that this variable consists of.

The structure of NORBULK is given in **Figure 12**. General economic development has been divided in two components: One variable that captures the general trend of economic activity and one variable that focuses on the deviations from the trend. These two variables together determine total demand for dry bulk commodities, measured in tonnes. A separate relation translates tonnes into TM. On the supply side, the total fleet is an indication of the total potential carrying capacity and the fuel price is used as a main determinant for speed, which is the main productivity factor for dry bulk transportation.
The four grey boxes in **Figure 12** indicate that the variables are exogenous to the model. The most central aspect of NORBULK is the feedback mechanism between the spot rate (d) and demand and supply (e).

To quantify the model, all equations are written in multiplicative form. This has the advantage that all estimated parameters can be given the interpretation of elasticities. A main problem was how to handle the lay-up situation, as no simple mathematical function can represent a supply schedule of the nature described in section 9.5.1, where the supply curve is first zero, then completely elastic, then completely inelastic, then elastic and eventually completely inelastic once more. In NORBULK the simple solution was to combine two curves - an elastic curve with constant elasticity along the curve and an infinitely elastic curve - a straight line to indicate the lay-up level. This is illustrated in **Figure 13**, where the bold line is the supply curve actually used.

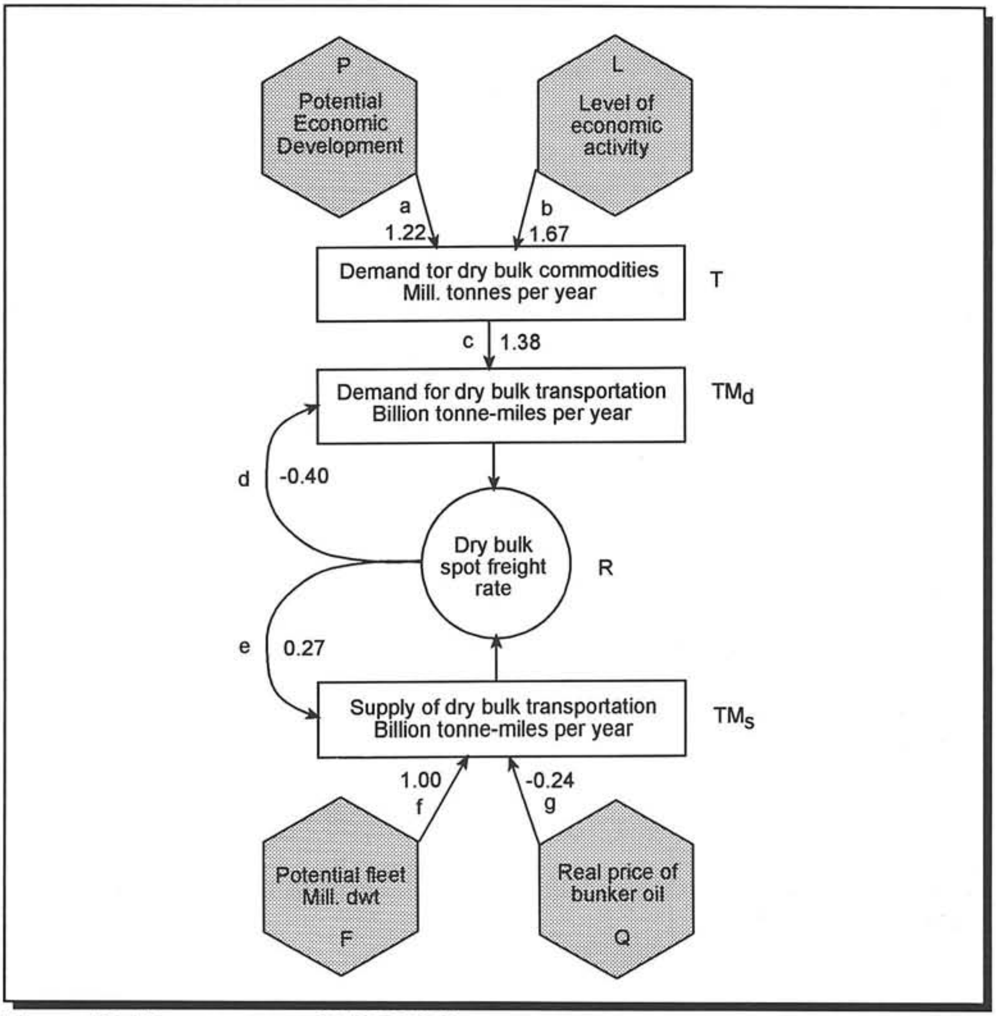


Figure 12: The structure of NORBULK

The model can simply be specified as follows, using the notation from **Figure 12.**

$$T_1 = P^a * L^b$$

$$TM_d = C_2 * T^c * R^d = c_3 * P^{ac} * L^{ac} * R^d$$

$$TM_s = c_4 * F^f * Q^g * R^e$$

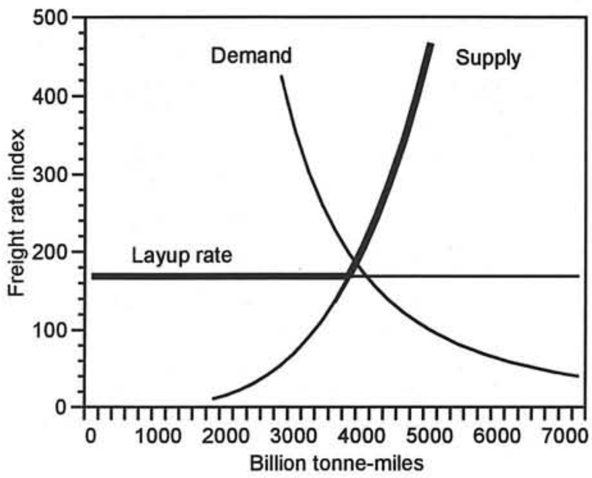


Figure 13: Demand and supply curves in NORBULK

Since this is an equilibrium model, demand must be equal to supply, so the equilibrium is characterised by:

$$c_3 * P^{ac} * L^{ac} * R^{d} = c_4 * F^{f} * Q^{g} * R^{e}$$

which can be solved for R as a function of the four exogenous variables:

$$R = c_5 * F^{\frac{f}{d-e}} * Q^{\frac{g}{d-e}} * P^{\frac{-ac}{d-e}} * L^{\frac{-bc}{d-e}}$$

where new constants have just been added without concern for the interrelations among them.

To get an operational model, the seven parameters a up to and including g must be estimated. There are several ways in which that can be done. One possibility is to estimate directly the last equation where the model is on reduced form. Another possibility is to estimate separately the structural relations as given before. Since the equations are dependent on each other, ordinary least squares methods cannot be used directly. It is beyond the scope of this section to discuss the econometrical details, but one fundamental problem should be emphasised. The estimation of the supply curve is an estimation of the smooth looking curve in **Figure 12**. What can be observed in reality is the intersection of demand and supply. One should, therefore, try to avoid using data where the equilibrium is characterised by a lot of lay-up (as it would be if the demand curve intersects supply to the left of the kinked point on the supply curve). This was one of the reasons why data for 1965-1974 were chosen for the estimation. Another reason for limiting the estimations to only a subset of the data (this was performed in 1980) was that then one had unused data available, which could be used for the testing of the simulation performance of the model outside of the estimation period. This is something which is rarely done when constructing models.

The variables were operationalised using the following data sources:

The freight rate is measured as the former Norwegian Shipping News' (now called Shipping News International) dry bulk index. The fleet was measured as the average total dry bulk fleet including tonnage of combination carriers trading in dry bulk as measured by Fearnleys. The trade data both in tonnes and TM were taken from Fearnleys World Bulk Trades. The fuel price was measured as the average fuel price in eight different ports, deflated by a general OECD price index. The main problem was to find good data candidates for the potential economic development and the level of economic activity. The best data set was a trend variable for the OECD GDP development for the variable P and an index of the activity in the OECD iron and steel industry as an approximation of L.

It was impossible to get one, unambiguous, set of estimates for the seven relations in the model, which was consistent both with a priory information and only one set of estimation techniques. The resulting set of parameters must, therefore, be seen as a reasonable compromise among many possibilities. The model was finally set up with the following elasticities:

a = 1.22, which indicates that for each per cent the GDP trend is increasing, the demand for dry bulk commodities in tonnes, will increase by 1.22%

b = 1.67, which says that for each per cent the iron and steel production changes, the demand for dry bulk commodities changes 1.67%, i.e. the trade in dry bulk commodities is quite sensitive to changes in industrial production.

c = 1.38, which says that for each per cent the trade in tonnes increases, the demand for transportation increases by 1.38%. This is mainly a reflection of the fact that in the estimation period (and long after) the average length of haul in dry bulk trades has steadily increased.

d = -0.4, which says that for each per cent that the freight rate increases, demand will go down by 0.4%. This is consistent with the discussion above on the elasticity of demand.

e = 0.27, which says that for each per cent the freight rate increases, the supply will increase by 0.27%

f = 1.0, which says that if the fleet increases, then supply will increase proportionally.

g = -0.24, which says that if the fuel price goes up by one per cent, supply will go down by 0.24%. This elasticity should be in the order of magnitude of the inverse of the supply elasticity e, as it previously has been argued that optimum speed depends on the relative relation of freight rates and fuel prices.

The model has been estimated and tested on the yearly changes in each of the exogenous variables. The potential economic development - P - changed by a constant 2.56% in the testing period, and is not shown in the table below. The other variables changed fairly dramatically during the test period, which originally was from 1974-78, but which has been prolonged to 1981 in a later stage.

Table X summarises the tests, showing the percentage change in each variable, the simulated freight rate, the actual rate and the deviation from the actual rate. The simulated freight rate in 1973 was 230.

	Level of economic activity	Total deadweight	Fuel price	Simulated rate	Actual rate	Difference
1974	2.5%	19.2%	140.0%	310.9	300.8	3.4%
1975	-16.9%	11.9%	-12.3%	165.0	171.4	-3.7%
1976	7.1%	9.2%	2.9%	180.9	175.4	3.1%
1977	-1.9%	8.5%	4.6%	170.3	164.4	3.6%
1978	4.9%	8.3%	-16.9%	185.8	194.9	-4.6%
1979	4.6%	4.6%	57.4%	277.3	276.0	5.0%
1980	-7.8%	5.0%	16.6%	230.5	381.5	-39.6%
1981	-2.0%	6.1%	2.7%	222.2	333.7	-33.4%

Table X: The simulation performance of NORBULK

For the whole period 1974-79, the model seems able to simulate the freight rate development remarkably well. Both the direction of the changes as well as the level of the rates are close to the mark. In 1980 and 1981 this seems to have changed completely. The model simulates a decrease in freight rates from 1979 to 1980, but the actual development is a dramatic increase in freight rates.

This development is usual for models. Models can work reasonably well for a time, then all of a sudden they do not seem to work anymore. This can be due to at least two main factors: Either the models simply do not capture important pieces of reality any longer, because of structural changes in the market, or some unexpected, often short-lived, event influences the market in a way the model has not been designed to capture.

The case of the dry bulk market in 1980 is actually a good case, which may give insight both into how the market works and the relationship between a market model and the marketplace.

NORBULK is an aggregated model, basing its prediction on a fairly stable, long term relationship between economic activity and the demand for raw materials on the one hand, and the fleet and the fleet utilisation on the other. The model operates on yearly data, which means that short term phenomena are simply ignored.

In 1979, the oil price increased almost 60% in real terms. This set off a series of reactions the world had never experienced before. Oil was now so expensive that Japanese steel mills and producers of electricity decided to switch from oil to energy coal. This led to a fairly dramatic substitution away from oil towards coal. For 1979 the demand for coal rose by some impressive 25%. Almost the only place that had spare capacity to meet such an increase in demand, was the USA - more precisely Hampton Roads on the East Cost. The result was a steady stream of coal carriers trying to get loaded in Hampton Roads. Soon this created a serious congestion problem. In fact, for large parts of 1979 and 1980, ships could be waiting for months before they got their cargo. Much of the dry bulk fleet ended up being idle, instead of trading. This had the same effect on the market as if the ships had gone into lay-up.

Figure 14 shows the situation in the dry bulk market in 1978.

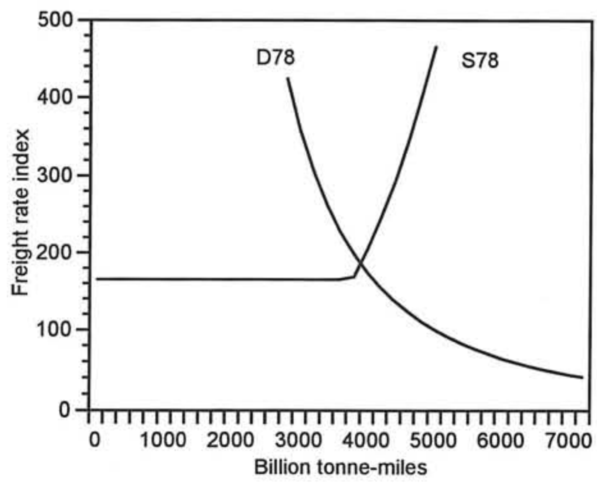


Figure 14: The market balance in dry bulk 1978

The world demand for dry bulk services in 1978 was around 3,800 billion tonne-miles and the freight rate level was 195.

Compared to the 1978 situation **Figure 15** shows the NORBULK simulation of the 1980 market. Both demand and supply have shifted outwards to a new equilibrium, with volumes going up to 4,600 billion tonne-miles and a corresponding freight rate of 230.

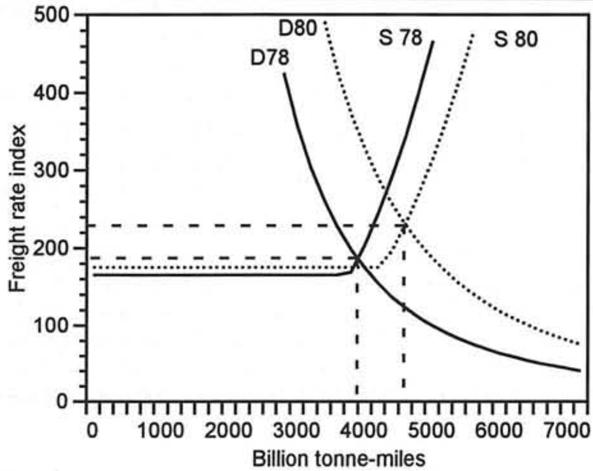


Figure 15: NORBULK simaltio nof the 1980 dry bulk market

This equilibrium reflects the long term relationship between general economic development and demand for raw materials and a normal utilisation of the existing fleet. The simple structure of NORBULK obviously cannot be expected to capture short term phenomena like massive congestion in a port. Neither can one blame a model based on historical data for not capturing new relationships between economic development and demand for raw materials, like the substitution effect of extreme oil prices, which was a new phenomenon at the time. It is possible, however, to use NORBULK to simulate such developments. The congestion problem is simply a matter of shifting the supply to the left by the percentage amount that corresponds to the amount of deadweight being idle. Similarly the extra demand for energy coal is simply a matter of shifting the demand curve further to the right. The result is shown in **Figure 16**.

The adjusted equilibrium can indeed reflect the actual 1980 situation, with the same volume in tonne-miles, but with freight rates up to 380, just like the actual situation.

What happened in the 1980 situation was a massive ordering of new vessels, mainly Panamax vessels. Dry bulk orders for 1980 totalled 18.7 million dwt, or 13.6% of the total fleet at the beginning of that year. In 1981 another 15.6 million dwt were contracted. When these ships came onto the market in 1982-83, things had started to normalise. Congestion was history, so were coal volumes, which were 13 million tonnes lower in 1983 than in 1981. **Figure 17** shows the 1982 situation compared to the special 1980 situation.

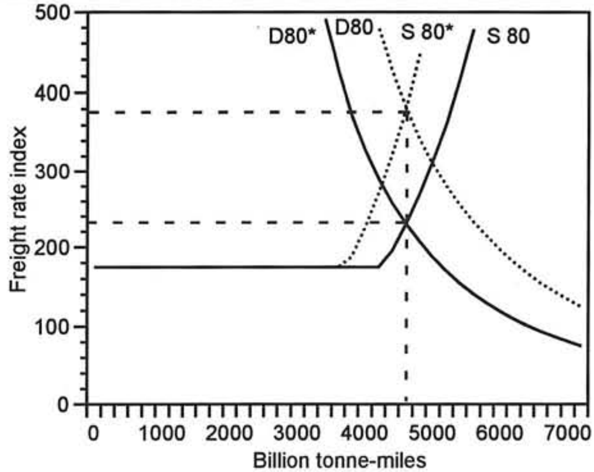


Figure 16: Adjustments for congestion and coal substitution

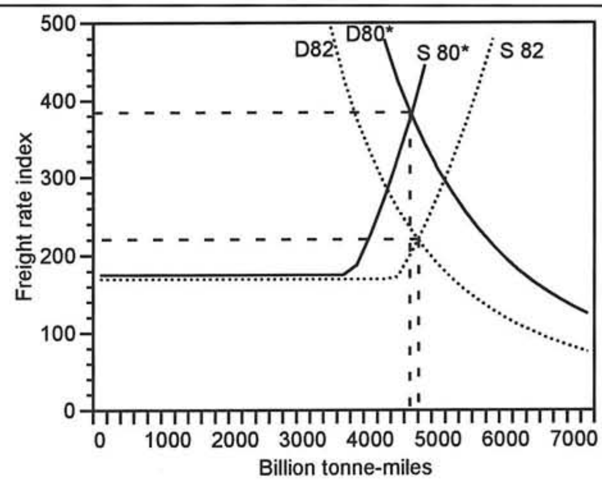


Figure 17: The 1982 market situation for dry bulk

Supply had again shifted to the right, partly because of the removal of congestion, partly because of the new deliveries. Demand is back to normal, reflecting the long term relationship with the general economic activity, and although total demand increased from 4,600 to 4,700 billion tonne-miles, freight rates are down from 380 to 220, a freight rate level where the newbuildings of the 1980 boom could not make profits.

The simulations of NORBULK for 1980 and 1981 as given in **Table X** were not accurate descriptions of the actual market situations, but they reflected the longer term relationships in the market. This demonstrates a very general problem when practitioners are trying to use forecasting models: Much too often the models become a substitute for own reasoning. One of the advantages of models like NORBULK is the simplicity. Anyone familiar with a spreadsheet program could make a version of NORBULK as it is a model with one single equation for the freight rate. The model should, however, be used with caution and one should always consider whether there are elements of reality that the model has not taken into account and then adjust the simulations accordingly.

9.6 Analysing non-bulk markets: A liner shipping case

So far, the bulk markets have received all the attention when it comes to market analysis and modelling. The main reason for this is that because the bulk markets exhibit the characteristics of a pure competitive market - it is an area where economists have models that could easily be applied.

In the other sectors of shipping, where economies of scale are present, other types of models must be employed. They are by nature more complex, and they often require data and insight which are not available to outside observers.

Liner shipping is different from bulk shipping in many respects. A main difference lies in the very concept of shipping goods: Bulk ships go wherever they are needed for transport from A to B, then move somewhere else. Liner shipping is a commitment to give a regular service between A and B. By this commitment, the liner operator creates a business where almost all the costs are fixed costs. The ships are committed to go whether there is enough cargo to make it profitable or not. The running costs of the vessels, including the voyage dependant costs, are thus fixed costs. Furthermore, the liner operator must have shore facilities, like warehousing. The only truly variable cost element, is the cost for loading and unloading cargo. This is the main economic reason why liner shipping cannot function under pure competition. In pure competition we know that prices will be equal to marginal costs. The marginal costs for liner shipping are basically cargo handling costs. No liner company can exist if their large fixed costs are not covered in the long run, so prices in liner shipping must be higher than marginal costs.

The liner industry is organised in so-called conferences. A conference is simply a formal cooperation of liner operators, who come together to set the price structure for the particular trade. There are two main types of conferences

- Open conferences;
- Closed conferences.

An open conference is one where membership is not restricted, and a closed conference is one where membership is restricted. Open conferences are typically found on the liner services with the USA, because there the antitrust law specifically prohibit conferences of the closed type. In economic terminology, a closed conference is like a cartel.

The conference produces a tariff book, or the tariff schedule, where literally thousands of prices for various commodities are to be found, often grouped together in 10-30 classes of goods. In the USA such tariff schedules are made publicly available under statutory tariff filing requirements, but in most other places, the tariff schedules are not available to the general public.

Even if they were, they may not reflect actual transport costs. This is because liner shipping also is using a system of rebates. A liner operator will try to tie shippers to their service as much as possible. By offering rebates based on the volumes shipped, customer loyalty is encouraged under the implicit threat that if the shipper starts using another operator, rebates are cancelled. This system creates an efficient barrier to entry for those outside of the conference.

Liner tariffs are very complicated. There may be different tariffs related to different types of cargo movements:

- Port-to-port, or the so-called all water tariff;
- Port-to-point, rates from export port to an inland destination;
- Point-to-port, rates from inland origin to discharging port;
- Point-to-point, the single factor intermodal tariff.

Then follow the many parts of the tariff. In addition to the basic tariff, which is the ocean freight cost, several 'add-ons' are possible:

- Terminal handling charges;
- Container service charges;
- Heavy lift charges;
- A currency adjustment factor;
- Bunker adjustment factor;
- Port congestion surcharge.

The first conference was created in 1875 on the trade between UK and Calcutta, and by the early 1970s more than 360 conferences existed. Most main trade routes in the world are dominated by a conference and conference members control 80-90% of all freight on many routes. Still, there is room for non-conference operators, the so-called outsiders.

To better understand how liner shipping can be analysed, a case could be instructive. Assume that an established conference controls most of the trade between two ports. A new liner company, Evergreen[1], has just ordered six big container vessels and is introducing a new concept, The round-the-world-service, where they plan to sail on regular frequencies with their six ships around the world in a fixed pattern. By announcing the ports they plan to service, the conference learns that they plan to service ports that so far were controlled by the conference. The

[1]The Taiwan based company Evergreen pioneered the so-called round-the-world services, so the case has clear resemblancies to real world problems.

conference is suddenly confronted with serious outsider competition and must decide on a strategy how to meet this competition.

One possibility would be to invite Evergreen to be a member, but the company has already signalled that they prefer to be an outsider. Given that the conference and Evergreen will have to pursue their strategies independently, what are the options?

Basically, they both have two main options:

- Play aggressively, i.e. by competition try to get a market share as high as possible;
- Play defensively, i.e. try to keep the prices as high as possible, accepting the presence of the other.

This gives a matrix of possible strategy combinations as given in **Table XI.**

		The outsider	
		Aggressive	Defensive
The conference	A		
	D		

Table XI

This is thus a game with four possible outcomes. If it is possible to calculate the outcome of the four game situations, this could give information helpful in terms of deciding which strategy is the best. Economic theory may be useful in this case. A study of the four outcomes can indicate why.

If both play defensively, it means that they accept each other presence and try to maximise prices (or profit). This is a good description of the so-called Cournot solution to the duopoly problem. Cournot suggests that each player is maximising his profit, taking the volume of the competitor as a given parameter that will not change. A little formal notation is useful. In this section the following symbols are used.

X_o = volumes shipped by the outsider
X_c = volumes shipped by the conference
Π_o = profit for the outsider
Π_c = profit for the conference
$P(X_c+X_o)$ = average freight rate per unit shipped
$C_o(X_o)$ = total costs for the outsider
$C_c(X_c)$ = total costs for the conference

Both will try to maximise their profit:

$$\Pi_o = P(X_c+X_o)*X_o-C_o(X_o)$$

Maximum profit is found by setting the first order derivative of the profit function equal to zero (the mark ´ is indicating the first order derivative)

$$\frac{\delta\Pi_o}{\delta X_o} = P*(C_c+X_o)+P'(X_c+X_o)*X_o-Cc'(X_c) = 0$$

The essence of the Cournot assumption is that when maximising his profit, the outsider will consider X_c as a constant, so the derivative P´ will only be dependent on the change in X_o. By solving this equation the outsider will find a solution for the optimum volume $X^\circ{}_o$, which is dependent on the actual value of X_c:

$$X^\circ{}_o = R_o(X_c)$$

The conference will do exactly the same and will also find an optimum which is dependent on the actual value for X_o:

$$X^\circ{}_c = R_c(X_o)$$

The functions $R_c(X_o)$ and $R_o(X_c)$ are called the reaction functions and an equilibrium is found when these reaction functions intersect.

The Cournot solution is based on a defensive attitude to competition - you just accept the presence of the competitor and makes the best of it.

If, however, you know the reaction function of your competitor, you may use this information to your advantage. This is known in the microeconomic theory as price leadership. One standard version of this is the Stackelberger price leader model. Assume that the conference takes on the role of price leader. Then the profit function looks like this:

$$\Pi_c = P*(X_c+R_o(X_c))*X_c-C_c(X_c)$$

The difference is now that the conference no longer assumes that the outsider will hold his volume constant, on the contrary, the conference utilises their knowledge of the outsider's reactions to conference volumes, so X_o is replaced by the reaction function $R_o(X_c)$. This solution will generally give lower prices, higher volumes and a larger market share for the price leader.

This is thus a situation where the conference is acting more aggressively and the outsider is a defensive (Cournot) follower. It could be the other way around, that the outsider is playing the tougher game and the conference is the defensive player.

Finally, one could have the obvious outcome if they both try to play aggressively, i.e. both try to be price leaders at the same time. That leads to what is called a

Stackelberger warfare situation. We can thus summarise the game outcomes like in **Table XII.**

The outsider

The conference		Aggressive	Defensive
	A	Stackelberger warfare	Stackelberger price-leader
	D	Stackelberger price leader	Cournot solution

Table XII

It is possible to solve for these outcomes in practise, when information on demand and on the cost structure of the players is available. The case is a good example of how more complex economic theories can find applications in shipping.

Game theory is becoming more and more used for strategic analyses in shipping, but it is beyond the scope of this book to cover this rather complicated area.

9.7 Estimating the formation of expections in TC- and secondhand markets

In chapter 8 it was indicated that expectations in shipping are of the so-called semi-rational type. This section presents some empirical evidence to support this. Semi-rational expectations means that the market agents have some notion of where the long term equilibrium should be, and this, together the with the current state of the market, form their expectations.

This is well known in the banking sector, where the notion of term structure of interest rates is widely used. This is illustrated in **Figure 18**. The agents are assumed to have a fairly consensus view on where the long term level of the interest rate will be. If the current interest rate is much lower than this long term equilibrium, a term structure of interest rates for papers with different remaining time to maturity will result, as indicated with curve A. Papers with long remaining time to maturity will be priced higher than short papers. The opposite situation occurs when the current interest rate is much higher than the expected long term rate. Because everyone expects the rate to fall in the longer run, the papers with longer time to maturity will be priced lower, as indicated by curve B.

The same phenomenon can be seen in shipping markets. Sometimes a three-year time charter may be priced higher than a six-months charter, sometimes it is the other way around.

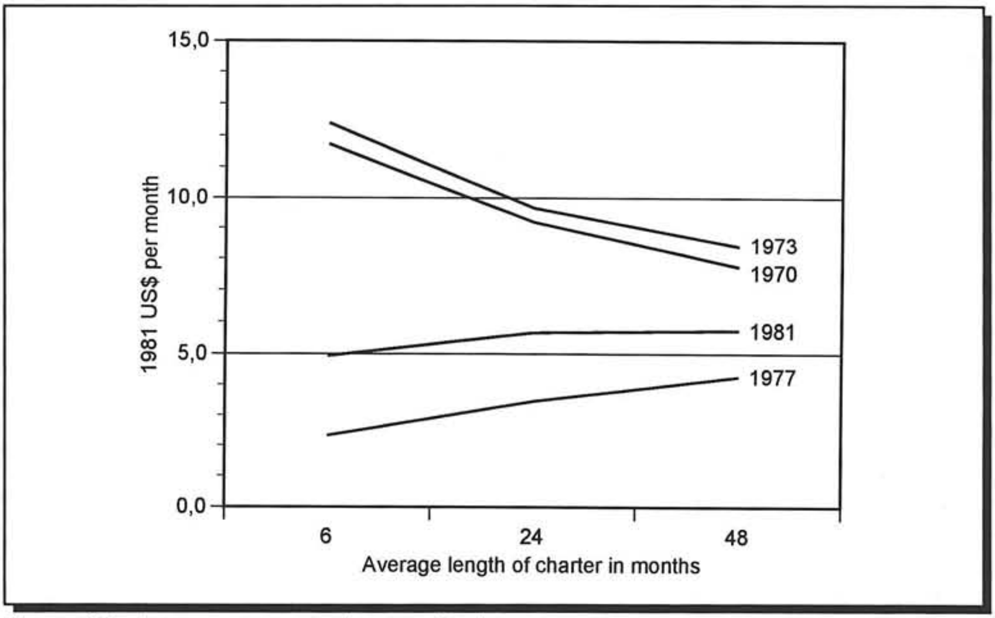


Figure 18: A term structure theory of prices

Figure 19 shows the situation for four selected years in the Panamax bulk carrier market. In the boom years of 1979 and 1973, longer charters were priced lower than shorter charters, but in the depressed markets of 1977 and 1981, the opposite was the case.

To test if this underlying theory of how expectations are formed is generally valid, a hypothesis can be formulated and checked against market data. Let the following variables be defined as:

TC_T = Time charter rate for charter of T months duration
S = Spot freight rate (as TC-equivalent)
L = Long term equilibrium spot freight rate (as TC-equivalent)
T = Average duration of time charter in months

We can now write the time charter rates as a function of the short term spot rate and the long term equilibrium rate.

$$TC_T = (a*S + b*L)$$

where:
a, b = Parameters measuring the importance of each of the freight rates.

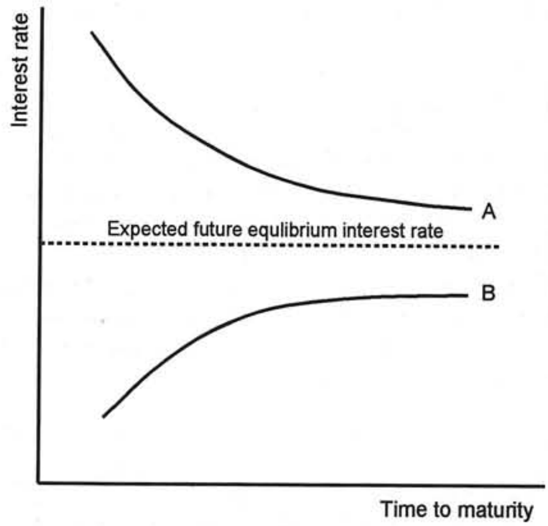


Figure 19: Term structure of time charter rates for Panamax bulk carriers

When uncertainty is not accounted for, (a+b) must be 1, as the TC-rates in that case can be written as an exact linear combination of S and L. It is, however, quite unrealistic to assume no uncertainty, so the relation might be rewritten as:

$$TC_T = p(T) * (a*S + b*L)$$

where:

p(T) = A market risk factor that increases with T.

If the semi-rational expectation theory of a term structure for time charter rates is valid, then the following hypotheses must be true:

- a decreases in value as T increases;
- b increases in value as T increases;
- (a+b) decreases in value as T increases (simply because p(T) is assumed to increase with T).

To test the above equation, relevant data must be found. It is fairly simple to find data for TC_T and for spot rates. It is not as straightforward to calculate the time charter equivalent for all spot rates, as this requires that a representative trade route can be found. This is fairly easy for tankers, as Middle East is a dominating trading route. For dry bulk vessels the trading pattern varies over time and thus the ballast factor also may vary substantially. In the period 1967-1979 the ballast share of the loaded leg varied between 0.58 and 0.80, with an average of 0.71.

As the variation of the ballast share seems to be fairly stochastic over time, the average of 0.71 was used[1] for an average dry bulk trade route.

The long term equilibrium freight rate is another problem. As future rates cannot be observed, some substitute data had to be found. In long term equilibrium under perfect competition, no super profit exists, so the marginal producer will only earn a 'normal' profit. By calculating the required freight rate on time charter terms that gives a 5 per cent nett real rate of return by buying a new vessel, a data series close to what one would expect to get under perfect competition is found. To calculate this, one basically needs the newbuilding price. This seems to be a good candidate for a long term freight rate expectation. Any shipowner in the world will calculate the required freight rate for a new investment, and newbuilding prices are well-known. It is reasonable to believe that there is consensus about this variable in the market place.

The results from the estimation of the parameters a and b is given in **Table XIII.**

Time charter rate	a	b	(a+b)	R^2
Panamax market 1968-81				
0-12 months TC rates	0.56	0.38	0.94	0.93
12-36 months TC rates	0.31	0.54	0.85	0.80
over 36 months TC rates	0.16	0.43	0.59	0.71
Medium size tankers 1969-81				
0-12 months TC rates	0.60	0.44*	1.04	0.51
12-36 months TC rates	0.47	0.51	0.98	0.73
over 36 months TC rates	0.26	0.70	0.96	0.77
Large tankers 1970-80				
0-12 months TC rates	0.71	0.31*	1.02	0.92
12-36 months TC rates	0.53	0.41	0.94	0.87
over 36 months TC rates	0.21	0.68	0.89	0.71

* The estimated parameter is not significantly different from 0 with 97.5% probability

Source: Strandenes (1984)

Table XIII: Estimate of term structure coefficients for time charter markets

Except for in one case, the Panamax long term time charter, where the coefficient b is 0.43, which is lower than for 12-36 months charter, all the results are consistent with the hypotheses specified above. The two non-significant parameters causes (a+b) to exceed 1, which does not make much sense. The average R^2 is

[1]This introduces a bias in estimates achieved with the OLS (Ordinary Least Squares) method. To counteract this problem a two-stage least square's method was used. See Strandenes (1984) for details.

as high as 0.77, or 0.81[1] if one excludes the only less satisfactory equation - the market for short TCs for medium sized tankers. The general conclusion is, therefore, that the hypothesis of a term structure for time charter freight rates that reflects semi-rational expectations, has a lot of empirical support.

If the assumption of semi-rational expectations holds for TC-markets, it should also be valid for secondhand prices. In the equation above, a weighted sum of current earnings and future expected earnings could be seen as an average future expected earning. The value of a ship would in a perfect market simply be the net discounted value of future earnings:

$$VN = \Sigma \frac{C_1}{(1+r)} + \frac{C_2}{(1+r)^2} + \frac{C_3}{(1+r)^3} + ... + \frac{C_N}{(1+r)^N}$$

where:

VN = The value
C_i = The nett cash flows in each period i = 1..N
r = An appropriate discount factor
N = The number of expected years of trading

Instead of assuming a finite number of years, one could let N go to infinity and instead include the real rate of depreciation in the discount factor. Let d be the depreciation rate. By replacing the individual cash flows C_i by an average expected earning per year, called E, the value of the ship could be written:

$$VN = E * \Sigma \frac{C_1}{(1 + (r+d)} + \frac{C_2}{(1 + (r+d)^2} + \frac{C_3}{(1 + (r+d))^3} + ...$$

but the sum of an infinite geometrical progression is simply 1/(r+d), so the value could be written simply as:

$$VN = \frac{E}{(r+d)}$$

The expected earnings can be written as a weighted sum of current earnings and future expected long term earnings:

$$E = (k * (S-C) + (1-k) * (L-C)) * 350$$

where:

S = The TC-equivalent of the spot rate in US\$/day
L = The expected future equilibrium TC-equivalent
C = Expected operational costs in US\$/day
The weighted average of S - C and L - C is the expected nett cash flows per day

[1]The R^2 measures how much of the variation in the dependent variable that can be explained by the estimated model.

By multiplying this by 350 (assuming 15 days off hire), This can be substituted in the formula for NV. The value VN is still, however, the value of a new ship. By using the real depreciation factor to correct for the ship's age, a general formula for the value V of any ship regardless of age can be written as:

$$V = e^{-d(t-b)} * (k * (S-C) + (1-k) * (L-C)) * \frac{350}{(r+d)}$$

where:

t = The year of the transaction and b is the building year of the ship

The age correction factor will for various values of d and (t - b) be as indicated in **Table XIV**.

	Real depreciation rate		
Age of ship (t-b)	0,05	0,075	0,1
5	0,78	0,69	0,61
10	0,61	0,47	0,37
15	0,47	0,32	0,22
20	0,37	0,22	0,14
25	0,29	0,15	0,08
30	0,22	0,11	0,05

Table XIV: The value of $e^{-d(t-b)}$ for various depreciation factors and ship ages

It is possible to obtain data for secondhand values of ships of a known age, and by assuming r = 0.05 and d = 0.075[1], one can rewrite the equation to become

$$V * e^{-d(t-b)} * \frac{(r+d)}{350} = k * (S-C) + (1-k) * (L-C)$$

which has a form suitable for the estimation of the parameter k.

Table XV gives the result for the same three markets as above.

Again the regression results seem to give strong support towards a hypothesis that secondhand values are determined in a market where the agents have semi-rational expectations. It is also interesting to note the big difference between the large tanker market on the one hand and the two other markets on the other hand. In the large tanker market, the short term spot earnings will influence the

[1]A real depreciation rate of 7,5% was found by Eriksen and Norman (1973). Several tests were made using other values for d, but with poorer results.

Market	k	(1-k)	R^2
Panamax bulk carriers	0.23	0.77	0.87
Medium size tankers	0.23	0.77	0.79
Large tankers	0.66	0.34	0.98

Source: Strandenes (1984)

Table XV

secondhand values much stronger than for smaller vessels.

9.8 A note on the organisation of the tanker market

Sometimes it is argued that the volatile nature of tanker shipping and the fact that tanker shipping has been in a crisis situation for more than 20 years indicate that there is something wrong with the industry.

It can be argued that the opposite is true. The freight rate fluctuations can be seen as a sign of a market where the market mechanism is really functioning. As to the fact that oversupply and depressed markets seem to be the normal, could also be argued that this is as it should be. To see this latter point, assume a dictator is given the power to completely plan and control the entire tanker fleet. How large would then the fleet be?

This can be analysed formally. The following symbols are used.

k = Fleet of tankers
b = Cost of providing one unit of transportation extra
v = The value for the oil company of getting an extra transportation unite when capacity is scarce
P(k) = Probability of having too little capacity if the fleet is k

With these definitions, the planning problem is fairly trivial:

The optimum fleet k', must be so large that the value for the oil company of getting an extra unit of transportation capacity, weighted by the probability that this capacity should be scarce, is equal to the cost of getting this extra capacity:

$$P(k') * v = b$$

But this means that:

$$P(k') = \frac{b}{v}$$

The cost b must be equal to the break-even rates for newbuildings. How large the value v is, may be more difficult. It is at least equal to the value of one tonne of crude oil, which is several times as large as the transport cost. If capacity gets really scarce, the worst thing that can happen for an oil company is that the refinery must close down because of lack of raw materials for the production. This cost is many times as large as the value of the cargo.

It follows from this that v is many times as large as b, even at current newbuilding costs. Then it follows that the optimum fleet should be as large as to reflect the relative level of b vs. v.

If the tanker industry considered not from the point of view of shipowners, but from the transportation user, it is both rational and indeed optimal, having a tanker shipping business that most of the time has sufficient overcapacity to prevent a real scarcity situation.

CHAPTER 10: SHIP OPERATIONS

10.1 Tender procedures and shipbuilding contracts

What does a shipowner do when he wants to order a new ship? The standard tender procedure is schematically shown in **Figure 1**. First, the shipowner defines the outline specification of the vessel, which he sends to a relatively large number of potential yards. The selection of these yards depends on the specialty of each yard, some are renowned for VLCCs others for LNG, cruise ships or small ships. This initial long list of 10-15 yards will receive a fax with the outline specification and they may give the shipowner an indication of the newbuilding price and delivery date. On this basis the long list is reduced to a short list of realistic possibilities.

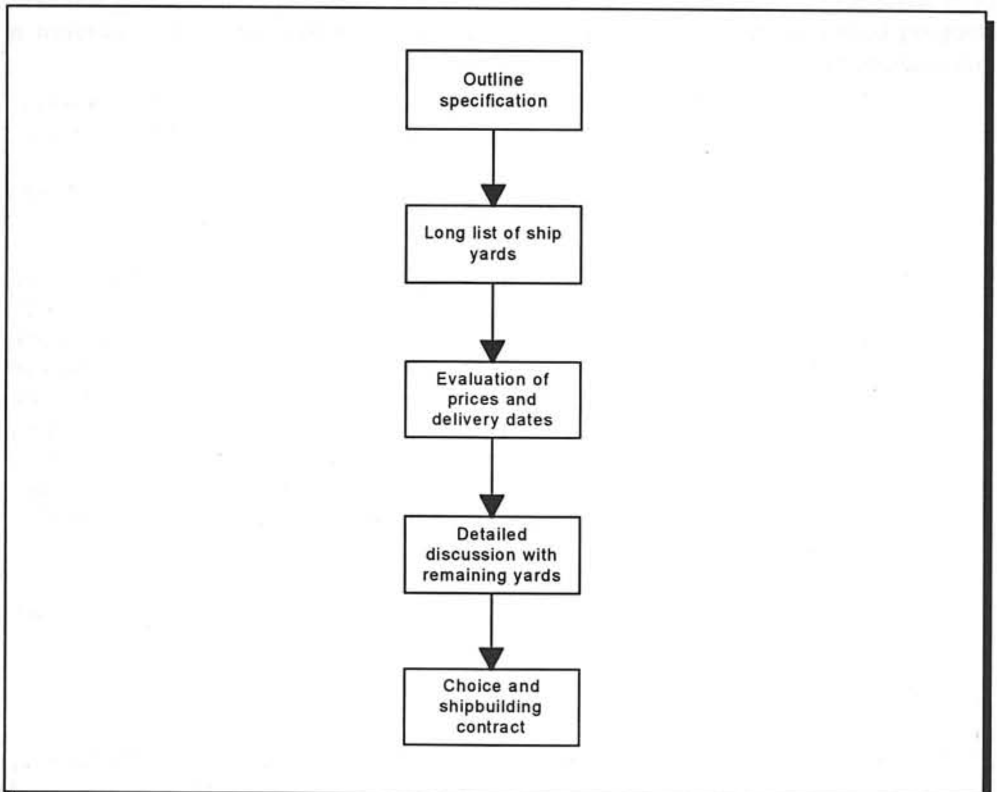


Figure 1: Standard tender procedure

The shipowner thus enters into a more detailed discussion, regarding the technical details of the yard's design, but also the payment schedule, guarantees, etc. In the end, two or three contenders remain and then the shipowner will try to squeeze the price of the yards further by playing the yards against each other. The final negotiations with the yard end in a shipbuilding contract.

This chapter contains an example of the outline specification for a 4,500 m^3 LPG carrier, defined by the Dutch shipping company Anthony Veder, which they circulated in November 1994 with international shipyards.
This section will be followed by with an overview of the main articles of a standard shipbuilding contract, as defined by the Association of West European Shipbuilders (AWES), which dates from 1972.

10.1.1 Anthony Veder - outline specification for an LPG carrier

This section shows an example of an outline specification for an LPG carrier.

0. General

0.1 General description

This outline specification concerns a single screw motor vessel, for worldwide navigation with engine room and accommodation situated aft, forecastle forward.

The ship is intended for the transport of liquefied gases with a maximum cargo density of 0.972 t/m^3, in independent type C - tanks.

The vessel shall comply with all relevant requirements of a gas carrier, 1983 amendments to the international convention SOLAS (Safety Of Life At Sea), 1974, Volume III, International Code for the construction and equipment of ships carrying liquefied gases in bulk, for a type IIG ship, for the carriage of Commercial Propane (Propane/Ethane Mixtures max 2.5 mol % Ethane at 1.0 bar), Butane (iso-/n-), Propane/Butane mixtures. Anhydrous Ammonia, Propylene, Butadiene, Butylene, VCM, C4 streams, C5, NGL, Propylene oxide, Isoprene Monomer, Acetaldehyde, Diethyl Ether, Dimethylamine, Isopropylamine, Monoethylamine, Vinyl Ethyl Ether, P.O./E.O. mix with max. 30% E.O., Ethylchloride/Methylchloride.

The vessel will be able to carry all the aforementioned products in quantities between zero and 98%.

The vessel to be constructed without sheer or camber.

The vessel to be arranged for a complement of 15 men crew. Separate cabin for pilot to be provided. One crew cabin to be arranged for two persons.

One main engine to be installed, driving a controllable pitch propeller via a reduction gearbox.

For electric power 2 diesel generator sets, each 100% power, and 1 shaft driven generator will be installed.
Shaft generator power to be sufficient for all sea requirements including cargo requirements.

0.2 Main characteristics

Main dimensions to be optimal within the following parameters:

- Cargo tank capacity — 4,500 m^3 (100%)
- Gross tonnage (Convention of London 1969) — below 4,000
- Endurance — 10,000 nautical miles
- No permanent ballast
- No ballast in fully loaded condition
- Maximum deadweight to include full cargo of VCM and 100% consumables.

0.3 Speed

The speed of the vessel under trial conditions will be such to ensure a service speed of not less than 15 knots with a full cargo of LPG (s.g. 0.58) and 50% consumables, with engaged shaft generator for electrical seaload plus 10%, including pressure maintenance for such full LPG cargo at sea, taking into account a service margin of 12% with main engine developing not more than 90% of its max. 12% with a main engine developing not more than 90% of its max. continuous rating and not more than ..... kW (Please indicate minimum kW required).

Speed trials/power measurements to be carried out by independent recognised specialists approved by Owners.

Calculation of service speed based on results of speed trials to be done by selected Model test Institute.

Reference conditions for trials:

- Wind force 2-3;
- Deep water;
- Clean hull;

0.4 Classification

The vessel shall be designed, built, equipped, outfitted and completed under the supervision of Bureau Veritas or equivalent in the Owners' option and shall be classed in the class:

B.V. + I 3/3 E Liquid Gas Tanker minus 48 Degrees Centigrade 9.3 bar gauge (alternative 13 bar gauge) Type II G Ice class IB AUT. MS. INERT or equivalent.

The vessel shall be designed, built, equipped, outfitted and completed in accordance with high quality shipbuilding practices/standards prevailing in Northwest Europe and from/with first class new materials, suitable for the intended purpose.

The arrangement of the vessel to be optimal with regard to cargo handling, manoeuvrability, course-stability, seaworthiness and comfort within the further design criteria.

0.5 Regulations

The vessel shall also be designed, built, equipped, outfitted and completed in compliance with the following rules, regulations and requirements and to the satisfaction and/or approval of the following authorities concerned:

a) The rules, regulations and requirements of the Shipping Inspection of the Netherlands (N.S.I.) and/or the Shipping Inspection of the Netherlands Antilles (S.I.N.A.), including 0+-man's watch-attendance (berth to berth);

b) The International Convention for the Safety of Life at Sea, 1960 + 1974 and Protocol of SOLAS 1978 plus amendments 1981 + 1983 and any other I.M.O. legislation in force on the date of contract signing;

c) International Load Line Convention, 1966 including 1971, 1975, 1979 and 1983 Amendments and Protocol of 1988 relating to the International Convention on load lines 1966;

d) International Telecommunication Convention 1973 and Radio Regulations 1974. Standard Specifications of the International Maritime Satellite Communication System for Ships and INMARSAT Regulations. GMDSS rules and requirements as per I.M.O. Resolution 665 to be included;

e) U.S.C.G. and I.M.O. stability criteria;

f) I.M.O. Resolution A 327 (IX), concerning fire safety requirements for cargo ships

g) International Convention for Prevention of Collision at Sea, 1972 and amendment, 1981

h) ISO 6954 *"Guidelines for the Evaluation of Vertical and Horizontal Vibration of Merchant Ships"* (Vibrations limited to half line of average band width)

i) Panama Canal Regulations/Authorities; inclusive tonnage measurements

j) Suez Canal Regulations/Authorities; inclusive tonnage measurements

k) International Convention for the prevention of Pollution from Ships 1973, including Protocol of 1978 as far as annex I, II, IV, V and VI are concerned.

The vessel moreover to comply with SOPEP regulation 26 entering into force 5th April 1995

l) The rules, regulations and requirements of the US Coast Guard; as required for vessels registered outside USA for ships transporting liquefied gases in bulk

m) IMO recommendations for sewage and transfer of oil in ports

n) International Conference Tonnage Measurement of Ships, 1969

o) The rules, regulations and requirements for the Kieler Canal

p) 1983 amendments to the International convention for the safety of life at sea, 1974, Volume III, International Code for the construction and equipment of ships carrying liquefied gases in bulk

q) The rules, regulations and requirements of the Port of Bordeaux Authorities

r) USA Public Health Department's requirements regarding sanitary and catering installations, as far as applicable to foreign flag vessels

s) International Medical Rules for this type of vessel

t) The shipping Inspection of the Netherlands (NSI) Noise Level requirements

u) US Coast Guard regulation applicable to foreign ships in US ports

v) Dutch Port Labour Inspection

w) OCIMF: Standardisation of manifolds for refrigerated liquefied gas carriers for cargoes from 0°C to minus 48°C

x) IMO Resolution A.342 (IX) *"Recommendation on performance standards for automatic pilots"*.

y) All other rules, regulations and requirements as stipulated in the Specification, or necessary for this type of ship, or for the types of cargo referred to in the specification

0.6 Model tests, by recognised Institute, to include:

- Resistance/propulsion tests at LPG/VCM/ballast drafts;
- Bilge keel test (size/location);
- Wake Improvement Duct effect.

Design to be optimised as required in accordance with the model test results without extra cost to Owners.

1 Hull

1.1 General

The vessel to be built as full scantling vessel and to be constructed of steel - fully welded construction - of grades in accordance with the rules of the concerning classification society and/or other authorities to receive the certificates as mentioned in paragraph 0.4 and 0.5

Heat transfer calculations to be produced well in advance for approval by all parties concerned

1.2 Hull construction

The vessel to have combined transverse/longitudinal framing.

A double bottom to be provided for the storage of fuel/ballast water/fresh water. The double bottom to extend into the engine room.

The bottom structure at forward to be additionally reinforced above class requirements in order to improve the slamming resistance.

A fully enclosed cofferdam to be provided around/below the main engine.

Sea chests to be clear of oil tanks and to be provided with stainless steel gratings. (One grating only for each chest at port/starboard).

All weldings in wet spaces/areas including forecastle spaces and void spaces/cargo holds to be continuous.

Increased plate thickness/reinforcements to be applied in way of sea chests, chain locker, hold bilge wells, hawse pipes, machinery foundations and similar. Minimum thickness of bulwark plating/shell plating to be 10 mm.

The main steel structure in general to be such to avoid any disturbing vibrations and furthermore the steel structure to be maintenance friendly.

Sheer strake to extend 50 mm above deck level.

Bilge keels of optimal size to be fitted as per model tests results.

Anchors to be free from shell plating by means of standard box construction or similar. Slipping arrangement to be made on deck including securing devices.

Bulwark stanchions on forecastle deck to be fitted on doublers.

Suitable means for access, drainage etc. to be provided.

Two rows of chafing bars at each port and starboard shell and at stern area to be provided. (To prevent contact damages and paint damage from mooring wires).

1.3 Steel structure of accommodation, deck houses and similar

Front plating to be min. 8 mm, side/aft plating min. 7 mm, exposed deck plating min. 7 mm.

Sanitary/domestic/other wet spaces to be 'water tight'.

Stairways/access ladders/platforms/safety rail including standard platform and safety rail along wheelhouse front windows to be provided.

Railing along weather deck to be placed 100-200 mm inside and to be adjusted/reinforced in way of cargo manifolds and bunker stations. Sufficient free deck space for shore gangway to be provided.

Funnel design to be such to ensure efficient disposal of exhaust gases from engine room.

Small fittings such as chains, tumbler pins, bolts and nuts etc. in way of weather exposed areas including fire flaps and shafts inside ventilators to be executed in stainless steel.

1.4 Rudder

Articulated type (flap) rudder to be fitted. Diameter of rudder stock to be 5 mm in excess of class requirements. Electric hydraulic steering gear to be fitted.

1.5 Bow thruster

The vessel to be equipped with a bow thruster of adequate size/capacity. (... kW to be indicated by yard).
Bow thruster to be powered independently by shaft generator and/or main generators.

1.6 Wake Improvement Duct

Separate price to be given for a Wake Improvement Duct together with speed gain/power savings as per model tests results.

1.7 Bulbous bow

Separate price to be given for a bulbous bow together with speed gain/power savings as per model tests results.

2. Painting

2.1 General

All steel plates and profiles to be grit blasted to SA 2.5 and to be treated with one coat of approved shop primer ensuring marine quality construction. (Sigmaweld MC or equal).

After construction and welding, all welds and butts/seams and damaged spots by welding and/or burning in way of exterior bottom and shell plating and internal structure of tanks/spaces for which coating is provided in this specification, to be grit blasted to SA 2.5, intact shop primer to be cleaned by light sweep blast.

Further requirements for painting and surface preparation as per owners' standards attached.

2.2 Specification

All paints to be Hempel or other approved system of equal quality. Final colours in owner's option.

Main paint system will be as follows:

Hull with attachments underwater, including sea chests and bow thruster tube:

1 layer HEMPADUR	1557E		80 micron
1 layer HEMPADUR	1513C		250 micron
1 layer HEMPATEX HB	4633		40 micron
2 layers HEMPEL'S ANTIFOULING NAUTIC TIN FREE	7690	2 * 75 =	150 micron

Hull topside, bulwark, coamings, hatches and remaining structure on deck:

1 layer HEMPADUR	1557A		80 micron
1 layer HEMPATEX HB	4641		100 micron
2 layers HEMPATEX ENAMEL	5636	2 * 40 =	80 micron

Accommodation (outside):

1 layer HEMPADUR	1557E		80 micron
1 layer HEMPADUR HB	4520P		100 micron
2 layers HEMPATHANE ENAMEL	5518	2 * 40 =	80 micron

Weather decks (non-skid in walking areas):

1 layer HEMPADUR	1557E		50 micron
2 layers HEMPADUR HB	4520E	2 * 75 =	150 micron

Holds:

tank top + abt 500 mm high edge at shell sides, bulkheads and other adjacent structures:

1 layer HEMPADUR	3553		150 micron

remaining areas at shell sides, bulkheads and under decks:

2 layers HEMPATEX HB	4641	2 * 75 =	150 micron

Exposed steel work in accommodation, engine room (above lower floor), stores, forecastle spaces, stores, bow thruster room above bottom part etc.:

1 layer HEMPALIN PRIMER HB	1320	50 micron
1 layer HEMPALIN UNDERCOAT	4246	40 micron
1 layer HEMPALIN ENAMEL	5214	40 micron

Ballast tanks, void tanks and similar:

1 layer HEMPADUR	3553E	250 micron

Chain locker:

1 layer HEMPADUR	4515	250 micron

Bow thruster room, bottom part:

1 layer HEMPADUR	3553E	250 micron

Fresh water tanks:

1 layer HEMPADUR	3553E	300 micron

Remaining steel interior behind sheathing and/or insulation:

1 layer HEMPINOL	1022	75 micron

Walk decks without deck covering in accommodation, engine room, stores, alleyways, etc.:

2 layers HEMPALIN DECKPAINT	5324	2 * 40 =	80 micron

Engine room between tank top and lower floor incl. foundations, pipelines, etc.:

1 layer HEMPADUR	4515	250 micron

Substitute paints of even quality to be applied in winter time, as per suppliers recommendations thereto.

Wooden shelves and gratings.

Hardwood to be varnished.

3 Miscellaneous

3.1 Cathodic protection

Zinc anodes to be fitted on shell plating, inlet chests, propeller boss, rudder and bow thruster tube, but clear of oil bunkers, based on protection for 2.5 years. A current pick up on the propeller shaft to be fitted.

Alternative: Impressed current system to be provided.

3.2 Insulation

Bulkhead and/or any other exposed insulation in cargo holds and other spaces to be steel-sheathed (1 mm galvanised plating). Steel plate at base of engine room bulkhead and adjacent shell side to be provided (in cargo hold).

4 Safety appliances

4.1 Life boat

Totally enclosed aluminum engine driven lifeboat of the freefall type, with sprinkler system to be provided. All regulations as referred to in paragraph 0.5 to be complied with.

4.2 Rescue boat/Davit

As per regulations referred to in paragraph 0.5.

4.3 Life rafts/Davit

As per regulations referred to in paragraph 0.5.

4.4 Crane

Combined lifeboat/store crane of ample capacity and outreach to be installed.

4.5 Fire fighting/Fire protection

Fire fighting for engine room (CO_2) and compressor room, accommodation and fire fighting on deck (including dry powder/waterspray system) as per regulations referred to in paragraphs 0.4 and 0.5.

Smoke detection system and fire alarm to be fitted. In accommodation this system to be connected to doors between separate decks by solenoid valves.

5 Accommodation

5.1 General

Accommodation to be provided for a total complement of 15 persons + 1 pilot and fitted out in accordance with high marine standards for workmanship and quality. Accommodation to be maintenance friendly as required for this type of vessel.

Cabins to be equipped with standard marine duty furniture which includes:

Officers: Writing desk including locker and drawers, one chair, double bed 2000 x 1200 mm, double locker, book rack, sofa armchair, two windows 800 x 600 mm closed type, curtains (including door curtain), table, refrigerator (60 l).
Office with adequate furniture including refrigerator 60 litres and pantry to be incorporated in the captain's cabin, which also to be provided with small safe.

Cabins for captain, chief engineer and chief officer to be provided with separate bedroom.

Crew: writing desk, bed 2000 * 900 mm, locker, settee, chair, one window, locker, curtains (including door curtain), small table.

All cabins for officers and crew to be provided with separate bathrooms with shower, toilet, washbasin, tap cock, toilet locker and curtain.

Separate messrooms/smoke rooms for officers and crew with adequate furniture and each one 60 litre refrigerator to be provided.

Two drinking water coolers to be provided.

One extra toilet on bridge deck, one extra toilet on main deck, changing room and cargo control room to be provided.
Sufficient lockers/storerooms for a vessel of this type to be fitted.

All walls/ceilings in cabins, alleyways, messrooms etc. to be covered with approved marine duty lining (TNF-system or equal). Passage ways in accommodation to have a minimum width of 1000 mm. Minimum free height in accommodation to be 21 mm. All stairs (in fully enclosed steel staircase) to be of steel construction, covered with non-skid floor covering material. Hand rails to be of teak.

Sound/thermal insulation to be provided as required.

All outside doors to accommodation to be of teak. Where steel doors are required, teak inner doors to be provided.

All floors to be covered with approved (sound insulating) under floor. Officer's cabins to be provided with fixed carpet. Crew's cabins and Officers' and crew's messrooms, alleyways etc. to be covered with pvc-flooring. Wet spaces including galley to be covered with tiles.

5.2 Galley

The galley (steel boundary bulkheads) to fitted out with the following equipment:

- 1 ship's range with 4 cooking plates, and 1 thermostatically controlled baking oven;
- 1 frying pan;
- 1 universal kitchen machine (Hobart);
- 1 coffee maker;
- 1 meat slicing machine;
- 1 refrigerator, 250 litres;
- 1 dishwasher;
- 1 stainless steel sink table with 2 sinks and taps for cold/hot water;
- 1 stainless steel work table, with stainless steel lockers underneath;
- 1 stainless steel rack for dishes;
- 1 chopping block;
- 1 comprimator for wet and dry waste (including suitable steel storage box on deck) or one incinerator.

Galley to be equipped with serving hatch to crew's messroom and elevator to officers' messroom (in case situated on different decks).

5.3 Provision stores

The following insulated compartments to be provided for:

- Freezing, about 8 m^3, -20 d.c.;
- Cooling, about 12 m^3, + 4 d.c..

Furthermore a non-insulated compartment to be provided for dry provisions with a capacity of about 30 m^3, with the necessary racks, cupboards and shelves and with a separate (wooden) hopper for storage of potatoes.

5.4 Laundry

Laundry (steel boundary bulkheads) to be equipped with:

- 1 washer-extractor, cap. 6-7 kg dry clothes;
- 1 dryer, cap. 6-7 kg dry clothes;
- 1 working table;
- 1 wash basin;
- 1 ironing board;
- Sufficient lockers.

5.5 Outside-decks

Bridge wings to be covered with hard wooden gratings or rubber ring-mats (depending on wheelhouse floor construction). All outside decks to be painted (non-skid).

5.6 Wheelhouse/Chartroom

Wheelhouse/chart room situated on the bridge deck to be built of steel (antimagnetic material to be applied as required). Gas tight outer doors of teak to be fitted. All front windows to be provided with electric window wipers including window heating, defrosting and fresh water washing device.

The required book shelves/book racks, chart table with drawers for navigation charts, writing desk, sofa, pilot chair, tables for radio, washbasin, etc., all of marine duty material, to be provided. PVC floor covering to be applied.

6 Deck equipment

6.1 Deck machinery

Two combined windlass/mooring winch units, two mooring winches, anchors (H.H.P. self-balancing bow anchors and one spare anchor), high quality chains, two chain stoppers, sufficient bollards, fair leads, ropes, lines etc., all to ensure efficient anchoring/mooring to be provided. Self-stowing flush chain lockers of sufficient capacity for easy stowage of chains to be provided.

Mooring winches to be suitable for two speeds i.e. 10/30 meter per minute and equipped with remote control.

Layout of mooring arrangement to be suitable for Braefoot Bay.

6.2 Masts

One Radar mast/Christmas tree on top of wheelhouse.
One signaling mast on weather deck/forecastle deck to be fitted. Separate mast/foundation for Satcom to be provided.

6.3 Pilot ladder

Two pilot ladders including permanent provisions for safe access in railings port and starboard to be arranged. Two rope ladders for life rafts to be fitted.

6.4 Accommodation ladder

Two sea water resistant aluminium self-stowing type accommodation ladder with electric hoisting equipment to be provided.
One sea water resistant aluminium gangway of sufficient length to be delivered and suitably stored/secured on board.

6.5 Forecastle

Forecastle space to be provided with separate paint locker with fixed fire equipment. Sufficient storage racks to be fitted in both spaces. One workbench with vice to be fitted. Store hatch with hoisting beam to be provided.

6.6 Hose handling

One hydraulic crane with sufficient SWL/outreach (min. 5 metres), serving port and starboard cargo manifolds, to be provided. Crane also to serve as 'Suez crane' with minimum 4 ton SWL.

7 Ventilation, air-conditioning

Living quarters:	Approved system of air-conditioning
Sanitary spaces, galley, Laundry, provision stores:	Mechanical (exhaust) ventilation
Deck stores:	Natural ventilation
Engine room:	Mechanical ventilation. One speed fan to be applied. Dehumidifiers to be provided (Location of inlet air to be especially considered and agreed upon)
Control room in engine room:	Approved system of air-conditioning (No cooling water inside e.c.r.)
Cargo compressor room/E-room:	Mechanical (forced) ventilation as per regulations referred to in paragraph 0.5 Two speed fans to be applied (IMO requirements at lowest speed to be complied with)

8 Owner's supplies

- Fuel oil, unused lubricating oil, thermal oil etc. in excess of trials (all oil in systems to be considered as used oil);
- Spare parts and tools in excess of Classification requirements and standard of subcontractors;
- Inventory, such as mattresses, linen, pottery, crockery, glassware etc. exceeding an amount of NLG 100,000;
- Nautical books and charts in excess of regulations referred to in paragraph 0.5;
- Loose wireless and T.V. sets.

9 Ship's model

After delivery of the vessel one ship's model 1:100 to be supplied to owners.

10 Electric plant

10.1 Distribution system

440V, 60Hz for power
220V, 60Hz for lightening
24V DC systems for emergency operation

10.2 Electrical power-supply equipment

Normal power

2 diesel engine driven main alternators of sufficient power, each 100%.
One shaft generator of sufficient power for all electrical requirements at sea.

One emergency diesel alternator set to be installed as per regulations referred to in paragraph 0.5.
Set also to be used as harbour generator.

Note:

All cable trays including supports and cable protections on weather exposed decks to be executed in stainless steel.

11 Communication equipment

11.1 Telephone system

Automatic telephone system to include all cabins, wheelhouse, engine room, steering room, inert gas room, cargo compressor room, e-room, control rooms, galley and messrooms, forecastle and aft ship. (Bridge and Engine room to have preference numbers). System to be combined with A.P. alarm and general alarm.

11.2 Equipment to be delivered and installed

1 AM/FM/TV central aerial system with outlets in each public room and cabin (for TV only in officers' cabins and public rooms).

11.3 Navigation/communication equipment

For navigation and communication equipment an amount of NLG 700,000.-- to be included. This amount to be used for the supply in owner's option of equipment only. (Special cabling, installation, commissioning etc. as well as a standard compass with second reading on the bridge to be allowed for extra by builders).

12 Machinery installation

The main propulsion plant to consist of a medium speed four stroke non-reversible in-line, low NO_x emission engine of reputable make/type, coupled via a reduction gearbox (with p.t.o. for shaft generator) to a controllable pitch propeller of optimal diameter. (One spare propeller blade to be supplied and stored on board). Tail shaft to be bedded in white metal bearing and to be provided with patent oil sealing glands with temperature sensors. Diameter of tail shaft to be 7 mm in excess of class requirements.

Main engine to be suitable for heavy fuel oil with a maximum viscosity of 700 cst/50 dc for quay to quay operation. Main engine to be provided with adequate cleaning unit for scavenge air cooler and exhaust gas blower (air side and gas side).

For generating the electric power, two diesel generator sets and a shaft generator of reputable make/type to be installed on board. Auxiliary diesel engines to be suitable for burning marine diesel oil MDO acc. BS 2869: 1970 Class B1 and to be equipped with exhaust gas monitoring system (for each cylinder) and with waste gate valves as appropriate.

One emergency set to be installed outside the engine room. This set to be capable to serve as harbour generator for hotel services.

For heating purposes one exhaust gas thermal oil heater and one oil-fired thermal oil heater suitable for burning marine diesel oil to be installed on board.

Control of the complete machinery installation from a separate air-conditioned and fully sound-insulated (max. 75 dba) control room in the engine room.

An integrated modular ship automation monitoring control and alarm system with sufficient points to be provided for main propulsion, diesel generator, power management and ballast system, complete with monitor in engine control room and separate panels for engineers' watch in engineers' cabins and officers' messroom.
Portable monitor for engineers cabins to be provided including connection in these cabins. Fixed monitor to be provided in chief engineer's cabin.

Local and remote indicators for temperatures, pressures and levels and relevant alarm indicators - incorporated in the ship's automation system - to be provided for a suitable functional check of main engine, diesel generators and auxiliary equipment, including the necessary software/hardware package for each work station and a printer in the engine control room.

For torsional - and lateral vibration levels on board ships see Design Criteria - Propulsion Installation attached.

Aluminium chequered plates on steel angle bar supports to be fitted around main engine.

Workshop to be provided in engine room. Equipment in workshop to include:

- Lathe 1000 mm;
- Electric driven double grinder, stone dia 200 mm;
- Electric drilling machine, dia 20 mm, column type, including vice;
- Workbench with vice and drawers underneath;
- Nozzle tester;
- Rectifier for welding including accessories;
- Autogenic apparatus including accessories;
- Two gas bottles and three oxygen bottles (To be stored in locker on outside deck with necessary piping to engine room);
- Sufficient racks, lockers for spares and tools.

Hoisting equipment in engine room above main engine and with means for transportation to workshop and access hatch in engine room to be provided.

13 Compressed air system

A compressed air system including two main air compressors and one working air compressor to be provided for starting the main and auxiliary diesel engines and for supply of compressed air to pneumatic equipment, including air dryer system. Air bottles to be provided with automatic condense trays.

14 Fuel oil system

A fuel oil system to be installed permitting the transferring, purifying, heating and supplying of fuel oil to main engine, auxiliary engines and boiler.

The engine HFO system to be designed as a one fuel system with one common settling tank and one daily service tank for the main engine. The settling tank to be filled up automatically and both tanks to be provided with automatic temperature controls and level alarms. Remote quick closing of the fuel valves to be hydraulically operated.

Pressurised HFO booster system to be provided for fuel supply to the main engine.

Separate systems to be provided for heavy fuel oil and marine diesel oil for both main engine and auxiliary diesel engines.

Central deaeration system for fuel tanks to be provided.

Central bunkering system including overflow tank to be provided.

Separate fuel oil supply meters for main engine and auxiliary engines to be provided.

Electric fuel oil and heater to be installed parallel to thermal heater.

All heaters to be of shell/tube type.

15 Lubricating oil system

A lubricating oil system permitting transferring, purifying, heating, cooling and supplying of lubricating oil to main engine and reduction gear. Independent lubricating oil system to be provided for auxiliary diesel engines.

The necessary storage tanks of sufficient capacity to be provided for lubricating oil and miscellaneous products. Separate drain tank for automatic lubricating oil filter to be provided (1 m^3). Separate drain tank for sump oil to be provided.

16 Cooling water system

A central cooling water system with high and low temperature circuit, including plate type heat exchangers with a fouling factor of 25% and standby provisions to be installed and this system to be connected to main engine, auxiliary engines, gearbox and air-conditioning plant.

Sea cooling water piping system to be of 'cunifer' material or similar. System to be provided with marine growth preventer. (Velocity of salt water/fresh water lines to be indicated).

Alternative: Heat exchangers of shell/tube type to be installed.

17 Thermal oil system

For heating purposes including heavy fuel oil heating a thermal oil system with circulating pumps, storage tank, gravity tank and emergency tank to be provided. Heating of thermal oil to be effected by oil fired boiler and exhaust gas boiler. Heavy fuel oil tanks to be equipped with heating coils as required.

18 Remaining systems

One ballast system to be installed with hydraulically remote controlled valves for the ballast tanks. Remote control and monitoring of the ballast system to be arranged from engine control room and cargo control room.

The necessary provisions to be made for efficient sounding, bilging, drainage, sludge removal, fire fighting, general services, sanitary services, domestic services etc.

A remote controlled sounding system integrated in the ship's monitoring and control systems for ballast tanks, freshwater tanks, fuel tanks and lubricating oil tanks (main storage tanks and sump) to be provided. Fittings in tanks to be of stainless steel.

A bilge water separator of approved make and type with heating and 15 ppm alarm to be fitted as per regulations referred to in paragraph 0.5.

A sewage treatment plant of approved make and type, capacity 20 persons, to be fitted as per regulations as referred to in paragraph 0.5.

A vacuum toilet system to be provided with a vacuum collecting unit connected to the toilet black water system.

A fresh water generator of ample capacity to be installed. Fresh water system to be equipped with coil filters and U.V. steriliser.

All piping on weather exposed decks up to 25 mm dia to be of stainless steel.

19 Accessibility

The design/layout of the engine room and systems to be maintenance friendly and with good accessibility to all equipment installed.

Special attention to be paid to accessibility in way of shaft generator, main generators and other main equipment with a view to removal for repairs.

'Soft patches' and/or other means as well as sufficient hoisting arrangement to be incorporated in the ship's design as required.

20 Cargo handling and reliquefaction plant including cargo tanks

A cargo plant of approved make and type to be provided for the transportation of products mentioned in paragraph 0.1 referred to above.

Design conditions for the above plant to be as follows:

No. of tanks	2
Tank volume (geometric)	approx. 4,500 m^3
Tank no. 1	approx. .... m^3 (to be indicated by yards)
Tank no. 2	approx. ....m^3 (to be indicated by yards)
Max. operating pressure	
acc. to BV/IGC Code,	9.0 bar gauge (alt. 13 bar gauge)
acc. to USCG	6.3 bar gauge (alt. .. bar gauge)
Max. external tank pressure	0.5 bar
Max. specific gravity	0.972 tonnes/m3
Min. transport temperature	-48 dc
K-value of insulation approx.	0.3 kcal/m^2/h dc
Type of insulation	P.U. slabs covered with 0.5-1mm galvanised steel protection sheating

Max. sea water temperature	+32 dc
Min. sea water temperature	0 dc
Max. ambient temperature	+45 dc

The system to be equipped with means for warming up of cargo during discharging.

For gas freeing of cargo tanks and piping system an inert gas plant of the regeneration system of approved make and type (nitrogen production plant) to be installed.

Gas installation to be installed under shelter on open deck.

Cargo control room to be provided in accommodation.

Permanent staging to be provided around cargo tanks for periodical inspection of insulation.

Stainless steel drip trays with accessories to be provided under cargo manifolds.

21 Electronic Documents

An electronic document system to be provided for the main propulsion, auxiliary and ancillary equipment. The system, including electronic planned maintenance information, to be compatible with AMOS-D.

General Notes:

1. This outline specification is to be construed as giving main details only. Non-specified work to be executed according to good shipbuilding practice for a commercial vessel of the type and size described here in;

2. A general arrangement plan to be submitted together with yard's quotation;

3. Attached to this specification are:
   - Maker's list (Final choice of actual make/type of main and auxiliary machinery and main equipment and other essential fittings to be in owner's option at no extra costs to owners);
   - Owner's standards for painting and surface preparation;
   - Design criteria - Propulsion installation.

ITEM		MAKER/MANUFACTURER/SUPPLIER
1.	Main Engine	Sulzer ZA40, MAK, Wärtsilä
2.	Reduction Gear	Tacke, L&S, Wärtsilä
3.	Flexible Couplings	Vulcan, Spiroflex
4.	Shaft Seals	Waukesha Lips, HDW
5a.	C.P. Propeller	Lips, Berg, Kamewa, Wärtsilä
5b.	Bow thruster	Lips, Jastram, Kamewa, Schottel
6.	Auxiliary Engines	Sulzer, Deutz-MWM (816BAM), MAK, SWD, Yanmar, Daihatsu
7.	Centrifugal Pumps	Svanehoj, Iron, Nijhuis, Allweiler Houttuin, Taiko, Shinho
8.	Screw/Gear Pumps	IMO, Allweiler, Kral, Taiko, Shinho
9.	Starting Air Compressors	Sperre, Hatlapa, Deno, Tanabe
10.	Working Air Compressor	Atlas, Copco, Sperre, Hydrovane Compair, Tanabe
11.	Fuel Oil/Marine Diesel Oil/ Lubricating Oil Separators	Westfalia, Mitsubishi
12.	Bilge Water Separator	HDW, Heishin, R.W.O., Facet
13.	Windlass/Mooring Winches	Norwinch, Hatlapa, Ten Horn
14.	Steering Gear	Frydenbo, Tenfjord, Yamamoto
15.	Exhaust Gas Boiler	Konus, Wiesloch
16.	Oil fired Boiler	Konus, Wiesloch
17a.	Sewage System	Hamworthy, Bio Compack (Salzkotten)
17b.	Vacuum System	Evac, Jets, Vickers
18.	Free fall Lifeboat	Verhoef, Mulder en Rijke, Hatteke
19.	Lifeboat/Store Crane/Hosehandling Crane	Verhoef, NMF, Normarine

20.	Life rafts	Viking, RFD, Autoflug
21.	Accommodation Ladder/Gangway	Verhoef
22.	Laundry Machines	Volund
23.	Corrosion Prevention	Hempel, Sigma
24.	Fire Detection System	Walter Kidde, Autronica
25.	CO_2 System	Walter Kidde, Van Rijn, De Boer, Unitor
26.	Welding Equipment	Unitor's Ship Service
27.	Generators	Indar, Van Kaick, Siemens, ASEA
28.	Switchboard	BBC, AEG or own panel of selected electrical installation firm
29.	Electric Motors	AEG, Loher, MEZ, ASEA, Siemens, NDSK
30.	Telephone Installation	Vingtor
31.	Gas plant	LGA, TGE
32.	Inert Gas plant	Smit Ovens, TGE
33.	Electrical Systems/outfitting	Croon & Co, Rietschoten & Houwens, Terrasaki
34.	Integrated Ship's Automation System	Praxis, Siemac, Lynso-Valmet, Autronics

10.1.2 Index standard shipbuilding contract

This section shows an index of a standard shipbuilding contract.

10.2 Classification and certification of ships

Classification is the assessment of ships (and offshore units) against classification society rules in respect of structural integrity and essential engineering systems for their intended purpose. However, classification societies undertake other work, such as acting on behalf of flag states that delegate statutory roles to them.
There are over 40 classification societies in the world, but only a handful of them is considered to be of sufficient size and technological competence in order to undertake the tasks at hand. These large classification societies have created in 1968 the International Association of Classification Societies, IACS, while its origins goes back to 1930.
The members of IACS are American Bureau of Shipping, Bureau Veritas, Det Norske Veritas, Germanischer Lloyd, Lloyd's Register of Shipping, Nippon Kaiji Kyokai, Registro Italiano Navale, China Classification Society, Korean Register of Shipping, Polish Register of Shipping, and the Maritime Register of Shipping (of Russia).
IACS members classify more than ninety percent of the world's merchant tonnage measured in grt, and more than fifty percent of the number of merchant ships currently trading. IACS members are delegated authority by well over 150 flag states and national administrations in respect of statutory surveys.
Within this category, there is the emerging certification of ship/shore activities against quality management codes such as the International Safety Management Code. Apart from this rather new activity of management systems audits, the traditional work of the classification society will be described in this chapter. It is based on a lecture by R.J. Vienneau, chief surveyor with the American Bureau of Shipping in 1990 for the maritime students at the Faculty of Mechanical Engineering and Marine Technology, Delft University of Technology.

10.2.1 Basic functions of ABS

In order to grasp the complexities of classification and certification, the basic functions of ABS must be understood. They are as follows:

1. Preparation and promulgation of rules and guidelines for the design, review and construction of ships and a variety of other marine craft and structures, including material specifications and detail regulations for periodic surveys. These rules are modified from time to time in order to keep pace with developments in shipbuilding and marine engineering; they are the standards by which the eligibility of vessels submitted for Classification is determined;

2. Publication of an annual record of the essential details of hull and machinery of all ABS Classed vessels and the due dates of principal surveys.

3. Review and analysis of the plans and specifications of proposed new vessels, or conversions of existing vessels, to verify that they meet the standards set by the Society's rules;

4. Carrying out structural analysis of new or unusual vessels for which rules have not yet been developed, this incorporates computer-aided research;

5. Survey during construction of the hull and its propulsion machinery, boilers, and vital auxiliaries; and survey of the conversion of existing vessels, for compliance with the rules;

6. The testing of materials for construction of hull and machinery;

7. Survey of the completed vessel throughout its Classed life as called for by the rules. Reports of these surveys are forwarded to the shipowner from which he is able to confirm the maintenance of the vessel, establish due diligence for insurance arrangements and claims, and satisfy government requirements.

8. Carrying out statutory, surveys such as Load Line, SOLAS, MARPOL, and Tonnage measurement; and issuance of the relevant certificates under the authority of the cognisant government and international convention;

9. Issuance of cargo gear or crane Registers. These normally are statements of compliance with internationally recognised standards for safety of cargo handling gear and are required (up-to-date) in practically all ports prior to loading or discharging cargo;

10. Issuance of certificates of character of Classed vessels such as Classification Certificates, Certificates of Fitness to Proceed, Confirmation of Class and Maintenance of Class. These are usually essential for insurance or sale purposes.

11. Maintenance of a history of the surveys from the time of keel laying and during the vessel's entire Classed life. The Classification Society is able to collate this data on both hull and machinery towards improvement of design and operation. Owners often do the same thing for their own ships, but the Classification Society does it for all ships classed with it, and is thus able to formulate an overall picture.

Some other activities are:

12. Representation on technical committees and panels of the various national and international standard-making bodies, such as the Society of Naval Architects and Marine Engineers, Ship Structure Committee, Institute of Electrical and Electronic Engineers, American Society of Mechanical Engineers, American Society for testing Materials, and many others.

13. Participation by staff members on various university, industry or government committees furthering research or developing regulations on marine matters.

14. Carrying out on-board ship-motion, stress and vibration studies.

Points of order and definitions:

1. The parties involved in the construction of a vessel must recognise that the class society usually has a contract with the shipbuilder who signed the Request for Classification Agreement. The owner must have an agreement with the shipbuilder to share all information between the shipyard, the class society, and the owner;

2. The parties involved in the construction of a vessel should be fully aware of the differences between contractual conditions vs. rule requirements and between inspection versus surveying;

3. Occasionally differences of opinion will arise in which a Classification Society will be asked to arbitrate. The Society is guided by rule requirements and normally cannot comment on a contractual condition such as vibration, noise levels or fuel consumption. Vibrations which obviously represent a hazard to the vessel would be addressed;

4. 'Inspection' is the responsibility and function of the builder's quality control arrangements. 'Surveying' is a free and random access to all portions of the builder's facilities. The rules do require the specific attendance of a Surveyor at some construction activities such as tank testing. However, the overall responsibility belongs to the builder, and the Surveyor checks the builder's arrangements.

5. Classification is a representation by the Bureau as to the structural and mechanical fitness for a particular use or service, in accordance with its rules and standards (Rules for the Construction and Classification of Steel Vessels, Section 1.3 copy attached). The classification process includes performance of a schedule of surveys by ABS during the service life of a vessel.

6. Certification is:
   - An attestation or a statement of fact as to the condition of a piece of equipment or a vessel at a specific time;
   - A representation by the Bureau that a survey was carried out in compliance with one or more of the rules, guides, standard or other criteria of ABS, or in compliance with other specific standards;
   - A representation by the Bureau that a piece of equipment, such as a mooring chain, complies with one or more of the rules, guides, standards or other criteria of ABS, or complies with other specific standards.

7. A Survey is an examination of a piece of equipment or a vessel in accordance with the appropriate ABS rules, guides, standards or other criteria of ABS or

in accordance with other specific standards. The examination may be pursuant to Classification, certification or requested as a result of damage sustained by the piece of equipment or vessel.

8. The primary function of the ABS Surveyor is the determination of, and reporting on, the fitness for service relative to the applicable ABS rules of ships and other marine structures during construction and service life. Other functions of ABS Surveyors are to survey ships or marine structures for compliance with statutory requirements on behalf of the cognisant government administration and to issue the relevant certificates including those for Safety of Life at Sea, Load Line, Tonnage and Pollution Prevention.

Considerations for the shipyard during construction:

1. A firm commitment by the management to support the quality efforts;
2. An independent quality organisation with authority to implement and administer a quality assurance program;
3. A quality manual outlining the program;
4. Written procedures and work instructions;
5. Appropriate training for workers;
6. A system for proper control of drawings and documents;
7. A system for adequate material control;
8. Calibration of measurement instruments/gauges, etc. on a routine basis;
9. A comprehensive inspection system;
10. Appropriate retention of documentation.

Surveys during construction

The rules are written so that hold points are established in the construction of a vessel to check the quality of construction.

Basically, there must be approved drawings, approved materials, qualified weld procedures, qualified welders, and a sufficient number of qualified shipyard supervisors to oversee the construction of the vessel.

The formal classification procedure begins when an official request for the classification of a ship or marine structure is voluntarily submitted to ABS. This usually results from an owner specifying to a shipyard a desire for ABS classification. The shipyard then contracts for classification services with ABS.

The vessel design is then submitted to ABS for verification that the plans conform to accepted standards of good practice for vessel design embodied in the *"ABS Rules for Building and Classing Steel Vessels"*, or other of the various ABS rules or guides. So when ABS reviews a given set of design plans, it compares them with a compendium of experience factors and proven scientific principles. In this way, ABS is able to determine that the design is adequate insofar as the rules require in its structural and mechanical concept and therefore able to be translated into an acceptable vessel.

To conduct the plan review function, ABS employs technical staff surveyors trained in the skills of naval architecture, marine engineering, and other associated disciplines. These specialists review the vessel's design to confirm that the details comply with the standards set forth in the published rules. Their review may also include sophisticated analytical procedures employing one of the many ABS computer programs. If the design is found not to be in compliance with the rules, ABS notifies the builder or designer of the departures from the rule requirements. During the entire review process, ABS is available for consultations with the builder and designer.

After a design has been reviewed by ABS technical surveyors and found to be in conformity with the rules, ABS field surveyors, experienced in the construction of hulls, and fabrication of machinery and components, attend the vessel at the shipyard from keel laying to delivery and check quality control procedures in conjunction with the surveyors' own inspections. Surveyors survey the vessels during construction to assure that the plans are followed, that workmanship is of an acceptable standard, and that the rules are adhered to in all respects. Field surveyors also witness testing of materials, machinery, and components at manufacturers' plants and fabricators' shops to determine that they also comply with the rules.
During the entire construction period, ABS maintains an ongoing dialogue with the shipyard to make sure the rules are understood and adhered to and also to assist in resolving any differences that may arise.

When completed, a vessel undergoes sea trials and an ABS Surveyor attends the trials to verify that the vessel performs according to requirements specified in the rules. In order for a vessel to be classed, a report must be presented to the ABS Classification Committee. This committee, composed of prominent individuals from the maritime industry, meets once a month to perform a final review of a vessel's credentials. A vessel found to be acceptable in all respects, according to the rules, is then granted ABS classification by that committee. In classing a vessel, the committee is saying, in essence, that the vessel conforms with the ABS rules and to that extent is mechanically and structurally fit for its intended service.

Cycle of surveys following delivery

The graph (**Figure 2**) is of a typical five year cycle predicated on all surveys being performed on their due dates and the vessel having a regular schedule. The ideal example is a ferry boat. Once a vessel is out of its schedule then extensions of surveys are routinely requested.

The key point to be noted is that the owner is responsible for the maintenance, loading and operation of the vessel. The owner must present the vessel to ABS when it is due for surveys or when it has been damaged.

Trends in newer vessels have made the Surveyor's job more complex. Technological improvements such as direct engineering analysis, the use of higher strength

```
       0   4   8  12  16  20  24  28  32  36  40  44  48  52  56  60  64  68
----------------------------------------------------------------------------
AS   |         ...x...     ...x...     ...x...     ...x...        x
ALLI |         ...x...     ...x...     ...x...     ...x...        x\\\\\\
INT  |                          .....x.....
SSH  |                                                x\\\\\\\\\\\
SSM  |                                                x\\\\\\\\\\\
DD   |                               x\\\\
SLC  |                                                            x\\\\\\
SLE  |                        x\\\\\\                 x\\\\\\
SLR  |            x\\\\\\     x\\\\\\     x\\\\\\     x\\\\\\     x\\\\\\
IGC  |         ...x...     ...x... ....x....       ...x...     ...x...
TS   |                                                            x\\\\\\\\\\
BS   |                               x\\\\\\                           x\\\\\
AUXB |                               x\\\\\\                           x\\\\\
```

x	=	Due date	DD	=	Drydocking
..x..	=	Grace period	SLC	=	Safety construction
\\\\\	=	Maximum extention period	SLE	=	Safety equipment
AS	=	Classification and SOLAS surveys due on an annual basis	SLR	=	Safety radio
ALLI	=	Annual load line inspection	IGC	=	International code for construction and equipment of ships carrying liquefied gasses in bulk
INT	=	Intermediate inspection			
SSH	=	Special survey - hull	TS	=	Oil bearing shaft
SSM	=	Special survey - machinery	BS	=	Boiler survey (main or auxiliary)

Figure 2: Typical 5 year cycle of surveys

materials, more efficient structures, machinery and piping are less forgiving of a lack of maintenance. The classic expectations of reliability are highly depending upon frequent maintenance.

Non-compliance with the rules results in an *outstanding recommendation*. This is also known as a *condition of class*. These outstandings remain in the vessel's permanent record. When corrected, they are noted as having *been complied with*. These outstanding recommendations are privileged information released only at the authorisation of the owner or at the request of the administration of the country of registry.

During the service life of a vessel, the following are Class surveys that may apply:

1. *Drydocking*, to check hull fairness, hull fittings, coatings, propeller, rudder;
2. *Annual survey of hull*, to check hull fittings, coatings;
3. *Intermediate survey*, to check ballast tanks, cargo holds, coatings;
4. *Special survey* of hull, drydocking and gaugings and all parts of the hull;
5. *Annual survey of machinery*, to check maintenance and operation of machinery;
6. *Special survey of machinery*, a detailed examination of sea valves, windlass, auxiliary machinery, main machinery;
7. *Tail shaft surveys*;
8. *Boiler surveys*, main boilers, auxiliary boilers, safety valves;
9. *Electrical equipment*, main propulsion, auxiliary equipment, insulation testing;

10. *Automatic & remote control equipment*, operative testing, insulation testing;
11. *Cargo refrigeration*, operative testing, insulation testing;
12. *LNG vessels*, containment systems, venting, safety devices;
13. *Inert gas systems*, operative testing examination;
14. *Underwater survey* in lieu of drydocking.

The special surveys can be done as a *continuous survey* which would be a five year cycle during which all items of hull or machinery would be examined at least once or as a *periodic survey*, which differs in that all items of hull and machinery would be due for inspection four years after delivery, and a year of grace is available to complete these surveys during the 4th to 5th year.

Damage surveys

The request for a damage survey is initiated by the Owner when he believes the vessel has sustained a damage affecting the vessel's Classification.

Statutory surveys

Include load line surveys, safety construction surveys, radio surveys, firefighting and lifesaving equipment surveys, marine pollution related surveys and others.

These surveys are too complex for a brief discussion. When they are conducted, the surveyors use a checkoff type report form for their guidance and the surveys are conducted at the specific request of the country of registry of the vessel, or the vessel's owners.

In 1989 22,000 reports covering 45,000 classification surveys were prepared by 438 exclusive ABS surveyors. These surveyors also prepared 13,000 statutory surveys at the request of 106 governments. ABS also used 140 nonexclusive surveyors during the year in order to cover ABS's fleet of approximately 12,300 vessels with a class of A1 or greater

10.2.2 On Line Class, a new classification approach

In June 1994, three members of IACS, Bureau Veritas, Germanischer Lloyd and Registro Italiano Navale introduced an extended classification concept, known as *On Line Class*.
Classification of ships was created to allow an assessment of the degree of confidence a ship deserved faced to risks inherent to the maritime trade activity. This fundamental mission was translated into the traditional classification scheme, as discussed previously, and which has the following aspects:

- Standards, or *rules*, are defined for design, construction and service of a ship;

- Design and construction are controlled to assure compliance with the rules, on the basis of which a *certificate* of conformity is issued;
- To assess ship's seaworthiness periodical inspections are done and their results are compared to the applicable service rules;
- Rules requirements being met, the certificate of conformity is renewed with a certain validity.

The process is schematically shown in **Figure 3**. From this diagram it becomes clear that classification is mainly a linear process, where each stage of the ship's life is treated rather separately from the others. Once the standard is met one passes to the next stage. It is a process in which the only possible output is a statement of compliance or non-compliance with the rules.

Input	Stage	Assessment	Standard	Records	Output
Plans from client	▸ Design	▸ Design review	▸ Design rules	▸ Calculation notes and plans	▸ Stamped plans
Stamped plans	▸ Construction	▸ Construction survey	▸ Construction rules	▸ Construction reports	▸ Original certificate
Original certificate	▸ Service	▸ Periodical inspection	▸ In service rules	▸ Survey reports	▸ Certificate renewal

Figure 3

The drawbacks of the current classification procedures are related to the major aspects, such as design review, construction survey, in-service survey, and reporting:

- *Design review*: design rules for hull structures are based on the theory of strength of materials and a deterministic estimation of loads. Experience with ships in-service, provides feedback, which in turn leads to a calibration of the rules. However, to be general and viable for practical application, many simplifications must be made to derive at the design rules. So, they are mandatorily conservative. It also means that in some highly stressed elements safety factors are often just complied with, while in less stressed parts safety factors might be too high.

- *Construction survey*: at this stage a continuous survey is made to assure that reviewed plans are followed correctly, materials conform to specifications and construction is executed to acceptable standards.

- *In-service survey*: hull corrosion and structural problems, such as buckling or cracks, are controlled at periodical surveys. If wear values are within accepted tolerance, then the classification certificate is renewed. In case wear values exceed those tolerances or structural problems are detected, repairs are required as a condition for the renewal of the class certificate.

- *Reporting*: at each stage of the classification process there are plans, documents, reports, or records, which are filed and preserved during the entire life of the ship. There is also a computerised system to manage class status of all registered ships. This system keeps in memory due dates for surveys and pending remarks. Once solved, this information is no longer useful and thus deleted. Therefore, in practice, only paper supported records are available for consulting purposes on a permanent basis.

The above illustrates the deficiencies of the traditional classification approach, which can be overcome in various ways. The basic elements are:

- Hull design review by direct engineering analysis, also called engineering first principles. This approach was first introduced by American Bureau of Shipping under the brand name SafeHull, but rapidly followed by Lloyd's Register of Shipping, Bureau Veritas and Det Norske Veritas.
- The setup of a comprehensive and permanent computerised database for each ship, in which all design, class and survey information is stored and directly accessible.
- Based on the systematic evaluation of the ship's hull and condition evolution during the special survey, the shipowner can be advised on his maintenance strategy, and at the design rules may be changed accordingly.

In short, the new approach, as proposed by some IACS members, means a more professional design process and the deliberate creation of a feedback from the service experience of the ship to the design and class requirements. This is all very logical and a necessary development in the maritime industry. It will be clear that the investment in new software and systems development requires a minimum scale of activity of the classification society.

10.3 Chartering of ships

Chartering of ships is a basic function in shipping. Owners of cargo, the so-called shippers or receivers, look for ships that are able to transport the commodities at a competitive rate in the required time frame, while shipowners look for cargo to be transported. The two major players in the (bulk) freight market are thus the shippers or receivers and the shipowners. These are cemented together by shipbrokers, who are an intermediary between demand for and supply of ships and cargo.

10.3.1 Ship brokers

There are three types of brokers: Competitive broker, owners broker and cargo broker. The cargo broker acts in the direct interest of the owner of the cargo and is often a part of its organisation. The owner's broker acts in the best interest of the shipowner, and is often a part of a shipping company. The competitive broker has no links with either the owner of ships nor the owner of the cargo. He acts as a pure intermediary with the only objective of concluding a deal, a fixture, and earn his 1.25% commission of the freight revenues. **Figure 4** shows the relationship between the various parties.

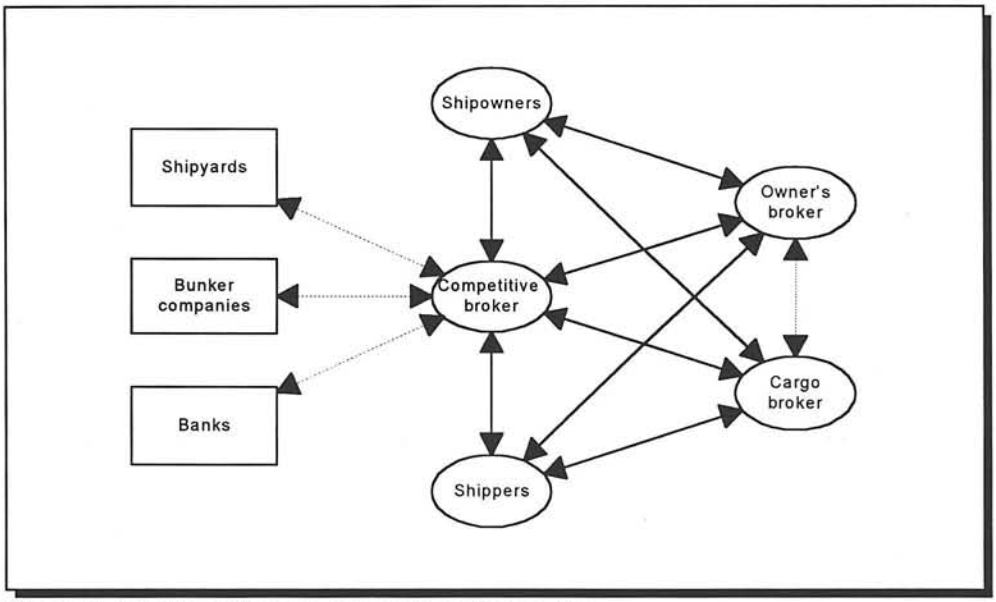


Figure 4: Relationships between chartering parties

Examples of leading brokers are: H. Clarkson & Company, Simpson and Spence & Young, both in London; Fearnley A/S, O-J. Libæk & Partners and Torvald Klaveness Group, all three in Oslo, and Barry Rogliano Salles in Paris. Apart from Klaveness, who is an owners broker, the others are all competitive brokers. They specialise in certain market niches, related to the different commodities such as dry cargo, tanker, gas, but also offshore, bunkers, sale & purchase of ships, financial engineering, research, consultancy, and project development. A profile of these major brokers is shown in **Table I**.

Activities/Broker	BRS	Clarkson	SSY	Fearnley	Libæk	Klaveness
Owners broker						x
Competitive broker	x					
Broking activities						
- Dry cargo	x	x	x	x	x	x
- Tanker	x	x	x	x	x	x
- Gas	x	x		x		x
- Offshore	x	x		x	x	x
- Bunker	x	x		x		x
- Sale and purchase	x	x	x	x	x	x
- Financial				x		
Side activities						
- Research		x	x	x		
- Advice	x	x		x		
- Project dev.					x	

Table I: Profile of major brokers

10.3.2 The chartering process

A shipowner has a ship open (empty, available for hire) in a certain port at a certain time in the future. The ship has specific characteristics, such as deadweight, speed, fuel consumption, main dimensions, cranes, etc. The owner has now two options. He can call shippers and inform them of the availability of his ship, or he may contact a ship broker and ask him to find a cargo for the ship. Using a ship broker saves the small shipowner a lot of time and money and the information about the ship's availability is circulated under a much larger audience than the shipowner could reach on his own. The shipowner sends a brief outline of the ship with the main particulars to the ship broker, which will be sent to the prospective charterer upon request.
The shipowner may wish to charter out his ship for a single voyage, a specific period or trip. The length of the period may depend on his expectations about the development of the charter hire. If he believes that the market will improve, he charters out for a short period, in the other case for a longer period.

The shipper or receiver of the cargo has a volume of cargo for transport and if he does not want to buy his own ships, than he can hire them in the open market. Sometimes he wants to cover his transport need for a single voyage, sometimes he may wish to charter a number of ships for a longer period. In other cases he may not wish to get himself involved in the chartering of ships at all. In that case he may conclude a contract of affreightment with a shipowner.

10.3.3 Types of charter

Figure 5 shows five types of charter schematically:

Bareboat charter is a contract by which the owner relinquishes all responsibility and rights in respect to his vessel for a specified period of time, in return for a prearranged, regular amount of hire. The charterer is responsible for all operating and voyage costs of the ship during this period. He becomes a 'disponent owner'. The relationship between the owner and charterer is laid down in a contract.

Period time charter is a contract by which the charterer hires a ship for a period of time. The owner still has to operate the ship under the instructions of the charterer, but the responsibility for the voyage costs is transferred to the charterer. The owner receives a daily hire paid monthly in advance.
A special variation is the *trip time charter*, which is related to the execution of a specific voyage and for the carriage of a specific cargo. The shipowner earns hire per day for the period determined by the voyage. **Table II** summarises the responsibility of the shipowner and the charterer under a time charter.

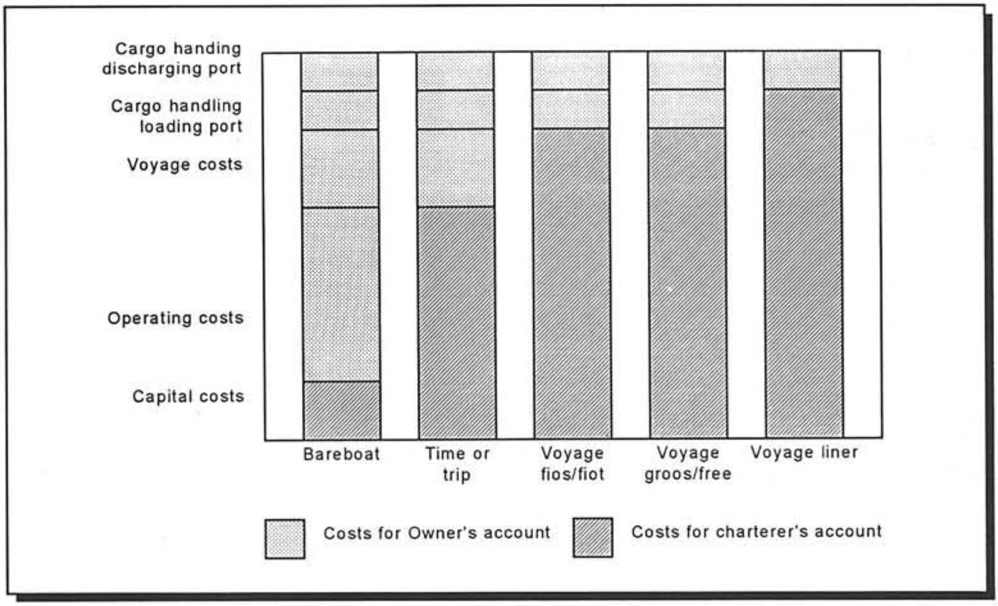


Figure 5: Types of charter

Voyage charter is a contract by which the owner earns a fixed amount of freight per tonne of cargo transported on the terms set out in the charter party, such as commodity, tonnage, ports of loading and discharging, laytime and demurrage. The freight money covers the owner's capital, operating and voyage costs. Depending on the type of voyage charter, the shipowner may also pay for the cargo handling costs. In the latter case, the voyage charter is *on liner terms*.

The owner provides:	The charterer provides:
- Provisions and stores - Galley fuel - Wages for officers and crew - Insurance of the ship - Maintenance of the vessel's hull and machinery in seaworthy condition - Maintenance and servicing of equipment - Classification maintenance and cargo-gear approval - Lights on deck and in holds - Fresh water for crew's consumption - De-ratisation exemption certificate - Conformity with accepted international convention on liability for pollution - Any dunnage/shifting boards which may be on board	- Bunkers - Water for boilers - Towage and pilotage - Port agency attendance - Payment of port charges/light/tonnage dues, etc. - Payment of any canal tolls - Cargo handling - Payment of consular charges/except those payable to consulates of the country of the vessel's flag - Any required dunnage/shifting boards not on board

Table II: Responsibilities of the owner and the charterer under a time charter

On occasions a ship is chartered for a whole series of voyages, each voyage being considered to be a separate contract, with its own freight rate and conditions. This charter is called *consecutive voyage charter*.

Contract of affreightment is a contract by which the shipowner transports a given quantity of a specific commodity on a particular route over a given period of time, against a fixed freight rate per tonne. The average parcel size and frequency of transport determines the ships that the owner may use. This type of chartering is often used in LPG-gas, chemical and reefer shipping.

The Baltic and International Maritime Council, BIMCO in Copenhagen has developed over the last century of its existence, a folder with *Forms of Approved Documents*, which contains some 115 standard contracts used in the maritime industry.

10.3.4 Definitions

The *shipper or receiver* (consignee) is the owner of the cargo to be transported by sea. The shipper is often the exporter, while the importer is the receiver. The responsibility for the chartering depends on the conditions of the sales contract of the cargo. The two main types of conditions are known as CIF and FOB, which stands for, 'Cost, Insurance and Freight' and 'Free On Board'.
Under CIF-terms, the purchase price of the goods includes the payment of insurance and freight. Under FOB-terms, the goods are purchased at cost and delivered free onboard in the port of export. The importer has to make the shipp-

ing arrangements. Under CIF-terms the shipper charters the vessel; under FOB-terms the receiver charters the vessel.

The *shipowner or ship operator* is the owner and operator of the ship. The contract between the charterer (shipper/receiver) and the shipowner is called a *charter party*. A charter party concluded between the shipper and owner is called a *fixture*.

Laytime is the period of time agreed between the charterer and the owner in a voyage charter for the loading and/or discharging of the cargo. If a ship is forced to stay longer in port than allowed for in the charter-party (laytime) than the owner is entitled to extra charter hire in order to compensate for this delay, which is called *demurrage*. If, on the contrary, the ship is discharged in a shorter period than defined by the laytime, the owner has to repay the charterer a part of the charter hire, which is called *dispatch*.

10.3.5 Fixture reports

The daily fixtures are published by the shipbrokers and the specialised press such as Lloyd's List. Specialised consultants like Plymouth Maritime Analysis Ltd. in Sheffield, UK, provide monthly overviews of the charter fixtures, which can be used by the shipowner or charterer to follow the market or a particular ship in great detail. **Figure 6** shows the number of fixtures in this database for Panamax bulk carriers over the period 1989-1994, for three types of charters: period, trip and voyage.

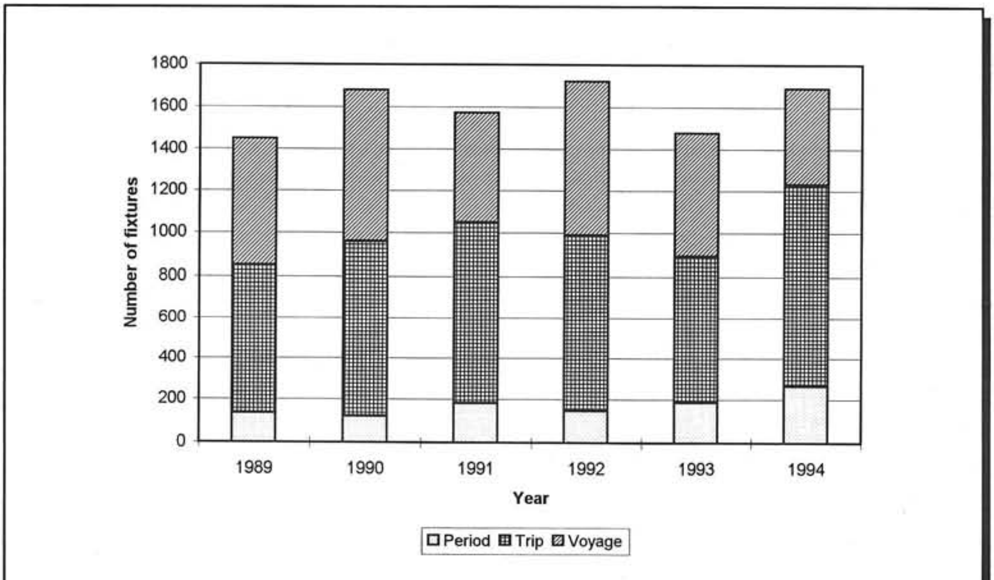


Figure 6: Annual number of fixtures of bulk carriers

10.4 Performance claims

Shipowners and charterers define their contractual relationship through a charter party, which contains all the elements for the definition of ship performance. In general these performance indicators boil down to four variables:

- Ship's speed;
- Revolutions/slip;
- Fuel consumption;
- Weather/sea conditions.

Ship's speed: most charter parties use the speed of the ship relative to the ground. This is distorted by the currents in the sea, and the extra resistance from waves and wind.
Revolutions/slip: the theoretical speed of the ship is calculated by multiplying the number of revolutions with a propeller constant (unique for each ship, and provided by the designer). Comparing this theoretical figure with the actual speed over the ground gives the apparent slip, expressed as:

$$\frac{(E-S)}{E}$$

Where:
E = engine speed
S = actual speed over the ground.

The apparent slip is very important for the calculation of the fuel consumption.
Fuel consumption: a ship uses often two types of fuels, for the main engine and boilers heavy or intermediate fuel, and for the auxiliary engines and galley marine diesel fuel. The fuel consumption is related to the speed of the ship and the amount of cargo in its hold, but also to the quality of the fuel.
Weather: most charter parties use as limit for the speed/fuel consumption the condition that the weather is *fair*, which means a wind force up to Beaufort 4. The Beaufort scale is shown in **Table III**. Ocean swell, wind waves and ocean currents are other important phenomena that impact the ship's speed.

The reader is referred to C.N. Hughes' book *"Ship Performance"* for a detailed discussion on the subject. Below follows a performance claim based on a trip time charter from a Dutch bulk carrier operator.

Number	Description	Wind speed (knots)
1	Light air	2
2	Light breeze	5
3	Gentle breeze	9
4	Moderate breeze	13
5	Fresh breeze	19
6	Strong breeze	24
7	Near gale	30
8	Gale	37
9	Strong gale	44
10	Storm	52
11	Violent storm	60
12	Hurricane	above 64

Table III: Beaufort scale

Charter party performance claims

Subject:

Evaluation of performance and fuel oil consumption during last laden voyage from Paranagua to Lorient:

m.v. General Grot Rowecki

Tonnage	GRT 23,409 tonnes NRT 13,760 tonnes
Port of Registry	Szczecin
Year of construction	1985
Owners	Polish Steamship Corp., Szczecin
Disponent Owners	Mafracht, Budapest
Operators	Thenamoris, Athens

In compliance with your instructions we attended on board the above vessel, as she lay moored alongside the premises and in drydock with Messrs. Wilton-Fijenoord in Schiedam, in order to hold survey as described under subject.

As per information obtained from the Master and Chief Engineer, which gentlemen informed us in accordance with the logbooks, from persual of relevant ship's documents and/or from own observation/calculation, the following was learned and/or noted:

General particulars:

Main engine — make: Sulzer
type: 6 RND 68 M
MCR: 7,950 kW. (10,800 BHP) at 137 rpm

Propeller pitch — according to the Chief Engineer: 3.45 meter, but official drawing not available.

Drydocking — 20th June 1987
First drydocking since her newbuilding

Speed and consumption according to Charter party — 15 knots on 28 t IFO plus 3 t MDO

Voyage Paranagua - Lorient

Departure Paranagua — 9th May 1987 at 11.30 hours (full away)
Draught forward 919 cm., After 1025 cm.
IFO 734 t - MDO 127 t

Arrival Lorient — 30th May 1987 at 15.30 hours (end of sea passage)
IFO 155.2 t - MDO 66 t

Date	Noon position		Distance steamed	Hours run	Average speed observed	Maximum wind force	Average engine r.p.m.
	Latitude	Longitude					
09/5			6	0.30	12.0	SE 3	-
10/5	23°50'S	43°46'W	261	24	10.9	S 5	116
11/5	21°25'S	40°02'W	257	24	10.7	SE 4	113.8
12/5	18°21'S	37°29'W	234	23	10.2	SE4/6	114.0
13/5	14°39'S	35°50'W	244	24	10.2	E 3	113.3
14/5	10°52'S	34°41'W	237	24	9.9	E 4/5	112.2
15/5	07°17'S	33°38'W	224	23	9.7	ESE 4	112.0
16/5	03°44'S	32°40'W	223	23	9.6	ESE 4/5	112.0
17/5	00°00'	31°24'W	236	24	9.8	ESE 4	113.0
18/5	04°02'N	30°11'W	253	24	10.5	ESE/N 2/3	112.8
19/5	07°58'N	28°54'W	248	24	10.3	N 4/5	112.0
20/5	11°39'N	27°42'W	232	23	10.1	NNE 5	112.0
21/5	15°32'N	26°27'W	243	24	10.1	NE 6/4	112.9
22/5	18°33'N	25°07'W	197	19.3	10.1	NE 6/7	-
23/5	22°14'N	23°14'W	245	24	10.2	NE 6/4	117.0
24/5	25°57'N	21°14'W	248	24	10.3	NE 3/4	115.8
25/5	29°37'N	19°16'W	245	23	10.6	NW 2/4	115.8
26/5	33°30'N	16°54'W	262	24	10.9	SSW 2/4	116.3
27/5	37°11'N	14°17'W	256	24	10.7	SSW 3/4	115.5
28/5	40°51'N	11°28'W	256	23.15	11.0	NE 3/4	116.3
29/5	44°10'N	08°17'W	245	24	10.2	NE 6/7	118.0
30/5	47°18'N	04°09'W	37	3.30	10.7	S 3	-

Total distance at sea — 4,889 nm
True steaming time — 473.75 hours
Average speed observed — 10.32 knots
Average engine revolutions — 114.2 rpm

Average engine speed	12.76 knots
Average propellor slip	19.2%
Average daily IFO consumption	29.3 t
Average daily MDO consumption	3.1 t

Stoppages

According to entries in deck- and engine logbooks, the main engine was stopped at sea for repairs as follows:

16th May 1987, 01.00-02.00 hrs.	for replacing fuel injectors nos. 1-3 cylinders
21st May 1987, 12.45-17.15 hrs.	for cleaning scavenge air cooler (cooling water side)
27th May 1987, 20.45-21.30 hrs.	for replacing fuel injector no. 6 cylinder

Total duration of stoppages: *6 hours and 15 minutes*

According to statement of the Chief Engineer, during the stoppages the vessel consumed 1 m/t MDO in the auxiliaries and 1 m/t MDO in her main engine in lieu of intermediate fuel oil. In our opinion the quantities stated must be considered fair and reasonable.

Underperformance

As can be seen from the aforementioned voyage particulars, in not one single stage of the voyage, the vessel performed in conformity with her description, which fact the Master attributed to fouling of the underwater hull and adverse weather and current encountered en route.

The extremely high propeller slip of almost 20% also points to hull fouling.

The main engine exhaust gas temperatures had been logged as 430°C. maximum throughout the voyage. As this temperature for this type of engine is about the maximum permissible, the engine revolutions were maintained at 112/113 rpm and could not be increased.

Some improvement was achieved after cleaning the cooling water space of the scavenging air cooler on the 21st May 1987, when the engine revolutions. were slightly increased to about 116 rpm at equal exhaust gas temperatures.

In order to approach vessel's performed speed as accurately as possible, a comparison is drawn between the speed maintained during periods of good weather and periods of less favourable weather, according to the deck logbook, as follows:

	Dates with good weather	Dates with wind force exceeding Bft 4
Distance steamed	2524 nm	2365 nm
Steaming time	241.25 hrs	232.5 hrs
Average speed observed	10.46 knots	10.17 knots

Note:

Under good weather we understand winds up to and including force 4 on the Beaufort scale.

Weather factor: 10.46-10.17 = *- 0.29 knots*

The relevant pilot charts indicate an average current factor on the track followed of *- 0.3 knots*

Performed speed: *10.76 knots*

Time lost

Total distance steamed	4,889.0 miles
Equivalent of weather factor in miles (232.5 x 0.29)	67.4 miles
Equivalent of current factor in miles (473.75 x 0.3)	142.1 miles
Equivalent good weather distance	5,098.5 miles

True steaming time 473.75 hours.
Thus, time lost 473.75 - (5,098.5 / (12.5 - 0.5) = *48.9 hours*

Note:

At the request of our principals, we applied an allowance of 0.5 knot for the phrase 'about'.

Overconsumption

IFO consumption according to logbook	578.8 t
Calculated consumption in case vessel would have performed according to her description, including 0.5 knot allowance (5,098.5/12 * 28/24)	495.7 t
Overconsumption of IFO (578.8 - 495.7)	*83.1 t*

MDO consumption according to logbook minus consumption during stoppages	60.0 t
Calculated consumption, if vessel would have performed in accordance with her description including 0.5 knot allowance (5,098.5/12 * 3/24) =	53.1 t
Overconsumption of MDO	*6.9 t*

Note:

Since fuel consumption and speed relate to each other by the 3rd power, the allowance of 0.5 knot comes down to almost 12% allowance in fuel oil consumption.

Fouling

With the consent and approval of the Master, we re-attended on board on the 20th June 1987, when the vessel was placed in drydock and cleaning of the hull had not yet commenced.

It was noted that the hull below the waterline formed by the forward 3 metre and after 4.5 metre draught marks was seriously fouled with barnacles. The tallest barnacles (up to 2.5 cm.) turned up mainly in way of the turn of bilge, above and below the port- and starboard bilge keels and in patches on the flat bottom and sides. These areas obviously escaped the attention of divers during last underwater cleaning.

Above the waterline, mentioned above, up to loaded waterline, lesser scattered fouling was noted in the form of smaller barnacles, other animal species and plant origin, such as algae and weeds.

The hull plating, bare of any paint protection, proved to be rusted and scaled, which condition undoubtedly contributed to increased resistance. The Master stated that fouling was known already for a long time.

Heavy paint abrasion occurred in the winter of 1985/1986, when the vessel first in loaded condition and afterwards in ballast condition, proceeded in pack ice in the Baltic.

Underwater cleaning (by rota brushes) was effected for the first time at Hamburg in June 1986. Last underwater cleaning was carried out at Santos and Paranagua, just prior to delivery in current charter.

From available literature, it is known that barnacles start from a microscopic egg sage to reach the swimming stage in a period of about 4 weeks. After that they develop a suction disc with adhesive medium, by which they stick to solid surfaces, such as ship's bottoms.
It takes a period of about 8 months, depending on the prevailing conditions from the time of birth, till the animals become adult.

However, the transformation itself from the freely swimming larva to the barnacle firmly attached to ship's bottom, takes only about two to four days.

Barnacles usually exist in all temperature and warm zones. The risk of fouling is not the same in all water and during all seasons. In cold and temperate waters, the risk is less than in tropical waters. In the former fouling may be seasonal, contrary to the latter, in which fouling may develop all over the year.

Fouling by barnacles can only develop when the anti fouling paint has lost its effectiveness and when the vessel is lying idle and current speed less than two knots.

In view of the dimensions of the barnacles and lack of anti fouling, the original infestation must have taken place already a long time prior to commencement of the charter period.

Summary

Summarising the above particulars, we arrive at the following interferences:

- The vessel did not perform in accordance with her description, mainly due to hull fouling/roughness and to some lesser extent also due to defiled scavenging air cooler.The speed in good weather and corrected for current influence turned out to be about 10.76 knots only.
  The main engine revolutions were maintained at 112/116 rpm and could not be increased in view of high exhaust gas temperatures.
- The time lost and overconsumption of fuel oil was calculated as 48.9 hours and 83.1 m/t IFO plus 6.9 m/t MDO respectively.
- The main engine was stopped at sea for repairs for a total period of 6 hours and 15 minutes, during which the vessel consumed 1 m/t MDO in the auxiliary engines and 1 m/t MDO in the main engine in lieu of intermediate fuel oil.
- Fouling of the hull existed already before commencement of the charter period and obviously could come into existence, as a result of excessive anti fouling paint abrasion, when proceeding in ice in the Baltic in the winter of 1985/1986.
  Paint abrasion also resulted in increased roughness of the hull and therewith coherent increase of resistance.

10.5 Sale and purchase

The ship market is segmented into the newbuilding, secondhand and demolition market. Shipbrokers are often active in these markets as intermediaries between the seller and the buyer. In the newbuilding segment the broker is used for his knowledge of the available shipbuilding slots with the various yards around the world, and he adds value by helping to arrange finance, provide building supervision and he can keep the prospective owner's name anonymous. The secondhand ship sale and purchase market is one of the mainstays for the brokers. A part of this segment can be defined as the sale for scrap. As in ship chartering, sale and purchase (S&P) brokers are only paid a commission on successfully concluded deals, as a fixed percentage of the price.

The role of the S&P broker is to ascertain whether the information provided by the shipowner is correct and up-to-date and the certificates of flag and classification are valid. Ships are often renamed and modified during their lifetime. Classification societies publish Register Books with all the particulars of the ships. Fairplay publishes an Encyclopedia with quarterly updates on all the merchants ships in the world on cd-ROM.
A major function of the S&P broker is to value the ship for the owner, but also for the financial institution that provides the loan for a part of the purchase price. Brokers value ships by closely monitoring the historical price development of each ship type; Some brokers have developed an extensive knowledge of oil tankers, while others know everything of reefer ships or LPG carriers.
The S&P sales are reported in various journals and magazines, but also in newsletters from leading brokers. The ships that are for sale, are circulated by the brokers with prospective buyers. These may ask for further details of the vessel, and if they are interested, they will decide to make a firm offer for the purchase of the ship, conditional to among others the inspection of the vessel.

Once the buyer is satisfied that all his conditions are met, and the price is agreed, then the broker will draw up a standard contract known as BIMCO Sale. A detailed account of the S&P procedures can be found in W.V. Packard's *"Sale and Purchase"* (Fairplay Publications, 1988).

The supply side of ships is determined by the size of the existing fleet, the newbuildings on order, the losses through accidents and the scrapping. Scrapping or demolition is a very important variable, which is closely related to the level of the freight market and the price of scrap steel.
The level of the freight market is reflected in the amount of tonnage that is laid-up. **Figure 7** shows the development of the number and gross tonnage of the demolished ships over the period 1970-1989. In the years 1985 some 22 million gt was scrapped.

The buyer of the secondhand ship for demolition purposes is always a scrapyard. These yards like to know with great precision the ship's weight and delivery condition, such as delivery port and date, execution of tank cleaning, ship's condition and equipment. Based on this information the scrapyard will make a calculation of all costs and benefits involved in the purchase, ship breaking and sales of the material and equipment. An example of this calculation is shown below. The sales contract for demolition is also standardised and can be found as SALESCRAP 87 in the BIMCO forms of approved documents.

Example of estimates for purchasing ships

Table IV shows a calculation of the maximum price a shipyard can pay for a ship. The characteristics of the ship are:

Type:	Diesel ore/oil carrier
Gross tonnage:	48,900 gt,
Light ship weight:	16,040 tonnes

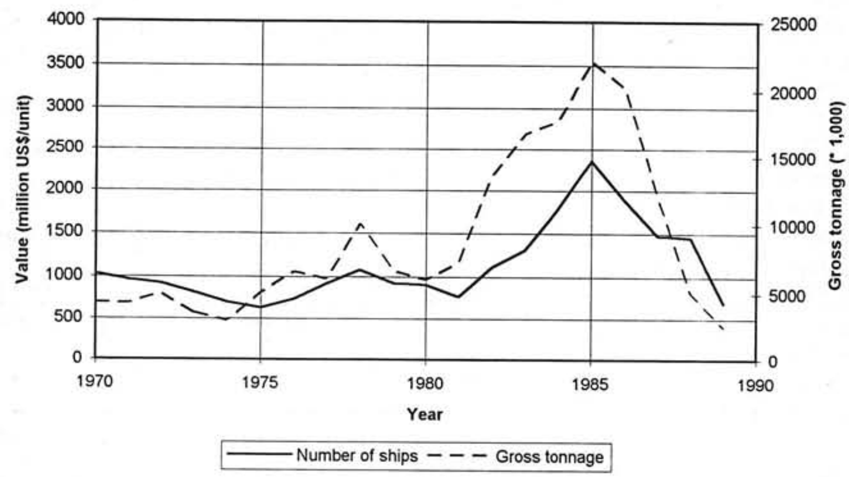


Figure 7: Number of ships and gross tonnage demolished

Age: 15 years
Estimated recovery rate: 92.0%

In the field of this business, ship's price is expressed in US$ per light displacement tonne (LDT) of the ship. So, negotiation shall be held with the seller's idea price based on this figure.

Total weight of products shows the value deducting estimated weights of worthless goods, wear and tears, reduction by gas curring, etc., from the ship's light displacement tonnes (LDT). Recovery rates are, though there are big fluctuations by the difference of ship size, type, age, particulars and grade of maintenance, etc., as follows:

	Larger ship	*Smaller ship*
Tanker, ore carrier	90 - 95%	85 - 89%
Bulk carrier	88 - 93%	85 - 88%
General cargo ship	85 - 91%	80 - 85%
Fishing boat or reefer ship	73 - 80%	68 - 75%

For the estimation of wages, payments for subcontractors, general indirect costs, etc., it is convenient to use estimated unit prices by tonnes of products, derived from accumulated data peculiar to the yard.

Item	% of total weight	Quantity (t)	Unit price (US$)	Price (US$)
Sales income				
Used steel plates	5.7	850	280	238,000
Rerolling materials	60.0	9,000	210	1,890,000
Common steel scraps	30.0	4,500	160	720,000
Cast iron scraps	1.3	190	140	26,600
Misc. steel materials	1.1	170	310	52,700
Non-ferrous metal scraps	0.8	120	1,700	204,000
Used machineries and equipments	1.1	170	450	76,500
Sales income total	100	15,000		3,207,800
Work expense Wages and/or payments for subcontractors, and General indirect cost		15,000	17 US$/t	255,000
Special estimated direct expense to the ship				
Mooring charge (tug boat hire fee)				2,400
Cleaning fee inside of ship				4,200
Hire fee of large capacity floating crane				7,000
Insurance (assume 0.01% of sales income)				3,200
Custom fee				136,400
Interest (about ship purchasing funds)				68,100
Work expense total				476,000
Expected profit				5,000
Limit ship's price to purchase			US$ 170/LDT	2,726,800

Table IV

10.6 Shipping management

The management of a ship is closely related to the type and size of shipping organisation. There is no standard shipping organisation, but some typical structures will be discussed here. The development from the traditional ship organisation to the more advanced concepts is well described in J.M. Downard's *"Managing Ships"*.
The traditional organisation was based on the sailing era, in which the ships departed on an adventure around the world, a world in which communication was virtually impossible as well as modern banking services. The master was the manager of the ship and actually of the shipping organisation. The introduction of the steam engine and later on the diesel engine, required a higher technical knowledge onshore as well as improved communications. The traditional shipping organisation had evolved in the 1930s to the form as depicted by **Figure 8**.

This organisation shows the development of separate functions for the engineer, the supply, accounts and insurance, but for most, the sales or commercial func-

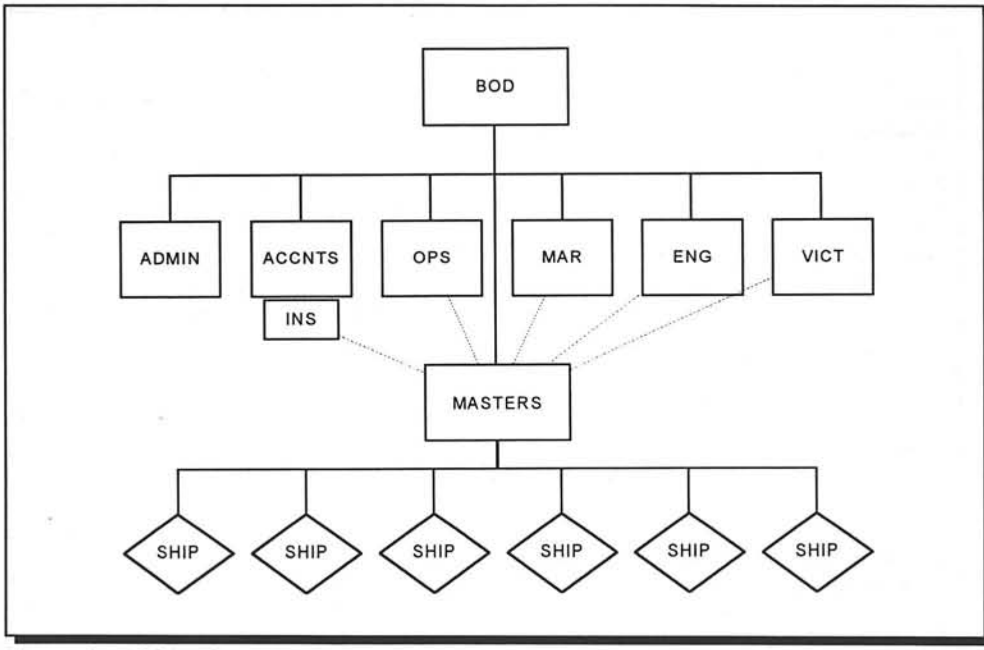


Figure 8: 1930s Organisation

tion, i.e. the chartering or liner departments ashore. The shipping organisation did not have to rely any more upon the masters to do business. The owner/manager function was supported by a staff of professionals, while the role of the master was reduced. In the seventies, this model evolved further into the ship group structure (**Figure 9**). This ship organisation saw the introduction of fleet managers, the predecessors of the modern independent ship management companies.

The typical shipping company today consists of a shore based organisation as shown in **Figure 10**, and a ship based organisation as shown in **Figure 11**. These figures are taken from Bureau Veritas' *"Manual for the introduction of management systems in shipping"* and are based on the International Safety Management (ISM) Code and the ISO 9002 standard. This manual also visualises the principles activities of the typical shipping company, in the form of flow charts. **Figure 12** shows the main process of the company, which can be segmented into four sub-processes: Voyage charter, time charter, bareboat charter and pool agreement. **Figure 13** shows the flow charts of the time chartering activity.

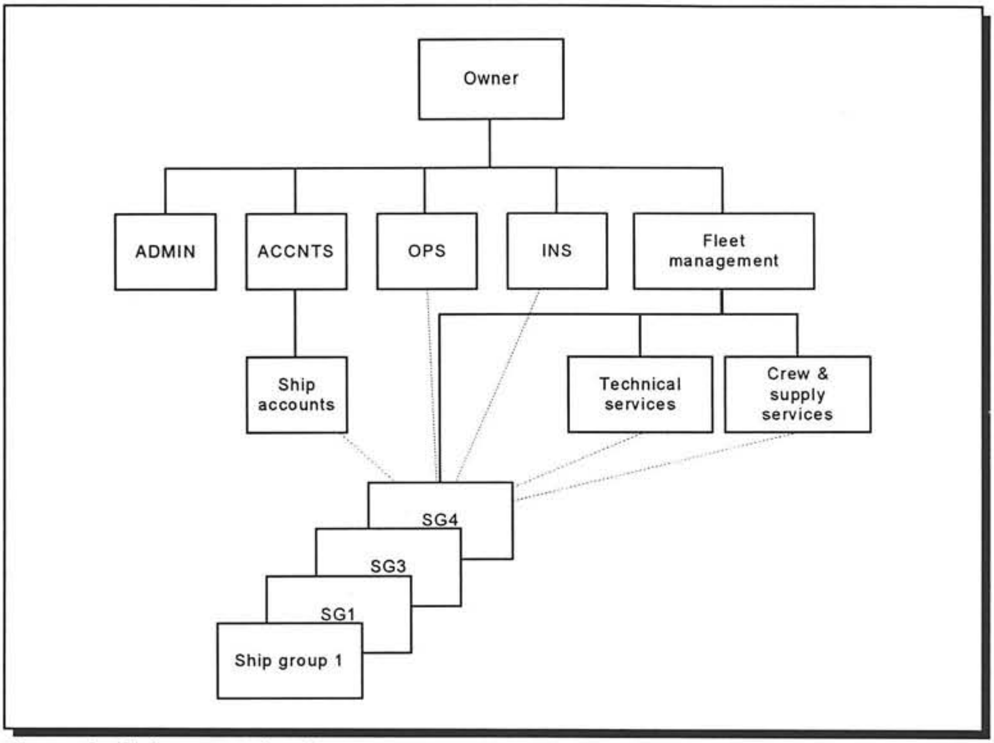


Figure 9: Ship group development

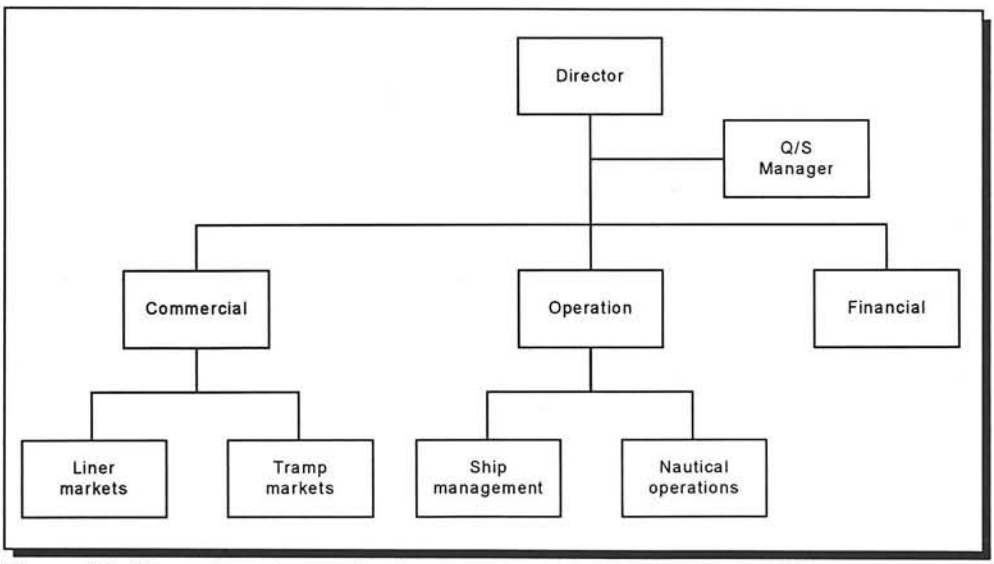


Figure 10: Shore based organisation

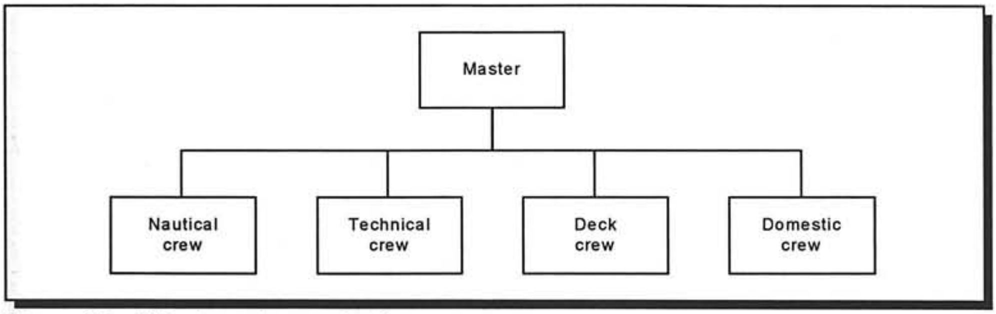


Figure 11: Ship based organisation

10.6.1 Technical and nautical ship management

Ship management also involves the management of the ship in the sense of keeping the ship in good condition and providing the competent crew at the right time. In **Figure 10** these items are captured under: Operation, ship management and nautical operations. Ships are very complex technical and operational systems, as can be illustrated by the diagram from Drewry Shipping Consultants, see **Figure 14**. The main elements of operational ship management are: Structure, machinery, services, navigation, pollution control, cargo, medical, mooring, communications, hotel, safety and steering.
This requires a competent shore based staff, but also ship based personnel that is able to solve problems on their own. The technical staff can rely on maintenance systems from the suppliers, and various management support systems.

The main focus of the nautical operations concerns the: Crew hiring, training and scheduling onboard the ships. This is often a very complex task, for example in the chemical tanker business. The officers and ratings need many qualifications in order to be allowed to work on ships that transport dangerous cargo.
An example of the complexities involved is provided by Stolt Parcel Tankers in Houston, which company developed the OnBoard software (*"Stoltn"*, December 1995). They developed a Windows application that is made up of three major user components and one system administration component. Each of these components supports the life cycle of the seafarer as illustrated by **Figure 15**.
The scheduling module consists of two components, each of which helps to ensure that the right personnel is assigned to a ship and that such assignments are made in a timely and efficient manner.

Yet another development in the management of ships are the extended services from companies like WNI Ocean routes. Onboard, the captain may chart his course on the basis of the latest, on-line weather forecasts, using advanced tools, such as provided by the Onboard Guidance System, Orion. **Figure 16** shows the display of weather and routing options. This information enables the captain to reduce the voyage costs of the ship.

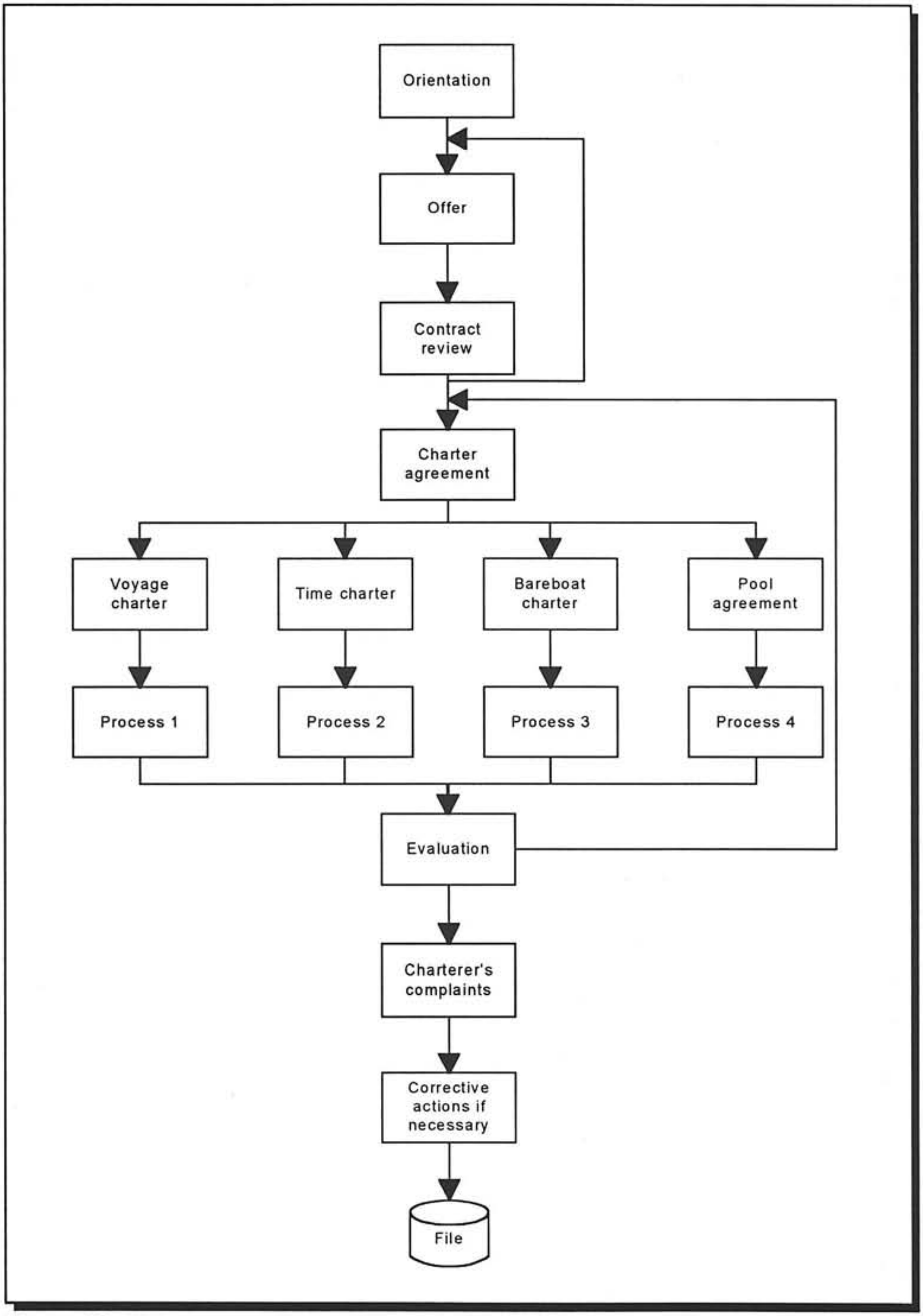


Figure 12: Main process of the company

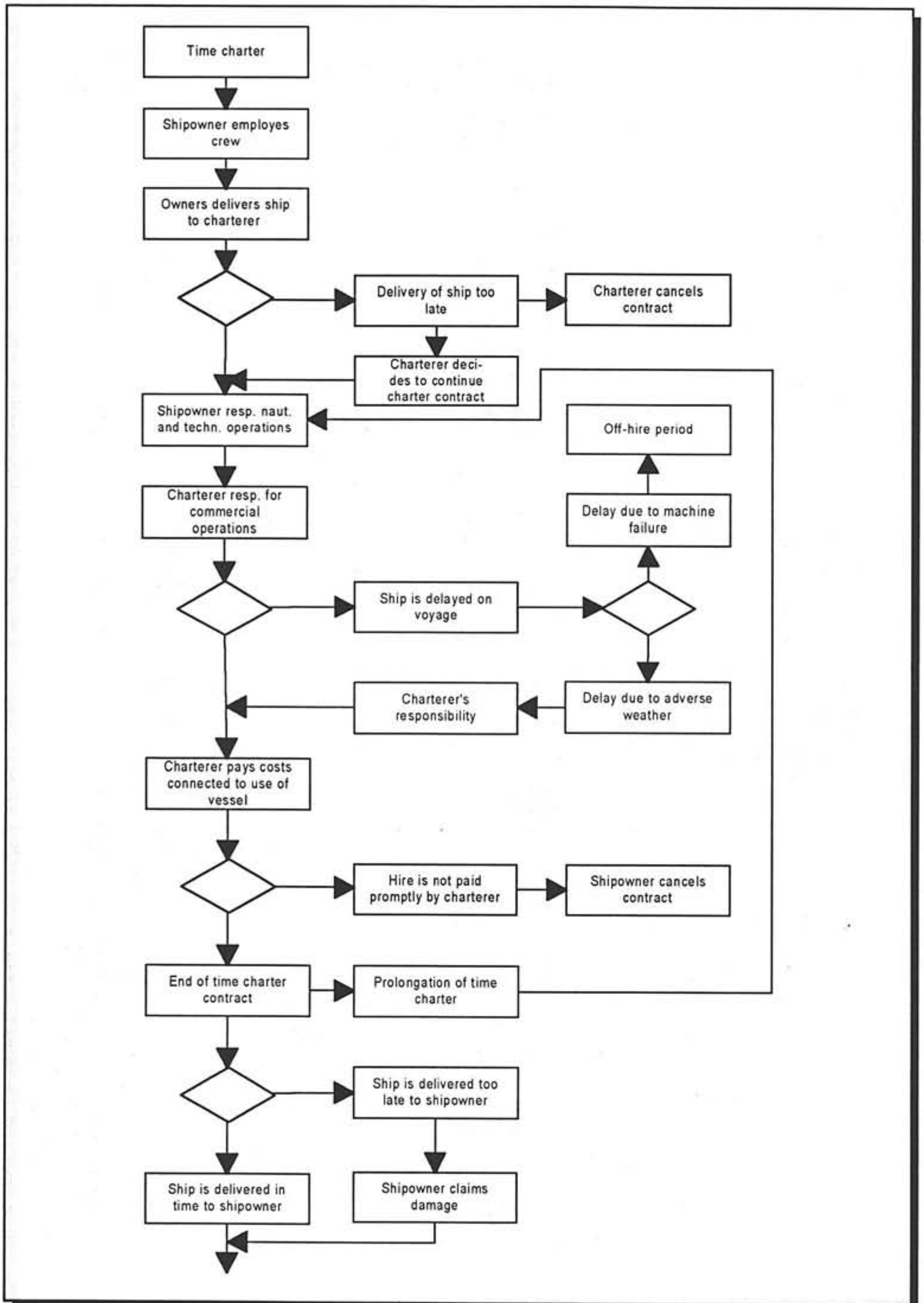


Figure 13: Time chartering activity

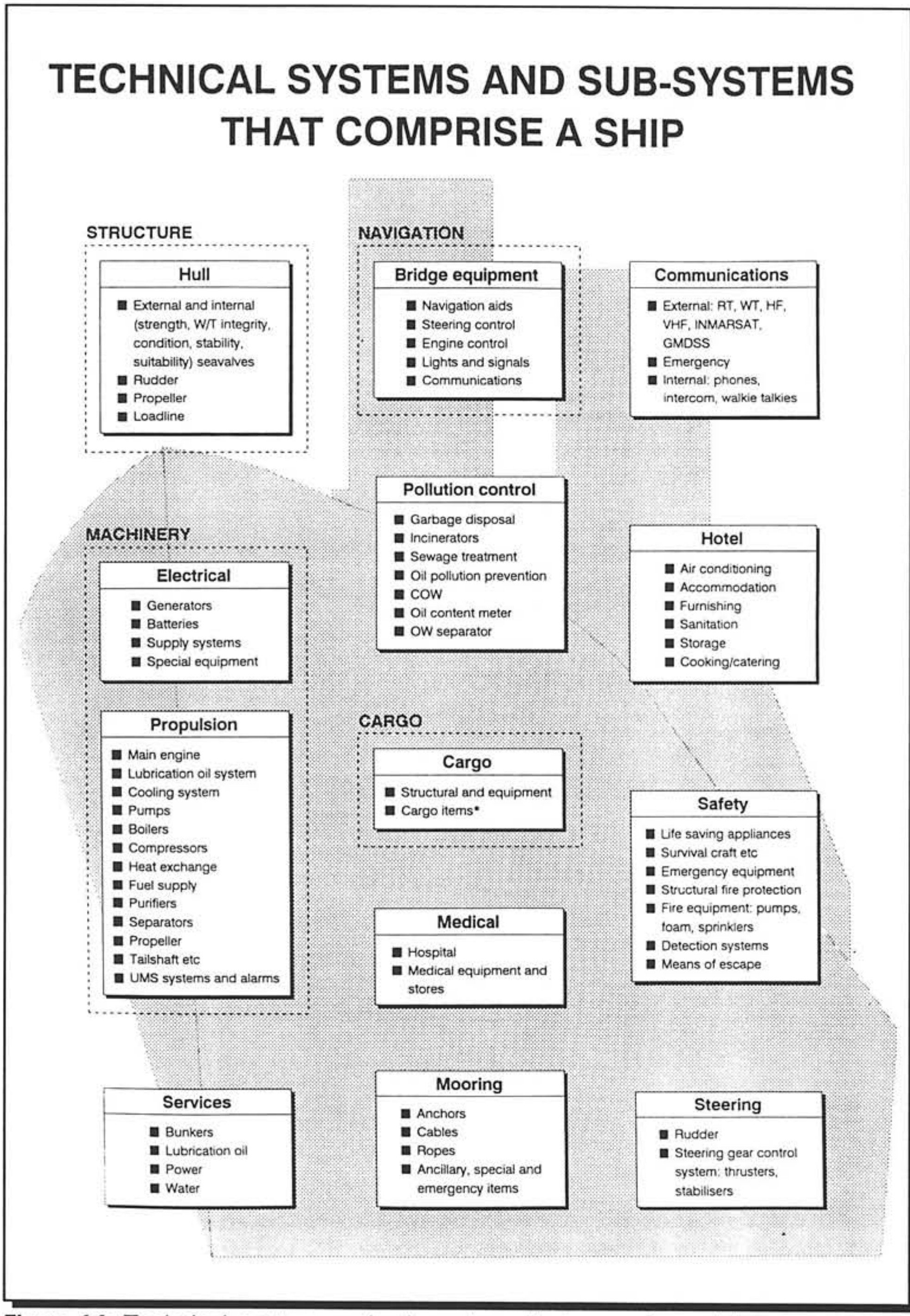


Figure 14: Technical systems and sub-systems that comprice a ship

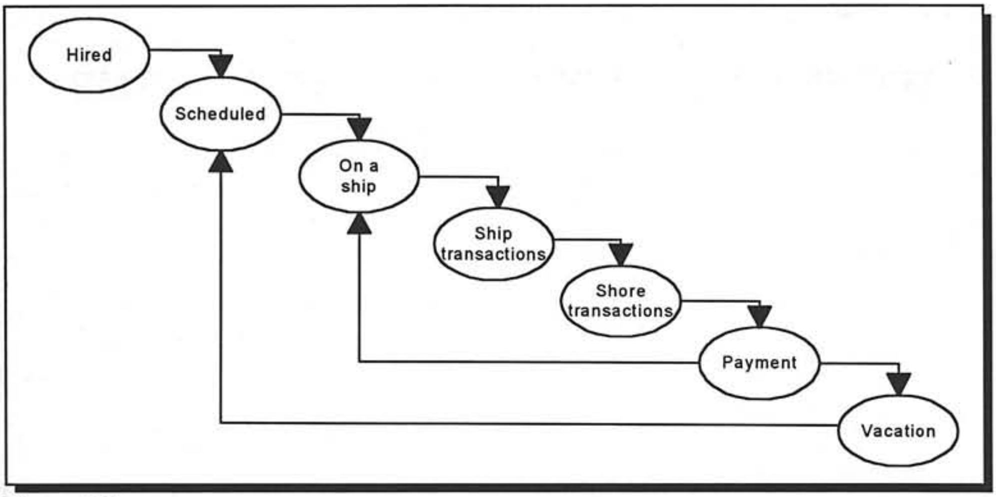


Figure 15

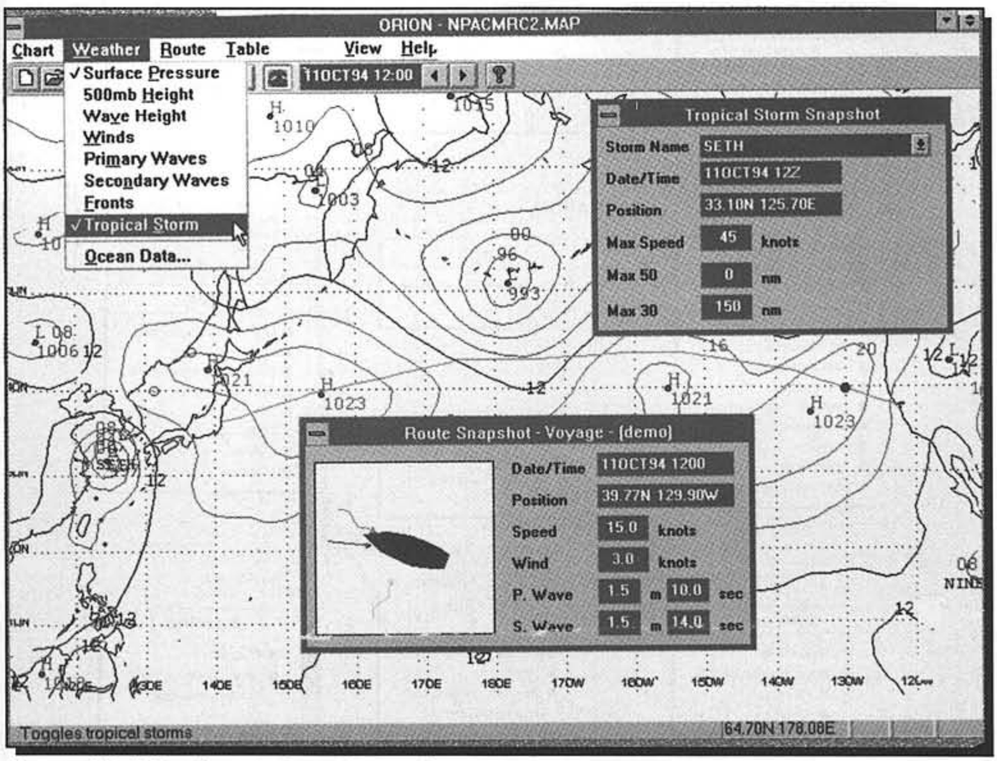


Figure 16: Weather and routing options

Onshore, the ship's course can be tracked with the help of the global positioning system. This enables the fleet management to make accurate predictions on estimated times of arrival and create an accurate database in case of charter performance disputes. **Figure 17** shows the typical display of this information.

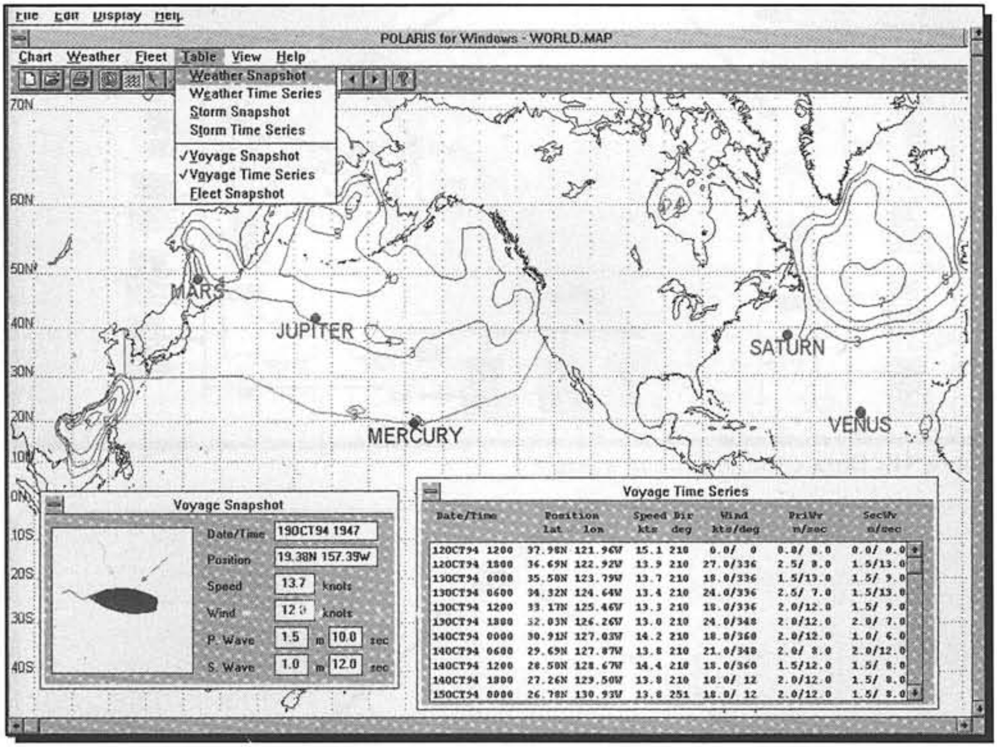


Figure 17: Fleet management information

Ship management has greatly advanced over the last years, which is mainly attributable to the increased possibilities and relatively low cost of satellite communications. This is illustrated by some diagrams from the magazine of Jo Tankers.

Figure 18 shows the ship's system, based on data communication via satellite, and how the information from the ship is processed at the shore based office.

The costs of communication can be greatly reduced as well. For example, a traditional telex message of 400 words sent via the Inmarsat network will take approximately 7 minutes, while using data communication, the same message can be sent in 15 seconds, including time to set up the connection. A reduction in communication costs of 85% seems possible.

Modems have also increased the efficiency of the captain on board. The captain is now able to send a message to the technical superintendent, a copy to the operator and a copy to a local agent in one transfer (**Figure 19**).

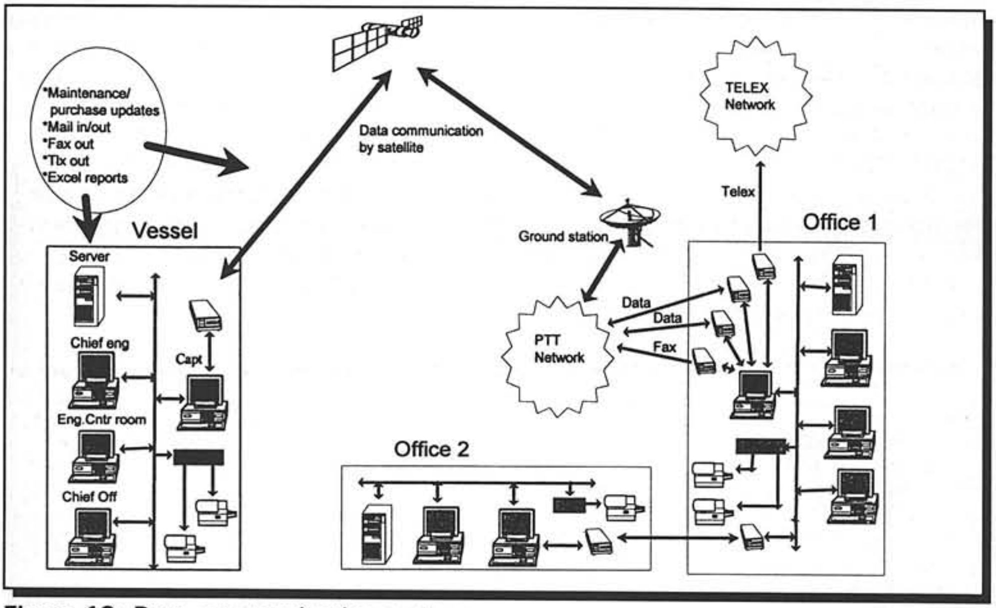


Figure 18: Data communication system

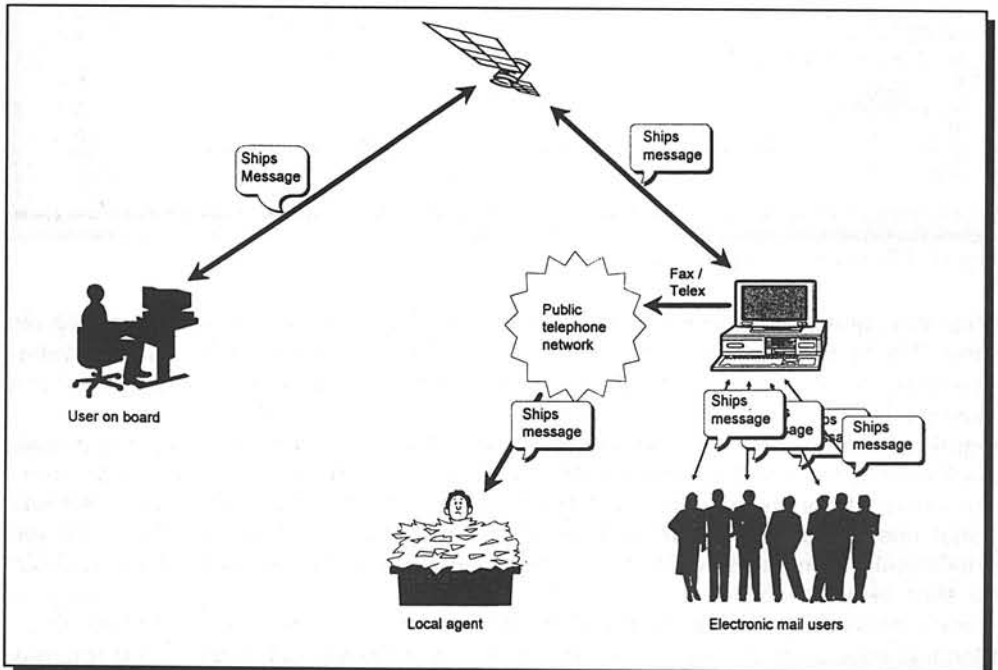


Figure 19

10.6.2 Quality management

All the major classification societies have issued a manual like the one of Bureau Veritas. The objective of these manuals is to facilitate the certification of the shipping company. The need for this has arisen since the accident level in shipping has risen to unacceptable levels. The basic causes of these accidents prove *human error* to be the most common cause of accidents. **Table V** shows an analysis of 7000 major casualties over the period 1981-1990 and their cause, which underscores this statement.

Cause	Percentage (%)
Grounding, stranding	19.3
Negligence of crew, repairer, owner, etc.	18.6
Collision, contact (with quay)	14.7
Hull failure (including due to heavy weather)	14.7
Failure of equipment, electrics, machinery	10.0
Unknown cause	8.1
Fire and/or explosion	4.6
War	3.3
Navigating in ice	2.2
Design by fault	1.4
Hurricane/typhoon	1.1
Latent defect	0.9
Miscellaneous	0.9
Cargo shift	0.2

Table V: Cause of casualties

The term human error may easily mislead us to draw too simple conclusions, as it tends to point the finger to the person who happened to do the mistake. The basic causes of accidents, however, are most often factors over which management exclusively has control i.e. shipboard and shore based management.
The understanding of this was why shipboard and shore based management was put on the agenda of the IMO Maritime Safety Committee and the Marine Environment Protection Committee in November 1987. This resulted in the development of the *International Management Code for the Safe Operation of Ships and for Pollution Prevention*, also referred to as the *International Safety management Code* or ISM Code.
The introduction of safety management into shipping is therefore not the result of shipping joining the quality movement that today penetrates most industries, but is rather based on the understanding that adequate levels of safety and environmental protection demands management of safety, onboard and onshore.

The ISM Code has already become mandatory for certain shipping activities like chemicals shipping, while it will become mandatory for all the other sectors in the years to come.

When one observes the losses of bulk carriers and spills caused by tanker accidents, the general public has a feeling that quality management is long overdue in shipping. These feelings are voiced and reinforced by journalists such as E. Nalder, who wrote *"Tankers Full of Trouble"*. In the aftermath of the *Exxon Valdez* accident, he investigated the life onboard the crude oil tanker Arco Anchorage, which transports oil from Valdez in Alaska to Cherry Point in Washington State.
His compelling story is rather topical; can one generalise from this example? Arthur McKenzie, publishes since 1982 the *"Guide for the Selection of Tankers"* in which he rates all the tankers in the world fleet over 10,000 dwt. He assigns a rating ranging from 5 (high), 4 (very good), 3 (good), 2 (fair), 1 (low), which is based on a number of factors, such as: Casualties, age, name changes, owner's total losses & oil spills, owner's length of time in ship owning, classification society, flag.
It is for example assumed that the greater the number of reported casualties, the greater risk the vessel poses for the charterer. **Table VI**, taken from the 1992 Guide, indicates the accuracy of the ratings as predictors of casualties, total losses & oil spills. About 15% of the tankers each year sustain a reported casualty. Approximately 2-3% of the vessels sustain an important casualty each year. Over a twenty year period an average of less than 0.5% of the oil carriers are total losses annually.

Ratings		All casualties		Total losses		Oil spills	
	Number	Number	%	Number	%	Number	%
High - 5	356	18	5.1	0	0.00	1	0.28
Very good - 4	1,009	115	11.4	0	0.00	4	0.40
Good - 3	862	123	14.3	4	0.46	7	0.81
Fair - 2	802	116	14.5	2	0.25	12	1.50
Low - 1	350	135	38.6	4	1.14	2	0.57

Table VI: Casualties

Table VII shows the very good rating (4) of Van Ommeren Tankers for the year 1992.

10.7 Third party ship management

Ships are traditionally managed by their owners. After the second oil crisis in 1979, the slump in the tanker industry led the managers to cut costs to the bone. This resulted in inadequate maintenance levels, the registration of ships in open

								Casualties		
Rating	Name	Mdw t	Age	Type	Hull	Flag	Class	Date	No	*
5	Mascarin	32	6	mt		fr	fr		0	0
5	Port bara	30	10	mt		fr	fr		0	0
4	Port au prince	33	13	mt		fr	uk		0	0
4	Port blanc	38	17	mt		fr	fr		0	0
4	Port royal	46	10	ms	d h	fr	uk	86	1	0
4	Port vendres	25	19	mt	ice	fr	fr		0	0
3	Port anna	11	21	ms	3	fr	fr	72	1	0
3	Port isabelle	40	10	ms		fr	fr	90	2	0
	Average	32	13						0.5	

Table VII: Rating of Van Ommeren Tankers

registries, the replacement of traditional seafarers, with cheap crews from developing nations. This movement was reinforced in the mid-eighties when the freight rates hit bottom in the dry bulk markets.
Another way to reduce overhead costs was to leave the management of the ships to specialised, independent ship managers, in particular when the shipowner only had a limited number of ships to manage. These developments led to the phenomena of the third party ship manager, which makes it his business to manage ships on behalf of owners. Banks may use ship managers, as they often become shipowner against their own will when the bank, as a first mortgage holder on the ship, had to auction the ship when the owner could not fulfill his financial obligations towards the bank.
In his book *"Ship Management"*, J. Spruyt shows a concise overview of the decision tree of the shipowner faced with survival choices (**Figure 20**). The ultimate option of the shipowner in the developed countries was to reflag the vessel and thus create the possibility of employing cheap crews. During this period of fundamental change in ship management, the types of shipowners have also evolved.

The independent ship manager provided a valuable new type of service in shipping. Specialised managers could create economies of scale in management and thus reduce the costs. In return these managers receive a modest fee for their work, which depends on the ship type and size, but hovers around US$ 100,000 per year per ship.
As the initial threshold for the third party ship manager was rather low, several hundreds of companies sprung up. An overview can be found in Fairplay's *"Ship managers Guide"* .

In order to raise the professional standards, the major ship managers in the world, known as the Group of Five (Barber International A/S, Oslo; Columbia Ship-

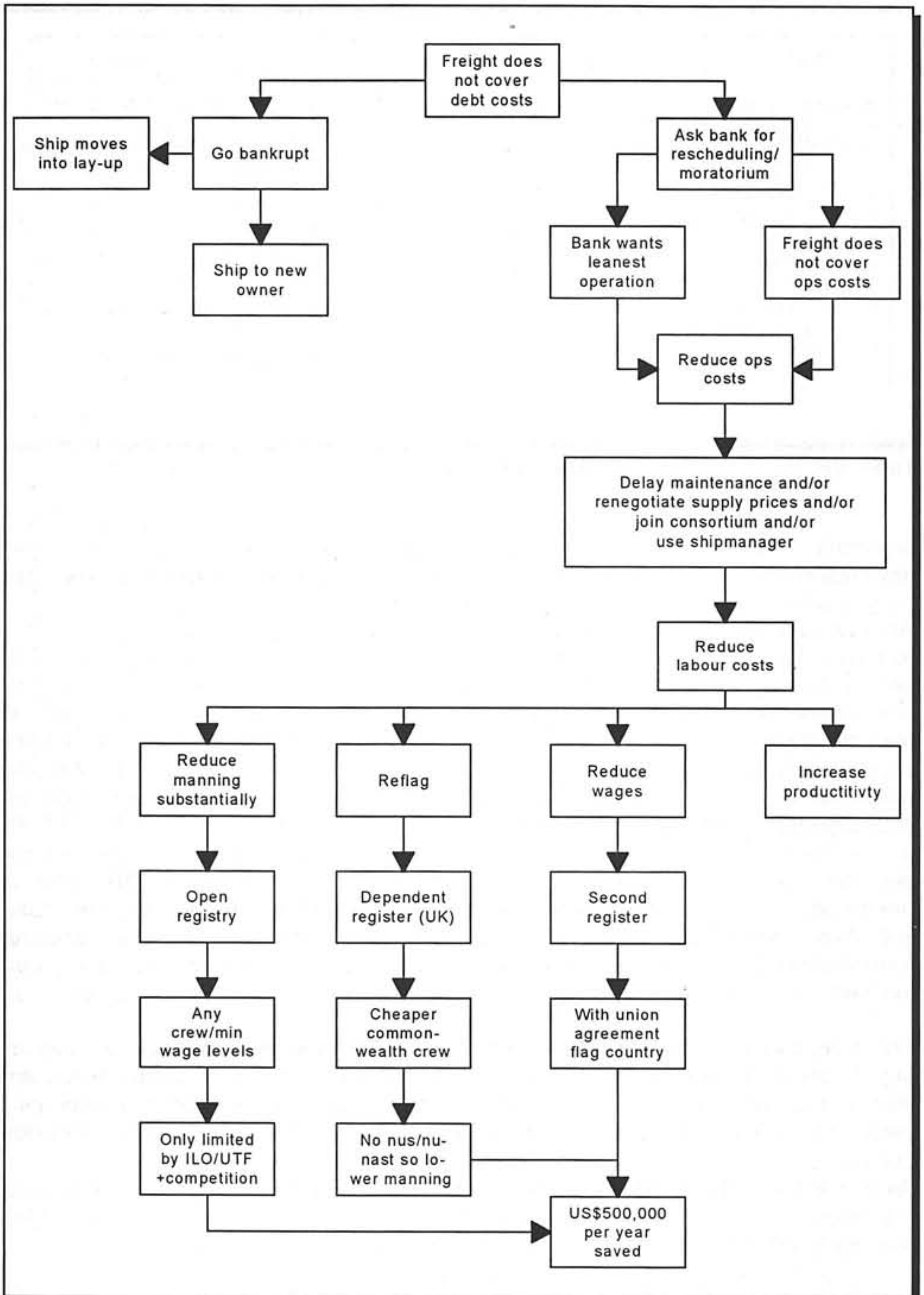


Figure 20: Shipowner in the 1980s with European flag and crew - survival choices

Owner type	Definition
Owner/manager	A company or individual that owns and wholly controls its own ships
Registered owner	The name of the company or individual under which a vessel is officially registered
Manager/managing agent	A company that specifically manages vessels for companies that do not have the resources to manage their own vessels and, in addition, may also manage vessels owned by itself or associated companies
Beneficial owner	Someone who has a contractual or equitable interest in the vessel other than the registered owner or mortgagee. The beneficial owner assumes the rights and liabilities of the registered owner
Managing owner	An individual, who acts as manager for a number of vessels in which he has a financial interest with a different group of individuals
Leasing company	A company formed usually by a financial organisation in order to finance the purchase of vessels. These vessels are then leased to various companies, which wholly operate them, the leasing company playing no part in the operation of them
Disponent owner	The disponent owner is the lessee company, which wholly operates a vessel, whose registered owner is a leasing company.
Operator	A loose term for any company or individual engaged in operating vessels

Table VIII: Owner type definitions

management Ltd., Limassol; Denholm Ship Management, Glasgow; Hanseatic Shipping Company Ltd., Limassol; Wescol International Marine, London), launched in June 1991 the *Code of Ship Management Standards* of the International Ship Managers Association (ISMA). This ISMA Code should not be confused with the ISM Code from the IMO.
The ISMA Code for Quality Ship Management specifies requirements for quality assured ship management and operation. Compliance with this Code by a ship management company will ensure that it operates with quality assured systems. The current members of ISMA are shown in **Table IX**.

The objectives of the code are defined as follows:

- Operating the ship and transporting cargo safely and efficiently;
- Avoiding injuries to personnel and loss of lifes;
- Conserving and protecting the environment;
- Protecting the owners' assets, which are entrusted to the ship manager;

Company	Country
Anglo Eastern Ship Management	Hong Kong
Wallem Shipmanagement Ltd	Hong Kong
Eurasia Shipping & Management Co	Hong Kong
Denholm Ship Management (Overseas) Ltd	Hong Kong
Arbross Ship Management	Hong Kong
Transocean ShipManagement GmbH	Germany
Chemikalien Seetransport GmbH	Germany
Amer Shipmanagement Pte Ltd	UK
Denholm Ship Management (Holdings) Ltd	Scotland
James Fisher & Sons pic	UK
Marine Management Services Ltd	Isle of Man
AV Seawork Ltd.	UK
Midocean Shipmanagement Ltd	UK
Split Ship Management	Croatia
Libra Group	Brazil
Neptune Shipmanagement Services (Pte)	Singapore
Thomas Ship Management Pte Ltd	Singapore
Sembawang Johnson Management Pte	Singapore
Hanseatic Shipping Co Ltd	Cyprus
Columbi Shipmanagament Ltd	Cyprus
Marlow Navigation Co Ltd	Cyprus
Navigo Management Co	Cyprus
Chrysses Demetriades & Co	Cyprus
Interorient Navigation Co Ltd	Cyprus
Chemical Tankers of America Inc	USA
Apex Marine Corporation	USA
International Marine Carriers	USA
Stolt Parcel Tanker Inc	USA
Jebsens Ship Management Holding	Norway
Schlumberber Geco Prakla	Norway
Seatrade Groningen BV	Netherlands
Islamic Republic of Iran Shipping Lines	Iran
Seabridge SA	Switzerland
Shiseree SA	Switzerland
Barber International Ltd	Malaysia

Table IX: ISMA members

- Complying with statutory and classification rules and requirements;
- Applying recognised industry standards when appropriate;
- Providing the owner with sufficient, accurate and timely information about the operation and status of the ship;
- Continuous development of skills, systems and understanding of the business;
- Preparing for emergencies.

Quotations for ship management

This section shows an example from the book *"Ship Management"*, about the quotation for New Bulk Shipping Ltd.

MV *Ashburnham*

1981 bulk carrier 26,354 dwt
Insured value US$ 12 million

	US$/month	% of Total
Wages, vacation and overtime	37,000	44.5
Relieving & repatriation	3,000	3.6
Port communications, misc.	3,000	3.6
Stores	5,000	6.0
LubricantsVictualing	4,000	4.8
	3,500	4.2
Running repairs	6,000	7.2
Spares	7,000	8.4
Management fee	6,000	7.2
Insurance	8,700	10.5
Total costs (excl drydocking)	**83,2000**	**100**

Daily operating cost (excluding drydocking) US$ 2,735/day

Assumptions

1. Crew complements for vessels are as follows, using European senior officers and Filipino junior officers and ratings:

European (2)	*Filipino (8)*	*Filipino (12)*
Master	Chief officer	Bosun
Chief engineer	Second officer	3 * AB
	Third officer	2 * Ordinary sailors
	Radio officer	2 * Motor men
	Second engineer	Fitter
	Third engineer	Chief steward/cook
	Fourth engineer	Second cook
	Electrician	Steward

2. Total crew cost concept (TCC) rates of pay have been used inclusive of a fixed overtime element and ITF approved. Filipino ratings will work up to 85 hours/month without additional payment. British and Filipino officers will work all reasonable hours required. An ITF Blue card will be an additional cost of approximately US$ 5,000.00 per year;

3. Approximate length of voyages undertaken by crew are as follows:
   - British - 5 months
   - Filipino - 10 months
4. A victualing rate of US$ 5.25/day/man has been assumed;
5. An exchange rate of £ 1.00- US$ 1.6 is assumed;
6. Lubricating oil cost is based on current Rotterdam prices.
7. Cost of spares and repairs, assume that vessel has no major defects and is in good operational condition;
8. No allowance has been made for damage repairs, or major steelwork repairs;
9. No allowance has been made for changing flag of vessel. Registration fee, tonnage dues etc. are not included.
10. Insurance:

Insured value US$ 12 million	*US$/year*	*Deductibles*
(a) H&M	70,000	15,000
(b) War	9,60	
(c) FD & D	4,940	5,00 EV
(d) P&I	27,500	10,000 EAOO
	103,400	

11. Charterer's communication costs are not allowed for;
12. Our quotation shows monthly costs. Please note that these are average values and expenditure will vary from month to month. Expenditure is expected to be higher during first few months - 'start up costs' incurred on crew travel, insurance, stores etc.;
13. This quotation is at cost and subject to additional comments as per technical inspection report prepared by our fleet manager;
14. Breakdown of crew cost, see **Table X**:

Ship management contract

Once an owner has accepted the quotation of a ship manager, an agreement is drawn up using standard contracts, like BIMCO's Standard Ship Management Contract, code named: SHIPMAN.

Position	Basic	Overtime fixed	Guaranteed	Leave	Pension	Gross
Master						5,000
Chief officer						4,200
Chief engineer						4,800
Second Engineer						4,200
4 European officers						18,200 (45% of cost)
Filipino junior officers and ratings						
Second officer	850	382.50		170	85	1,487.50
Third officer	800	360.00		160	80	1,400.00
Radio officer	850	383.50		170	85	1,487.50
Third engineer	850	382.50		170	85	1,487.50
Fourth engineer	800	260.00		160	80	1,500.00
Electrician	850	382.50		170	85	1,487.50
Bosun	600	334.05	(3.93)	120	60	1,114.05
Fitter	600	334.05	(3.93)	120	60	1,114.05
Pumpman	600	334.05	(3.93)	120	60	1,114.05
3 ABs	500	278.80	(3.28)	100	50	3 * 928.80
3 Os	360	200.60	(2.36)	72	36	3 * 668.60
2 Motormen	500	278.80	(3.28)	100	50	3 * 928.80
Wiper	360	200.60	(3.26)	72	36	668.60
Chief	850	362.50	(-)	170	85	1,487.50
Steward/cook	500	278.80	(3.28)	100	50	928.80
Second cook	360	200.60	(2.36)	72	36	668.60
Messman						
21 Filipino						22,495.45 (55% of costs)
Plus standby and over						4,224.30 (10% of costs)
Total wages, vacation, overtime						*40,695.45 (100% of costs)*

Breakdown of miscellaneous and overlap costs		
Miscellaneous costs		*3,010.0*
British	5% Gross pay	910.0
Filipino		2,100.0
Overlap		*1,214.3*
British	4.2% gross pay	764.4
Filipino	2% gross pay	449.9

Table X: Breakdown of crew costs

10.8 Insurance

The insurance markets are important supporting markets for shipping. It is possible to insure against a number of different risks. The two primary insurance markets are

- Hull and machinery insurance (H&M), protecting against loss or physical damage;
- Protection & Indemnity insurance (P&I), which provides cover against third party liabilities.

There are, however, also three other important insurance markets:

- Cargo insurance, protecting against damage to cargo;
- Pollution funds and Certificate of Liability Clubs (CLC), mutual funds to provide cover for environmental spills;
- Reinsurance, an important market for spreading the risks.

In **Table XI** a typical damage matrix is indicated for main sources of damage.

Damage	H&M	Cargo	P&I	CLC/Funds
Collision	x	x	x	x
Grounding	x	x	x	x
Contact	x	x	x	
Spill			x	x
Fire	x	x	x	
Stability		x	x	
Heavy weather	x			
Broken part	x	x		
Personal injury			x	
Damage at repair	x		x	
Loss of life			x	

Table XI: Typical coverage for various insurance schemes

The P&I insurance can be expanded to include a number of risk areas, like:

- Freight, demurrage[1] and defence, or simply 'defence' which covers expenses to legal assistance in contract conflicts. The cover is for the hiring of assistance and is not related to the outcome of the conflict;
- War risks;
- Strike risks;
- Through-transport, which is a general insurance covering all risks connected to a particular transport, e.g. a container with fresh fruit can get a through-transport policy to cover all risks independent of whether the container is on land, in a warehouse or onboard the ship;
- Loss of hire, covering freight earnings losses due to repair because of damage, etc.

The two main markets have a fundamentally different organisation, as the P&I insurance market consists a number of clubs, from which the shipowners are the owners and have mutual liability for the claims. The H&M market, however, is a corporate market, where professional insurance companies are the main actors. The main market for H&M is in London, which for all practical purposes is the very foundation of the marine insurance market.

10.8.1 The London insurance market

The main insurance market is closely related to the Lloyd's system. It all started with Edward Lloyd's Coffee House in Tower Street, which was established in 1688. Here information on ships was collected and distributed, and later the production of lists of ships and their movement and destinies were produced. The result of this activity was the establishment of Lloyd's Register in 1764 and in 1769 a competing coffee house, *The New Lloyd's Coffee House*, which in 1774 was reorganised to the company known today as Lloyd's of London. Now, more than 300 years after the first start, Lloyd's has been through a very tough period with heavy losses that has threatened the very existence of the entire system. The structure of Lloyd's is illustrated in **Figure 21**.

Behind Lloyd's is a traditional system of guarantors, *The Names*, who put their personal guarantee behind insurance claims. The guarantors form syndicates with their leaders being represented on the floor, the *Lloyd's Underwriting Room*. Here the selected brokers operate on behalf of their clients, the insured. The job of the brokers is to get sufficient underwritings on their slips (a slip specifies the amount and nature of the insurance policy) to get the total amount covered. In cases of very big insurances, the number of underwritings can go up to 400. There are about 260 broking companies with approval from the *The Council of Lloyd's* to operate in the Underwriting Room. Many brokers are highly specialised to handle

[1]Demurrage means payments made to the shipowner by the charterer for failing to complete loading or discharching within the time limits specified in the charter party.

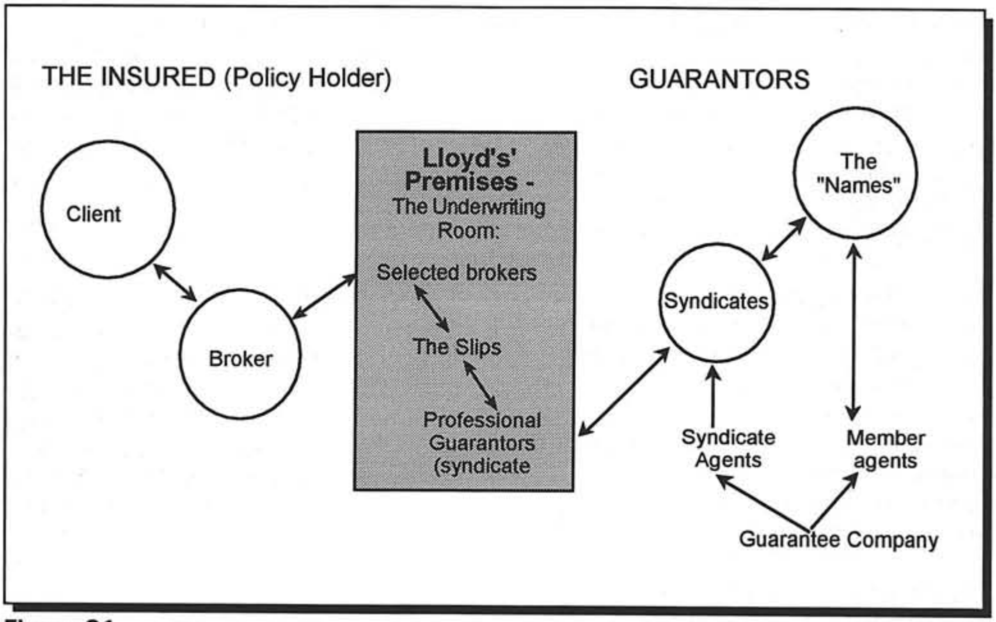


Figure 21

specific insurance, like H&M insurance for ships, and many syndicates of guarantors are also specialised. Almost anything can in principle be insured by Lloyd's.

1988 saw the highest number of names in the Lloyd's system ever, about 32,300. During the next couple of years 3,000-4,000 names left Lloyd's, and many more would have liked to do so were they not captured by their obligations in the syndicates. Particularly the years 1989-90 gave very large payments for The Names after several major catastrophes, as indicated in **Table XII.**

Event	Lloyd's payments in million US$
Nationalising of aircrafts in Kuwait, 1990	524
European storms, 1990	3,000
The hurricane Hugo, 1989	1,000
Explosion in refinery in Texas, 1989	500
Earthquake in San Francisco, 1989	400
Oil spill from *Exxon Valdez*, 1989	224

Table XII: Examples of major payments from the Lloyd's system

As can be seen, shipping has not at all been the major source of problems for Lloyd's. The problems actually goes back many years to the 1970s and 1980s, when Lloyd's syndicates backed insurance for American factories dealing with asbestos, chemicals and energy. Enormous payments have subsequently been made to cover compensation to asbestos victims and environmental cleaning costs. The problem is that most of these insurances have been reinsured many times over, and it takes literally many years before the final bill is on the table of the Lloyd's system. During the late summer of 1996, the news was that a major plan for restoring Lloyd's solidity seemed to be approved by a sufficient number of Names and creditors, so that the traditions of Lloyd's may be carried on.

Another important part of the London insurance market is the Institute of Lloyd's Underwriters (ILU), which is an association of large insurance companies acting as guarantors. The private names of Lloyd's of London have traditionally covered about 60% of the London market and ILU the remaining 40%. Within the ILU there is a group of firms who act as rate leaders, but the composition of the group of leaders changes rather quickly. 26 companies were in 1991 regarded as rate leaders, of which 15 from London, 4 from Scandinavia, 1 from the USA, 4 from France and 2 from Germany. In 1992, the list of rate leaders had about halved. The companies were then

- Albion Insurance Co. Ltd;
- British & Foreign Marine Insurance Co. Ltd.;
- Commercial Union Assurance Co. Plc.;
- Continental Insurance Co. (UK) Ltd.;
- Cornhill Insurance Plc.;
- Lombard Continental Insurance Plc.;
- London & Hull Maritime Insurance Co. Ltd.;
- Norwich Union Fire Insurance Society Ltd.;
- Pearl Assurance Co. Ltd.;
- Phoenix Assurance Plc.;
- Prudential Assurance Co. Ltd.;
- Royal Insurance (UK) Ltd.;
- Sovereign Marine & General Insurance Co. Ltd.

10.8.2 The P&I market

In 1992 the 12 largest P&I clubs were as indicated in **Table XIII**. The dominant one is British, but Norway has two large companies (Gard and Skuld) in the P&I market.

The 73.3% of the world fleet indicated, corresponds to about 89% of all insured ships. The 11% without insurance is either self-insured or owned by governments.

There are extensive cooperation schemes among the P&I companies. The main group is *The London Group*, mainly consisting of the firms 1, 3, 4, 6, 8, 9 and 11 from the table. Together with Gard and Skuld, the Swedish Group, Japan PIA, Liverpool and *The Shipowner's Mutual*, they constitute the *International Group Re-Insurance Pool*. The group is only engaged in P&I activities and with about 90% of

Company name	million gt	% of world fleet
1 United Kingdom	95	21.0
2 Gard	45	9.9
3 Britannia	43	9.5
4 Steamship Mutual	40	8.8
5 Japan	34	7.5
6 Skuld	23	5.1
7 Standard	23	5.1
8 London	8	1.8
9 North of England	7	1.6
10 Sveriges Ångfartys Assurans Förening	6	1.3
11 Newcastle	5	1.1
12 American	3	0.7
Total	332	73.3

Table XIII: Main companies in the international P&I market 1992

the insured world fleet within the group, a good spread of risk can be obtained. Since they all are reinsuring each other, a need for standardisation of insurance policies has emerged. The group meets, therefore, regularly and was in 1981 - incorporated to gain observer status in the IMO.

10.8.3 Certificate of Liability Clubs

This is a fairly new phenomenon coming as a result of the USA - Oil Pollution Act of 1990 (OPA90). This law requires that all ships that trade on the USA must carry a Certificate of Financial Responsibility (COFR), where the identification of whom should be liable in case of an oil spill is clearly stated. OPA90 opens up for individual states to impose almost unlimited liability for cleanup costs after an oil spill. No P&I insurance scheme is willing to go that far in coverage for this risk factor, and special clubs have been formed to meet this extra demand in the insurance markets.

A shipowners liabilities in relation to oil spills and other damage caused by ship accidents is to a large extent regulated by international conventions, voluntary agreements and national legislation. The most important convention for shipping that limits a shipowner's liabilities, is *The International Convention on Civil Liability for Oil Pollution Damage 1969* (CLC69) and its 1984 protocol of amendments (CLC84). This specifies a maximum amount for which insurance is made compulsory. This convention is not yet ratified by sufficient number of countries for it to be globally binding, and particularly the USA has been reluctant in ratifying, because that would imply giving away the right to make stricter rules and laws in USA waters. In order to get clear rules immediately, the so-called TOVALOP -

Tankers Owners Voluntary Agreement concerning Liability for Oil Pollution was agreed to in 1969 and finally accepted in 1975 and amended in 1979 so that it covers the same as CLC. The third set of regulations regarding oil spill liabilities are national laws of which two laws in the USA are important. The OPA90 is already mentioned, but also an old law exists, the Federal Water Pollution Control Act (FWPCA), which only concerns federal costs in relation to cleaning costs after pollution.

Table XIV indicates what the rules are under these various regulations. The figures given are for all ships above 3,000 grt.

	CLC69	CLC84	TOVALOP	TOVALOP	FWPCA	OPA90
US$ Minimum	3.8	3.5				
therafter US$/gt	156	538	147	493	150	1,200
US$ maximum	17.9	76.4	16.8	70	0.25	10

Source. Hammer (1991)

Table XIV: Rules are under these various regulations

Although OPA90 has a maximum liability level of 10 million US$, it has also opened up for the individual states to have different rules. Some states have unlimited liability for damage to the environment, so the tanker owners trading on the USA is facing a substantial risk for which the CLC clubs are meant to give coverage.

10.8.4 The insurance process

Shipowners will normally choose a P&I club close to headquarter because P&I clubs have much the same coverage and price level (because of the cooperation within the *International Group*). Then the only other parameter that counts is service. This is often easier to get when the club is close both in geographical and in cultural sense. Sometimes, however, P&I clubs will refuse membership or even ask a member to leave, because the club feels that the owner is substandard.

For H&M (and cargo) insurance, price is more and more the main competition parameter. Very often the shipowner will choose to use outside expertise in finding the right insurance solutions. There are a number of insurance brokers in the world, some of which are highly specialised for the shipping sector. It is not uncommon that a Greek shipowner goes to Bergen in Norway to get help from Henschien Insurance Services or Grieg Insurance.

When confronted with a potential customer, the insurance company will make a thorough assessment of a number of aspects related to this customer. The ship or the fleet will be thoroughly examined, and today compliance with ISO 9000 standards and higher management certificates will count, when premiums are to be set. More and more is the management of the company under scrutiny, routines are checked, quality control programs are examined etc. The shipping company on the other hand, must also do its homework before going into the market. Larger companies will handle the process of finding the right insurance themselves. The typical process would then be something like this:

- Evaluation of the company's accident statistics;
- Fleet evaluation and value assessment;
- Recalculation of statistics based on subgrouping of the fleet;
- Market evaluation, checking general price levels with various insurance companies;
- Writing tenders to selected companies;
- Negotiations with one or more companies;
- Selection of offers received, determining either one company or several companies for various types of insurance policies. It is becoming more and more common to have all policies with one single company;
- Notify mortgage holders of the solution chosen.

CHAPTER 11: MARITIME POLICY

11.1 Rules, regulations and regulatory bodies

The purpose of this section is to give a very brief overview of a part of the legal and regulatory framework that shipping is operating under. The field of maritime law is a very large subject far beyond the scope of this book to cover properly. Just a rudimentary sketch of some main issues will be discussed here.

11.1.1 The basic system of maritime law

There is no international legislative body that makes international shipping laws and no international court that tries cases against such laws. The system that exists is based on national legislation. The fundamental concepts are:

- Ship registration - which conveys nationality to a ship and brings it under the legal system of the country of registration;
- National law - which is the basis for international shipping, as a ship registered in a specific country will be subject to the laws of that country;
- Territorial law - which may come into effect for ships entering other nations' territorial waters.

Where ships are registered is, therefore, one of the most important issues that determines which laws and regulations come into force for the ship.

British Maritime Law plays an important role in international shipping, because it was Britain that first made important laws to regulate shipping, and British Law became a model for other nations' maritime laws. One of the most important laws was advocated strongly by the member of Parliament, Samuel Plimsoll, who managed to get the Plimsoll act to become law in 1876. In this law, the Board of Trade was empowered to survey ships, pass them fit for sea and mark them with a load line indicating the legal limit to which they could submerge. He had reacted against all the badly built, grossly overloaded (and sometimes over-insured) ships that were lost at sea.

The first truly international assembly that addressed general international rules for shipping, was the International Marine Conference in 1899, initiated by the USA and attended by representatives of 37 other maritime states. Although the conference only managed dealing with the first issue of the agenda, rules for prevention of collisions, it set a standard for how these issues could be dealt with internationally.

In 1948 the Inter-governmental Maritime Consultative Organisation (IMCO) came into operation with specific responsibility for drafting legislation related to maritime safety and pollution prevention. IMCO changed name in 1982 and became the International Maritime Organisation (IMO). There is no doubt that IMO is the most important international body for drafting conventions that later can become part of national maritime laws.

Two other international organisations that play a central role in relation to shipping are the ILO and the UNCTAD. The International Labour Organisation (ILO) was set up in 1919 and has been instrumental in bringing about important conventions dealing with working conditions on board ships. These includes provisions on manning, hours of work, pension, vacation, sick pay and minimum wages. The UN Conference on Trade and Development (UNCTAD) was established in 1964 and its Committee on Shipping is one of five standing committees and have a professional staff. UNCTAD has primarily been concerned about the maritime interests of the developing countries. In a later section, the UNCTAD efforts towards a Code of Conduct for Liner Shipping will be examined.

11.1.2 Some important conventions and regulations

This section will focus on the main conventions that have influenced shipping in this century and which no doubt also will form the foundation for the rules that will apply in the future.

SOLAS - The Safety of Life at Sea Convention

SOLAS is no doubt the most important of all international treaties dealing with maritime safety. It dates back all the way to 1914, but has been through several revisions since then. The first 'modern' version of SOLAS as we know it today, was adopted in 1960 at the first conference organised by the IMO. This version came into force in 1965 and had the following main sections:

- General structure;
- Machinery and electrical installations;
- Fire protection;
- Life-saving appliances;
- Communications;
- Safety of navigation.

SOLAS was amended several times in the 1960s and 1970s (66, 67, 68, 69, 71 and 73), but the procedures of adoption were slow, as two-third of all contracting parties had to ratify.

This changed somewhat in 1974 when SOLAS was updated and 'the principle of tacit acceptance' was introduced. This principle says that the convention and its amendments will automatically come into force at a specified date unless one-third of the contracting parties who account for more than 50% of world tonnage especially rejects it.

Some tanker accidents in 1976-77 led to initiatives that later became The 1978 Conference on Tanker Safety and Pollution Prevention (TSPP). This conference was convened to supplement SOLAS with a set of regulations actually going much further than SOLAS on several issues.

SOLAS underwent large scale amendments in 1981 (came into force in 1984), 1983 (came into force in 1986) and 1990.

Some of the many requirements specified in the various SOLAS versions that have had or will have great impacts on the shipping industry are:

- All ships must be fitted with both a main steering gear and an auxiliary gear;
- Tankers over 10,000 grt must have two remote steering gear control systems;
- Since 1981 all tankers above 20,000 grt must be fitted with inert gas systems (IGS), i.e. systems which pumps gases into the tanks, which become devoid of oxygen, so combustion cannot take place;
- Extensive regulation of lifesaving equipment;
- GMDSS (Global Maritime Distress and Safety System) shall gradually be phased in between 1992 and 1999. When complete this will be a satellite based communication system allowing ships in distress to alert relevant authorities rapidly even under extreme conditions. New ships today have to install EPIRBs (emergency-position-indicating radio beacons) and rescue operations will be coordinated by designated rescue coordination centres (RCCs);
- Detailed specifications on how to conduct surveys and stricter regulations for certification of ships.

MARPOL

MARPOL is a set of regulations aiming at reducing pollution from tanker operations. Present MARPOL policy takes place in three main areas:

- Regulations designed to contain operational pollution;
- Regulations designed to contain accidental pollution;
- Means necessary to enforce the regulations.

The beginning of MARPOL was the 1973 International Convention for the Prevention of Pollution from Ships. Later it was followed by the 1978 Protocol and thus became the first concerted answer to marine pollution. The two documents are collectively known as MARPOL 73/78, or just MARPOL.

Some main elements from MARPOL worth mentioning are:

- All new crude oil tankers over 20,000 dwt are to be fitted with segregated ballast tanks (SBT);

- All new crude oil tankers over 20,000 dwt must be equipped with a tank cleaning system using crude oil washing (COW);
- Maximum discharge regulations;
- Retention of residues - all ships must have slops tanks;
- Limitations on size and arrangement of cargo tanks;
- New rules for stability requirements;
- Compulsory fitting of SBTs as protective location.

A tanker was defined as 'new' in relation to the two first points as follows: Contract placed after 1 June 1979, keel laid after 1 January 1980 or delivered after 1 June 1982. This represents, therefore, an important distinction in tanker shipping and thus the term MARPOL ships and pre-MARPOL ships, where the pre-MARPOL ships typically do not have SBT. The idea behind SBT and COW was to eliminate the mixing of oil and water that invariably led to large quantities of polluted water being pumped into the sea.

The maximum discharge regulations say that discharges are permitted only if the vessel is not in a special area, is more than 50 miles from land, is sailing when discharging, does not discharge at a rate of more than 30 litres per nautical mile and 1:15,000 of its total quantity (1:30,000 for new tankers), and is fitted with the necessary oil discharge monitoring systems.

For enforcement of the regulations, MARPOL introduced the International Oil Pollution Prevention (IOPP) Certificate, later made compulsory by the IMO. The certificate requires some initial inspections, but also specifies regular inspections. The Certificate must be renewed every five years.

Collision avoidance

In 1972 IMO adopted a new convention on collision avoidance, where the main item was to introduce traffic separation schemes in congested parts of the world. The convention is ratified by more than 88 states.

Ships' load line

The Plimsoller Act has already been mentioned, and in 1930 an International Convention on Load Lines was adopted. A new and updated convention on this topic was adopted in 1966. It came into force in 1968 and has been ratified by more than 100 countries.

Tonnage measurements

In 1969 the first International Convention on Tonnage Measurement was adopted. This became a rather controversial convention dealing with sensitive issues. The idea behind the convention was to establish clearer rules for measurements of a ship' gross tonnage. This is important to shipowners because most port charges and canal dues are based on this measurement. This creates an incentive to manipulate the designs to get a lower gross tonnage, without getting lower cargo carrying capacity. Occasionally this was at the expense of stability and thus safety. It took 13 years before the convention had the required number of acceptances, so it was not until 1982 that the convention came into force.

STCW - Standards of Training, Certification and Watchkeeping for Seafarers

This convention was the first attempt of doing something constructive with the fact that most accidents are due to human errors and human errors increase inversely with education and proper training. It was adopted in 1978, but entered into force as late as 1984. The main aim of the convention is to ensure that a minimum number of the crew is certified as proficient in their duties. This convention has been ratified by some 80 countries.

OPA 90 - the 1990 US Oil Pollution Act

After the *Exxon Valdez* accident in 1989, an enormous pressure was put on the politicians to do something about oil pollution from ships. The result was a set of rules quite different from the conventions mentioned above. The 1990 US Oil Pollution Act is typically a port state initiative to protect local waters. Some of the main points in OPA90 are:

- Shipowners and operators responsible for oil spills are deemed jointly and severally, liable for all removal costs;
- The liability becomes unlimited if negligence or violation of regulations can be proved;
- Individual states are free to override federal law and impose unlimited liability;
- All vessels entering US waters must possess a certificate of financial responsibility (COFR);
- All new vessels must have double hulls;
- Single-hull vessels should be phased out by the year 2015.

This is no doubt the most radical response to pollution ever in the history of shipping, and OPA 90 has caused a number of changes in international tanker business. Some operators have actually ceased trading on the USA because of the potential liabilities. Other operators have reorganised their companies by setting up specific companies to deal with the US trades. This in order to try to limit the potential liabilities.

ISM Code - The International Safety Management Code

Acknowledging that the human factor is the main reason for accidents, much more attention has recently been devoted to regulations not only of the ship or the specific crew, but the entire management of ships. In 1993 the IMO adopted the ISM Code, through resolution A.741(18), and started working on guidelines for international adoption of the code to make in mandatory under SOLAS. Important guidelines were adopted in November 1995 through resolution A.788(19) and the IMO is currently urging governments to implement the ISM code and adhere to the guidelines and to force shipping companies to apply for certification under the ISM code.

The code basically specifies general requirements for a satisfactory safety-management system. It also addresses the Master's responsibility and qualifications, procedures for emergency preparedness, qualification of personnel, reports on non-conformities, maintenance, documentation, company verification and certification.

It is no doubt a far reaching code that will have a lot of impact on shipping companies. The code should not be confused with the new total quality management certificates offered by the classification societies.

11.1.3 Compliance with regulations

90-95% of the world fleet has adopted SOLAS and about 85% has adopted MARPOL. Adoption of the conventions is one thing, another matter is whether the conventions are lived up to in practice.

In 1991, Drewry Consultants concluded that of the 108 crude carriers over 20,000 dwt registered under flags affiliated with both SOLAS 74 and 78, 89 of the vessels were fitted with inert gas systems (compulsory according to the convention) and 19 were not. This means that almost 20% of the fleet was not in compliance with regulations accepted.

The same result was found for compliance with the STCW convention. Of the tanker fleet, about 80% were in compliance with the convention, 20% were not.

11.2 Flag states and port states

All ships in the world must be registered in a country. They must fly the flag of this country and obey the maritime laws. Those laws are in general based on international laws, which have been accepted and ratified by the flag country. A country that maintains a ship register is called a *flag state*. This can be a traditional maritime nation or a completely landlocked country. A Country that has a seaport is called a *port state*.
The flag state's laws define and regulate the relationship between the vessel, the owner, the holder of the mortgage on the ship, the crew, the manager, other states and third parties related to the commercial and operational activities of the ship. Without international laws, which are upheld by flags states, the seaborne transport scene would resemble complete anarchy (even to the point of piracy).

The flag states can be broadly divided into national and international registers. A national register is one that treats the shipping company in the same way as any other business in the country, while an international register is one that has been set up with the specific aim of offering shipowners internationally competitive terms.

The *international ship register* is set up as an economic activity as such. Other words used for the international register are *open registers* and *flags of convenience*. Open registers have been around since the 1920s. Over the last decades a number of hybrid register types have been created such as the *dependent register* and the *second register*.

The traditional *national register* can be characterised by a well-developed administration, detailed laws, which are enforced, ships crewed and certified by nationals. The costs of using the national register tend to be high, not so much for the registration as such, but rather for the obligation to employ high wage nationals. **Figure 1** shows a comparison of wage costs among some of the traditional flag states, such as the UK, Germany and Japan to the more recent flag states. **Figure 2** schematically shows the role of the traditional flag state and its registration administration.

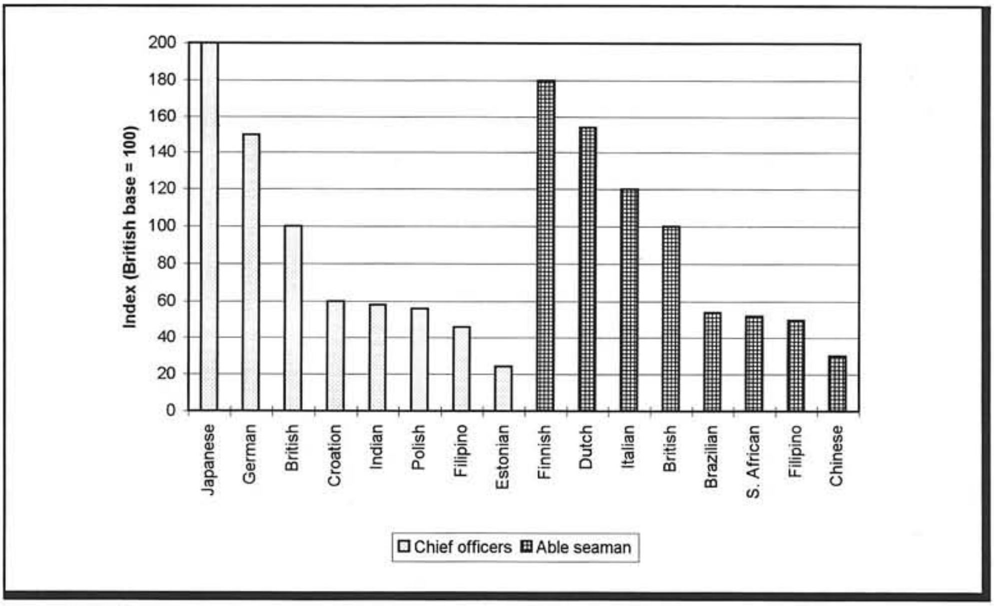


Figure 1: Comparative wage costs

The *dependent register* is created mainly within the former British Colonies, such as Hong Kong, Gibraltar, Bermuda, Cayman Islands, and the Isle of Man. The ships registered in these dependent registers fly the British flag and have the rights and obligations of the British Merchant Shipping Acts, but enjoy some special freedoms which are granted and controlled by the administration of the port of registry. These freedoms are mostly related to the nationality of the crew and tax exemption.

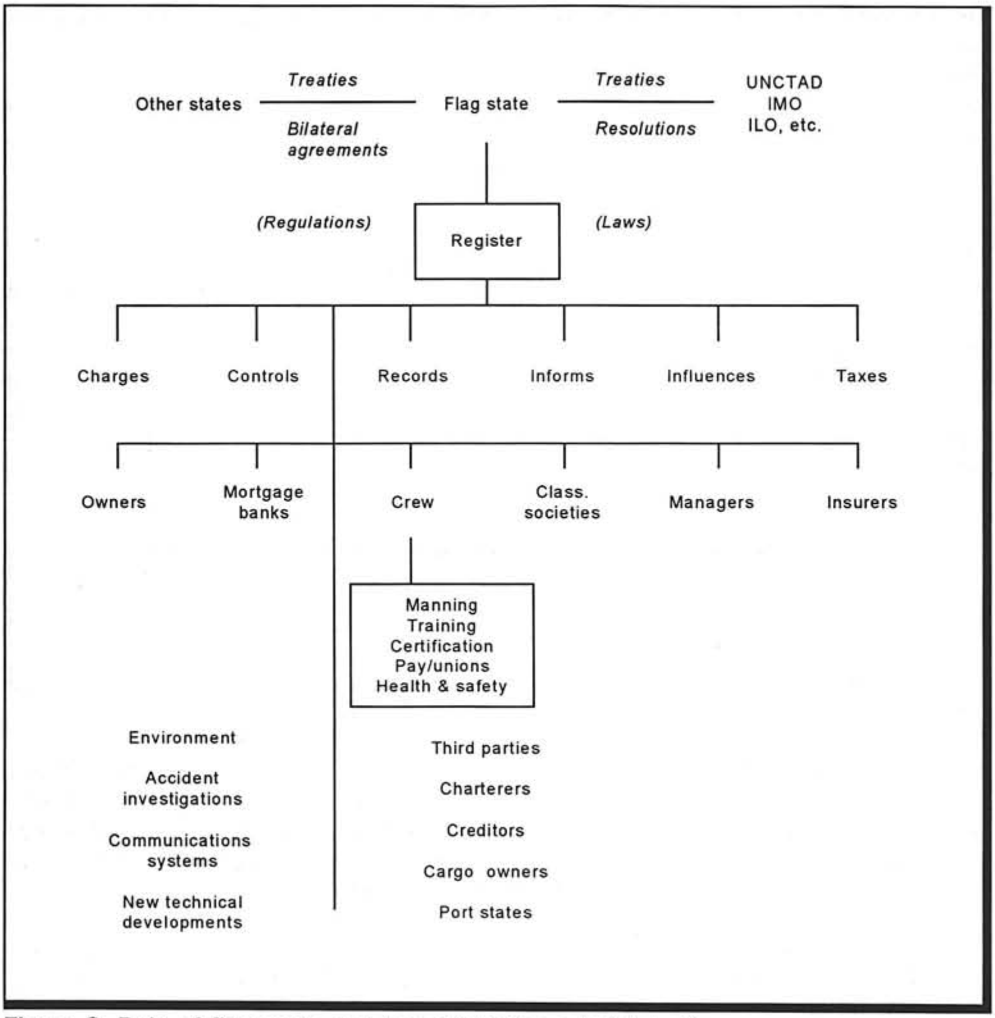


Figure 2: Role of flag state and its registration administration

Open or international registers provide the shipowners with considerable flexibility in legislation, financing structures, crew nationality and qualifications, tax regimes and 'policing'. Examples are Panama, Liberia, Cyprus, Bahamas, and St. Vincent. **Figure 3** illustrates the rapid growth of the latter register, which can now already boost 1400 vessels with 7.5 million dwt.

Second (international) registers were created in the eighties by the traditional flag states in order to create an open register, besides the national register. These second registers enjoy most of the benefits of the open registers, but have some restrictions. Countries with second registers are Norway, Denmark, Germany, France, Spain. The growth of the Norwegian International Ship (NIS) register has been spectacular. An example of the conditions to be met when registering under the NIS is summarised in **Table I**.

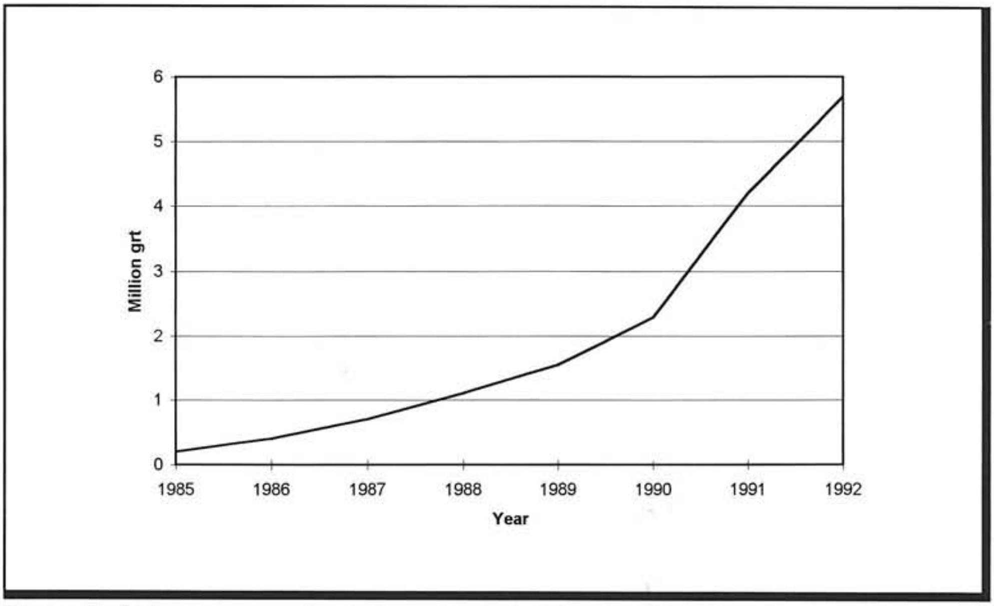


Figure 3: Ships registered in St Vincent and the Grenadines

One of the main reasons for the fast growth of NIS from the introduction in July 1987, was that this coincided with a period of rapidly increasing secondhand values. This was a double stimulation to an industry in depression for more than 20 years, and increasing values combined with an extremely favourable Norwegian tax system, led to unprecedented growth in the fleet.

The dramatic changes in flag are reflected in **Table II**, in which the top ten merchant fleets are listed for the years 1965, 1975, 1985, and 1995. The top-spot in 1965 was held by the UK, with 21.7% of the world fleet in grt. By 1995, the United Kingdom had disappeared from the top ten list. A similar fate is happening to Japan, while Greece is the only country which has been able to improve its position consistently over the last thirty years.

Port state control

Today, half of the world fleet is registered in a country the vessel may never visit; is operated by a company whose only connection with the flag state is a formal, legal one; and is crewed by seafarers who may never set foot in the country of registry, nor in that of the operator or owner. In such circumstances the concept of what constitutes the proper exercise of responsibility by the flag states has to be readdressed.

CONTACTS

Vessel Registration
Johan Mevatne
Norwegian International Ship Register
Taarnplassen 2
Tinghuset N-5013
Bergen, Norway
Tel: 47 5 326512/47 5 237000
Telex: 8441050
Teletex: 441050
Fax: 47 5 329341

Company Formation
Foretaksregisteret
N-8900 Brønnøysund
Tel: 47 86 25000

PRINCIPAL LAWS APPLICABLE TO SHIP REGISTRATION

The Act on Norwegian International Ships Register of 12 June 1987, No 48, Royal decree of 19 June 1987 (Regulations for registration of ships in NIS) and the Maritime Act of 1893. Note that Norwegian laws apply to any vessel entered in the NIS.

CONDITIONS OF ELIGIBILITY FOR REGISTRATION

To be eligible to join NIS vessels/owners must satisfy the following conditions: vessel type — all vessels meeting standards of the major classification societies and IMO regulations; ownership — Norwegian nationals or limited company with head office in Norway; management — Norwegian company with headquarters in Norway; trading area — vessels in international trade.

VESSEL AGE RESTRICTIONS

There are no age restrictions for vessels registering under the NIS.

VESSEL MANAGEMENT REQUIREMENTS

The management company must be a Norwegian company, or a Norwegian shipowning company with its head office in Norway. In the latter case the technical management function may be located abroad.

PARALLEL REGISTRATION

Not permitted.

CREWING REQUIREMENTS

Non-Norwegian seamen may be employed in all positions on board with the sole exception of the master. In compliance with the STCW Convention all seaman shall have undergone approved basic safety training or have relevant seagoing experience.

VESSEL SURVEYS

The following classification societies are authorised to survey for NIS: ABS, BV, GL, DnV, LR. A special arrangement exists with NKK. Surveys for vessels of less than 500grt are conducted by the Norwegian Maritime Directorate.

INTERNATIONAL CONVENTIONS ADOPTED

Norway has adopted all the major maritime conventions and vessels registered under NIS are similarly bound by these.
SOLAS 1974/78
Load Lines 1966
MARPOL 1973/78
COLREG 1972
STCW 1978
ILO 147

HISTORICAL DEVELOPMENT OF THE NIS

The NIS became operative on 1 July 1987. It has since grown to a fleet totalling 250 internationally trading vessels of 7,330,769grt. Of these 46% are tankers, 22% cargo vessels and 17% bulkers.

FEES, TAXES AND ADMINISTRATIVE CHARGES

Initial registration fees

TONNAGE	FEES
Cargo vessels (500grt and over)	
	Base fee NKr12,000 plus
Up to 5,000 nt	NKr5.00/nt
Up to 10,000	4.00/nt
Up to 30,000	3.00/nt
Up to 70,000	2.00/nt
Over 70,000	1.00/nt
Passenger vessels, example Norwegian newbuildings	
	Base fee NKr5,000 plus NKr0.50/nt plus
1,000 grt	NKr 200,720
5,000	484,380
10,000	614,230
15,000	723,600
20,000	849,380
30,000	937,190
50,000+	1,041,340

Note: NKr1.00 = US$0.1457

Annual tonnage fees

TONNAGE	FEES
Cargo vessels (500 grt and over)	
	Base fee NKr12,000 plus
Up to 5,000 nt	NKr3.00/nt
Next 5,000	2.50/nt
Next 20,000	2.00/nt
Next 40,000	1.50/nt
Over 70,000	1.00/nt
Passenger vessels, example Norwegian newbuildings	
	Base fee NKr2,000 plus NKr0.50/nt plus
1,000 grt	NKr 68,330
5,000	126,570
10,000	161,440
15,000	172,840
20,000	188,100
30,000	206,310
50,000+	235,770

Fees for other services
Mortgage registration — NKr350.00
Issuing certificates — NKr70.00

Fees

Initial, Annual

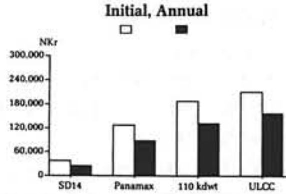


Table I: Norwegian international ship register

1965		1975		1985		1995	
UK	21.7	Liberia	65.7	Liberia	54.4	Panama	62.5
Liberia	18.4	Japan	37.9	Panama	40.4	Liberia	57.4
Norway	15.5	UK	32.1	Japan	37.4	Greece	29.9
US	11.9	Norway	25.8	Greece	29.1	Cyprus	22.8
Italy	11.4	Greece	22.4	USSR	17.2	Bahamas	22.6
USSR	8.2	Panama	13.3	US	16.7	Japan	20.6
Greece	5.9	USSR	12.3	UK	11.9	Norway	19.8
Germany	5.7	US	11.4	China	10.8	Malta	15.4
France	5.4	France	10.3	Norway	10.3	China	14.9
	5.0	Italy	9.9	Cyprus	9.4	US	13.2
Total	**159**	**Total**	**325**	**Total**	**386**	**Total**	**451**

Source: Lloyd's Register of Shipping

Table II: Top 10 merchant fleets by flag (million grt)

The level of performance by flag states is far from uniform, which is adequately monitored by the annual reports of the European Memorandum of Understanding on Port State Control, or the loss figures compiled by the Institute of London Underwriters. Port State Control was created to inspect the vessels that call in European ports. In 1994 inspectors made almost 17,000 inspections on vessels, which led to some 1,600 delays/detentions. These detentions are clearly correlated to the flag state. Poor performers are the national registers of countries that have experienced severe economic problems or have undergone a period of internal unrest. But, also a number of the larger and fastest-growing open registers appear, and it is this combination of continuing growth and poor performance that has concentrated attention to the need to focus more clearly on the obligations of the flag state.

Figure 4 shows 20 flag states with detention percentages exceeding a 3-year rolling average detention percentage, which are, therefore, targeted as priority cases for inspection in 1995/1996 by Port State Control. The dubious quality of some flag states is further illustrated by the loss statistics of the world fleet over the period of 1989-1993. (**Table III**).

It is of course the shipowner who is principally responsible for the safety and operation of their vessel, and if he operates with care and competence, the flag it flies is largely immaterial. Given a choice based on identical costs, most owners would opt for the national flag. But, an open register, with fiscal advantages and above all freedom from manning restrictions, offers cost savings and the chance of survival in a harshly competitive market. So, the owners opt more and more for open registers.

According to C. Horrocks of the International Chamber of Shipping, the suspicion arises, however, that shipowners are attracted to an open register where a more relaxed attitude to safe operating standards prevails. Even if this is a minority problem, it enables a number of ships - substandard ships - to undermine the com-

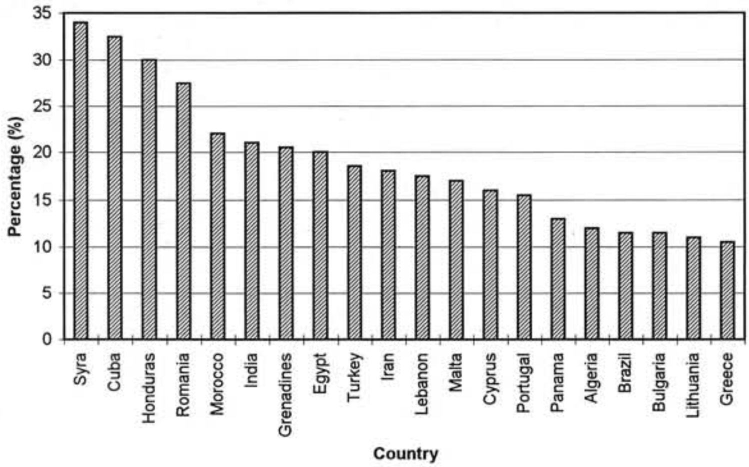


Figure 4: Flag state with large detention percentages

petitiveness of the rest of the fleet and present a hazard both to the crews they employ and to other shipping.
In order to tackle this problem, a subcommittee from IMO was created. The UK has proposed to define a number of criteria for countries that wish to operate a ship register and become a flag state. These countries should follow the following criteria:

- They should have a legislative framework for ships to comply with conventions;
- Generating finance for the flag state should not be the principle purpose;
- A fee structure should provide sufficient income to ensure enforcement of standards;
- Systems and procedures must be submitted for independent external audit;
- Organisations providing services should also be quality assured;
- STCW certificates must be issued on the basis of internally-run examinations, except where issued by other administrations whose standards have been approved;
- Entry to the register requiring full ship inspection except where mutual recognition formally agreed;
- All major incidents investigated by an independent body and reports made public.

Given the conflicts of interest that may arise for the many registers when these recommendations will be adopted, it will take a long while before any action to improve the quality of the flag states will be taken. In the meantime the expansion of the Port State Control concept into other geographical areas, like North America

Country	Tonnage afloat	Tonnage lost	% tonnage lost
Honduras	847,097	11,413	1.35
Irish Republic	118,641	1,894	1.01
Bangladesh	433,311	4,248	0.98
Thailand	738,317	6,721	0.91
Malta	7,534,653	64,438	0.86
Colombia	313,177	2,491	0.80
South Korea	7,673,301	61,383	0.80
Venezuela	949,125	7,199	0.76
Turkey	3,983,418	29,850	0.75
Cyprus	19,817,354	147,598	0.74
Pakistan	364,135	2,388	0.66
St. Vincent & Grenadines	3,126,482	18,032	0.58
Nigeria	502,044	2,609	0.53
Vanuata	1,905,536	9,472	0.50
Panama	47,277,480	224,572	0.48
Greece	23,479,181	109,874	0.47
Peru	55,825	2,609	0.47
Indonesia	2,253,386	9,857	0.44
Vietnam	520,218	2,230	0.43
Chile	603,881	2,305	0.38
Morocco	470,526	1,690	0.36
Bulgaria	1,354,009	4,664	0.34
Antigua & Barbuda	561,138	1,860	0.33
New Zealand	253,523	839	0.33
Philipines	8,755,413	28,775	0.33
Gibraltar	1,428,535	4,525	0.32
Italy	7,730,800	24,443	0.32
Cayman Islands	390,309	1,200	0.31
Cuba	769,775	2,768	0.28
Sri Lanka	314,067	870	0.28

Table III: Flags with losses above the world average

and South-East Asia may reduce the trading possibilities of substandard ships progressively and thus force owners to improve their operations anyhow.

11.3 Case in maritime policy: The Code of Conduct for liner shipping

UNCTAD has been the main forum in which the developing countries have been able to pursue their shipping policies. Ever since its start in 1964, UNCTAD was worked on establishing a Code of Conduct for Liner Conferences. The Code was adopted in 1974, but it took almost 10 years, until April 1983, before the conditions for the Code to take effect were fulfilled. This was due to the ratification of Germany and The Netherlands, which brought the share of the world fleet that had ratified on more than 25%, which was the minimum required.

The Code of Conduct has two main purposes:

- To regulate the monopoly behaviour of liner conferences;
- To help the less developed countries (LDCs) build up merchant fleets of their own, in order to increase the LDCs' share in income generated by world liner shipping, in particular to redistribute monopoly profits from rich to poor countries, and to improve their balance of payments.

In a way the two goals are not consistent with each other. The first goal is to eliminate monopoly prices to bring freight cost down, the second takes the monopoly profit as given and is more a matter of redistribution of income. The inconsistency reflects the fact that the various LDCs did not have uniform views on what the main problem was. Eventually the main emphasis was on the second goal - to increase the LDCs participation in world shipping.

The main outcome of the Code was the so-called 40-40-20 principle. In fact, 40-40-20 is never mentioned in the Code, but one can find the following formulations regarding the right to participate in a trade:

- The group of national shipping lines of each of two countries between which foreign trade is carried by the conference, shall have equal rights to participate in the freight and the volume of traffic generated by their mutual foreign trade and carried by the conference;
- Third-country shipping lines, if any, shall have the right to acquire a significant part, such as 20 per cent, in the freight and the volume of traffic generated by that trade.

The formulation 'such as 20 per cent' was suggested by Japan and so the 40-40-20 principle became a term. After the third country shipping lines have taken 20 per cent, the first principle is that of equal rights, i.e. 40 per cent each.

It is interesting to study what would have happened if the cargo sharing principle had been followed quite literally. By comparing data for the distribution of world fleet with the distribution of trade flows, estimates can be what redistribution would take place in the world fleet, to meet the 40-40-20 principle.

The data are from 1979, which was a year for which good statistics existed, both on the fleet, where the distinction between tramp and liner fleets was essential, and trade flows.

Table IV shows the distribution of trade measured in tonnes and tonne-miles.

The redistribution effects are calculated first by allocating 40% of the exports for each region to that region, then 40% of all imports to that region. That leaves 20%, which should be allocated to third-countries. This has been allocated according to the percentage of the fleet each region controlled in 1979. This may not be a good measurement of third-country cross-trading patterns, but it was difficult to find any other way of allocating the last 20%. The results are given in

	Region	% of tonnes	% of TM	ALH
1	EEC	28.3	21.2	2609
2	Nordic countries[a]	6.8	3.1	1592
3	North America	18.3	21.8	4149
4	Japan	10.7	12.8	4147
5	Oceania	3.3	5.5	5701
6	Other OECD countries	0.8	0.7	3096
	Total OECD	*68.2*	*65.1*	
7	Central America and Caribbean[b]	3.4	2.8	2923
8	East Coast of South America	2.0	2.8	4918
9	Other South America	1.9	2.3	4199
10	Mediterranean	3.9	4.3	3911
11	North and West Africa[c]	2.1	2.1	3552
12	East Coast of Africa	0.4	0.8	5854
13	South Asia	1.3	2.2	5735
14	South East Asia[d]	5.6	5.8	3570
15	Far East LDCs	4.6	5.1	3832
	Total LDCs excl. Open Registers	*25.2*	*28.2*	
16	Open Registry Countries	1.5	1.5	3521
17	Centrally Planned Economies	4.3	3.6	2939
18	South Africa	0.8	1.6	6571

a) Excl. Denmark
b) Excl. Panama
c) Excl. Liberia
d) Excl. Singapore

Table IV: Distribution of world seaborne trade in liner goods 1979

Table V. Column I shows the share of world fleet owned by that region in 1979. Column II shows the share of world trade that region is entitled to if trade is shared 40-40-20, based on trade in tonnes. Column III shows the same, but with tonne-miles as distribution criterion. Columns IV and V indicate what this redistribution would have meant in terms of tonnage, where the figures have been converted into numbers of standardised 15,000 dwt units. The 1979 fleet consisted of 55.5 million dwt liner vessels, corresponding to 3,700 vessels of a standard size of 15,000 dwt.

There are a few striking features about the results. First the number of ships to redistribute is small relative to the total fleet - only 827, or 23%. Of these ships, the OECD would actually gain 49%. It is, of course, the open registry countries that (together with the centrally planned economies) would have to 'give up' tonnage as their share of world fleet is much larger than a 40-40-20 distribution would give. However, even if the entire open registry fleet was allocated to the

	Region	% of fleet	40-40-20 redistribution based on % of tonnes	% of TM	Number of 15,000 dwt vessels to redistribute based on tonnes	based on TM
		I	II	III	IV	V
1	EEC	29.3	22.6	17.0	-28	-237
2	Nordic countries[a]	4.8	5.4	2.5	+58	-51
3	North America	7.3	14.6	17.5	+325	+430
4	Japan	6.8	8.6	10.2	+117	+179
5	Oceania	1.0	2.7	4.4	+67	+131
6	Other OECD countries	2.2	0.6	0.6	-41	-45
	Total OECD	*51.4*	*54.6*	*52.1*	*+498*	*+407*
7	Central America and Caribbean[b]	1.3	2.7	2.3	+63	+47
8	East Coast of South America	3.2	1.6	2.2	-37	-13
9	Other South America	2.3	1.5	1.8	-11	0
10	Mediterranean	4.2	3.1	3.5	-9	+6
11	North and West Africa[c]	1.5	1.7	1.7	+17	+18
12	East Coast of Africa	0.3	0.4	0.6	+5	+14
13	South Asia	4.8	1.0	1.7	-104	-78
14	South East Asia[d]	1.6	4.5	4.6	+119	+124
15	Far East LDCs	2.2	3.7	4.1	+71	+85
	Total LDCs excl. Open Registers	*21.3*	*20.1*	*22.5*	*+114*	*+203*
16	Open Registry Countries	12.9	1.2	1.2	-338	-338
17	Centrally Planned Economies	14.0	3.4	2.9	-289	-309
18	South Africa	0.3	0.7	1.3	+15	+37

a) Excl. Denmark
b) Excl. Panama
c) Excl. Liberia
d) Excl. Singapore

Table V: Redistribution of world fleet if 40-40-20 is used literally as principle

developed countries, the OECD area would still have a deficit of ships. Fairly large redistributions would take place within the group of LDCs, away from South Asia (mainly India) to the South East Asian countries.

The conclusion from this exercise is just to demonstrate how inadequate a cargo sharing rule like the 40-40-20 principle really is. Even if taken literally, the effects are far from the intentions of the UNCTAD.

In practice, the code will never be implemented like this. First of all, major international trading nations, like the USA, have not ratified the code. Some have ratified with reservations, like the EEC with their compromise in the so-called 'Brussels Package' where ratification was made on the understanding that the code would not apply to inter-EEC trades.

Secondly, the developing countries themselves have not been applying the code strictly. In some areas, like in South America, a principle of 50-50% has been practised by several countries even before the code was adopted. In other countries there has been great flexibility as to what should be regarded as a national carrier. Often this is a company owned in joint venture with Western shipowners and where the majority of ships come from developed countries.

Given all the effort of the UNCTAD to establish the code and given that it took 20 years before the code was ratified, it is a good example of how difficult it is to implement maritime policies in practice.

11.4 Case in maritime policy: Tanker shipping pollution

This section will address a problem that probably has received more attention than any other policy issue in postwar shipping - the pollution from ships and how to regulate a market like the tanker shipping industry.

11.4.1 Tanker shipping as a polluter of the seas

Shipping is not the main contributor to the pollution of the seas, although statistics are rather poor to document this. One study, which compares the years 1973 and 1981, concluded that much less than 50% of all pollution could be contributed to shipping.

Source	1983	1981
Shipping	2.1	1.5
of which accidents	*0.2*	*0.4*
Land based sources	2.7	1.2
Other sources (offshore, nature accidents, etc.)	1.3	0.6
Total pollution	**6.1**	**3.3**

Unit: million tonnes

Source: Bongaerts & de Bièvre, 1987

Table VI: Sources of oil pollution to the seas

These figures are consistent with those of a Japanese study from 1991, as summarised in **Table VII**.

Cause	%
Industrial spill and sewage systems	37
Oil spills from vessels	33
Tanker accidents	12
Other accidents	18

Source: JAMRI, 1991

Table VII: Causes of oil pollution

One problem with pollution from ships is that big spills attract a lot of attention, although such spills play a minor role in the total pollution in volume terms. The case of *Exxon Valdez* is a clear example of how a fairly small spill in the wrong place makes volume statistics rather worthless. **Table VIII** indicates that the *Exxon Valdez* accident was not among the biggest, but the cleanup costs after this accident go into the billions of US$, partly because the cleanup did more harm in itself than if the oil had been let alone.

Year	Vessel	Oil spill (tonnes)	Place
1967	*Torrey Canyon*	124,000	England
1978	*Amoco Cadiz*	221,000	France
1979	*Atlantic Empress*	257,000	West-India
1983	*Castillo de Bellver*	239,000	South Africa
1989	*Exxon Valdez*	36,000	Alaska
1991	*Haven*	140,000	Italy
1993	*Braer*	79,000	Shetland

Source: Hammer, 1991

Table VIII: Some memorable tanker accidents

The central question is of course whether shipping provides safe enough transportation. Taking into consideration the total number of trips carried out per year, tanker shipping has an impressive track record indeed. If we assume that larger ships, on average, make 5 trips per year and the smallest ships 15 trips per year, then international tanker shipping carries out about 32,000 trips per year. Since 1967, some 35 major accidents have occurred. In this period, tanker shipping made more than 800,000 trips, so in 99.9956% of the cases no major accident occurred. The overall performance of tanker shipping is, therefore, good and is constantly improving.

11.4.2 The human factor in accidents

After *Exxon Valdez*, a number of experts started to examine solutions to the pollution problem and much emphasis was put on technical solutions. This is in itself very typical for international regulations, technical standards and solutions are easy to measure and monitor and are thus good candidates for enforcement standards for rules and regulations. This happens in an environment where all participants are very well aware of the fact that it is the human factor that is the main problem. In fact one could question the relevance of statistics on causes of accidents, like in **Figure 5**.

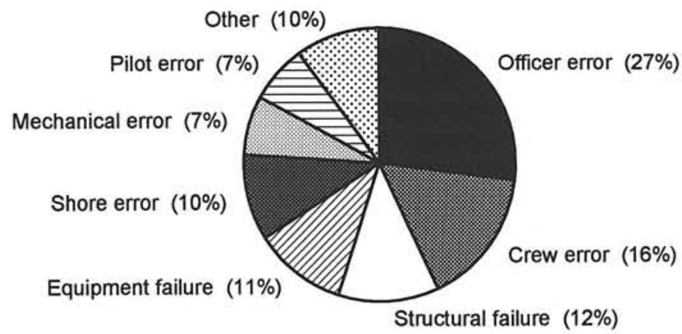


Figure 5: Causes of all maritime insurance claims 1991

Almost all the failures of machines, equipment and mechanical structures are the results of human failure in construction or human negligence in maintenance. One could thus argue that 100% of all accidents are directly or indirectly caused by human error, and that the challenge lies in reducing such errors, not only during operations, but also at the design and production stage.

11.4.3 Age of ships and accidents

If there would be a clear connection between the age of a ship and incidents connected to the ships, the age would be a good candidate for an objective criterion for the regulation of tanker shipping. In 1991 Clarkson Research conducted the most thorough study of the VLCCs ever, and some interesting data on accidents and age on the one hand, and age and overall ship quality on the other, has been presented. **Table IX** shows the number of reported incidents for the 1991 VLCC fleet of 449 ships. For 238 of them 526 incidents have been reported. These are all accidents, major and minor, many of which never led to any pollution.

The incident index indicates how the various age groups are performing relative to the total fleet average of 21.3. With the exception of the problem-81-tanker that

Year	Age	No vessels	No incidents	Aver. per ship	% incident index
1969	22	1	1	1.0	5
1970	21	3	14	4.7	22
1971	20	8	33	4.1	21
1972	19	19	61	3.2	17
1973	18	29	59	2.0	11
1974	17	54	109	2.0	12
1975	16	47	90	1.9	12
1976	15	40	78	2.0	13
1977	14	15	40	2.7	19
1978	13	9	19	2.1	16
1979	12	3	6	2.0	17
1981	10	1	6	6.0	60
1982	9	1	1	1.0	11
1983	8	1	1	1.0	13
1986	5	3	4	1.3	27
1987	4	1	1	1.0	25
1988	3	2	2	1.0	33
1989	2	1	1	1.0	50
Total		238	526	2.2	21.3

Table IX: VLCC accidents and year of build for the 1991 VLCC fleet

alone had 6 incidents, there is a tendency that older ships (70-72) on average have more incidents than the other age groups. The incident index is, however, lower than the average for these old ships. This indicates that age is not the main problem, but rather substandard operators. This is also confirmed by the fact that 25% of the VLCCs accounts for 75% of the incidents.

Clarkson Research performed a detailed survey on all the 449 VLCCs that existed in 1991 with the aim of categorising the ships according to overall quality, using the labels A-E, where A is a new or very well kept ship, C is an average ship and E is clearly a substandard vessel. Some results are given in **Table X**. As expected, the older ships generally have poorer quality, but still there are many old ships of very high quality. This makes age a poor candidate for regulation. If one wanted to get rid of all E ships by a regulation that uses age as a scrapping parameter, as many as 76 B ships and 122 C ships would have to be scrapped at the same time. At a cost of 85 million US$ per ship, these B and C ships represent replacement values of almost 17 billion US$.

Year of build	Total dwt	No of vessels					Total
		A	B	C	D	E	
1987-91	14.1	12	33	5	0	0	50
1982-86	4.1	1	16	1	0	0	18
1977-81	18.4	2	28	20	6	1	57
1972-76	77.7	0	76	121	79	34	308
1969-71	3.6	0	0	1	4	11	16
All	**117.9**	**15**	**153**	**148**	**87**	**46**	**449**

Source: Clarkson, 1991 and own calculations

Table X: The tanker age and quality dilemma illustrated by the 1991 VLCC fleet

11.4.4 Regulating regimes

The main political infrastructure for regulation of international shipping is the International Maritime Organisation (IMO). IMO is a flag state organisation, where the members have voting power according to their significance in the world fleet. IMO can implement international regulations and standards, but it is up to the individual member states to ratify and comply with the IMO regulations. IMO has no policing power, it is up to the individual coastal states to control and react against individual ships or companies that do not comply with the IMO regulations.

After the *Exxon Valdez* accident, international shipping saw a quick and dramatic reaction from the port states itself, by the introduction of the 1990 US Oil Pollution Act (OPA). OPA goes much further than any previous regulation in placing the responsibility of pollution on the operator of the ship. From 1995 OPA has introduced and is monitoring keenly the now compulsory Certificates of Financial Responsibility (COFR), a certificate stating clearly who is the financial responsible company behind each vessel carrying oil in US waters. From the year 2015 no tankers will be allowed to trade in US waters without double hull. Many international shipping companies have made it company policy not to trade in US waters because of the increased financial risk involved. Many other shipping companies have tried to reorganise their corporate structure to limit the total financial responsibility if something should happen in US waters.

It is important to world shipping and to world consumers what kind of regulatory international regime sets the rules for international shipping. If we are heading towards a regime where individual port state decisions determine the main guidelines for shipping, this will no doubt lead to a less efficient shipping industry and thus more expensive transportation. The shipping companies will have extra costs adjusting to different sets of rules. A global flag state regime is, therefore, much more preferred, but it should be one where the overwhelming majority of flag states not only participates, but actively follow up the supervisory role they have.

In this perspective it is interesting to try to interpret the latest policy paper from the European Commission called *"Towards a New Maritime Strategy"*. The paper has three main 'pillars' as summarised in **Table XI**.

The pillars	The main elements
Safety and fair competition	Define and enforce tighter flag state rules
	Common rules for Community ship registers (ratify the 1986 UNCTAD Ship Registration Convention)
	Increased port state control, including use of positive and negative financial incentives
	Increase cargo owner responsibility for using quality vessels and operators
	Special intra-European safety and working standards in special cases
Maintaining open markets	Supporting the work to get a GATS
	Use regulation 4058/86 on coordinated action to safeguard free access to cargoes in ocean trades
	Competition rules will be actively applied
	Acting against market access barriers through agreements
	Revising regulation 4047/86 against 'unfair competition'
A policy for competitiveness	Major emphasis on training and maritime education and R&D
	New signals as to State Aid - opening up for greater individuality, considering aid in terms of favourable corporate tax schemes, relieves on personal tax and social security payments to encourage use of European crews, aid towards promotion of maritime R&D

Source: Commission of the European Communities, 1996

Table XI: Main elements in the new EU maritime policy

Some of the new elements are important for the role of the port state in following up IMO conventions and regulations. It is also indicated that EU member states could impose special rules encouraging the use of quality vessels and operators. The EU position is therefore, that the main model should be the flag state model, but with a lot more emphasis on port state control. The thought of a common European flag, the Euro, is now abandoned and instead dust is brushed off the 10 year old UNCTAD Ship Registration Convention as the backbone of a policy to establish common rules for Community ship registers with no differentiation between 1st and 2nd registers and no strict nationality requirements on neither manning nor ownership.

In the area of competitiveness, the EU Commission sends out quite new signals on accepting individual solutions for individual countries. Tax systems involving tonnage tax to replace corporate tax is, one example. This has recently been implemented in The Netherlands and in the non-EU member country Norway.

In all the Commissions it is suggested that strong support for a free market with free competition should go hand in hand with port state measures to regulate markets and individual government aid schemes, to make European shipping companies more competitive.

Although the EU paper on maritime strategy only has the status of 'a Communication', it will no doubt be an instrument for the concrete work within the EU in defining the future EU policy. Since the EU is controlling more than 1/3 of the world fleet, their policy will also have an impact on shipping policies of other countries as well.

11.4.5 The public image of shipping

Shipping is in many ways suffering from a bad public image. The few times that larger accidents occur, the press is immediately labelling shipping companies as irresponsible profit hunters with no concern for safety and environment. Although Intertanko is actively trying to change this image of shipping, the organisation has not been very successful, partly because everyone sees the organisation as a spokesman for these irresponsible profit hunters.

After OPA it became clear that the shipping community needed to do something to satisfy public opinion and several member states pressed for some IMO action. At the meeting in London in March 1992, the IMO had the opportunity to do something to stall public criticism. The result was, however, not very radical.

11.4.6 The IMO options in 1992

A series of suggestions to reduce pollution and to get older ships out of the world fleet were suggested. The main elements were:

- Newbuildings should have double hulls;
- Existing vessels should have large areas of protective location[1];
- Ships should be hydrostatic balanced in loading[2];

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[1]The idea behind protective location is that statistically, in a collision between two ships, the point where one ship hits the other, could be anywhere on the surface of the ship at the waterline. If some of the space on ships is empty, then there will be no oil spill if hit exactly there. By making all ships with empty tanks on 30% of this surface, the probability of being hit in empty tanks increases and the probability of spilling oil decreases.

[2]Oil is heavier than water and in a fully laden vessel the inside bottom pressure in the tanks is higher that the pressure from the water outside the bottom. By reducing the intake of oil, this can be reversed, so that in a grounding, the pressure from outside will force water into the hole in the hull, rather than having oil flowing out. This will greatly reduce pollution from groundings.

- Pre-MARPOL ships should be equipped with segregated ballast tanks (SBT).

It is quite remarkable that all these suggestions concentrate on the ship itself. The only proposal dealing with the core problem, substandard operations, was to encourage inspections and class certificate control, but also this issue was limited to the ship itself, not to the operating organisation.

There were several proposals during this particular IMO meeting, including two proposals - one supported by Germany, Japan, UK and the Netherlands and one supported by Sweden and Norway. The main purpose of these proposals was to encourage early scrapping of tankers to get a young fleet with higher standards as a mean to reduce public criticism on the tanker industry.

The main elements of the Swedish-Norwegian proposal were:

- Pre-MARPOL ships must have SBTs at the age of 22 and 30% protective location;
- Pre-MARPOL ships must introduce hydrostatic loading at the age of 26;
- MARPOL ships must introduce hydrostatic loading at the age of 22.

The main idea was to propose restrictions so that only the very best pre-MARPOL ships might consider investing in segregated ballast tanks at the age of 22. This would have forced the majority of the 1972-74 built vessels out of the market by 1994-96.

Neither the Swedish-Norwegian nor any other radical proposal were able to attract sufficient support during the IMO meeting. Instead the result was:

- Older tankers can sail without any specific changes until the age of 25;
- More control and inspections of older ships;
- After the age of 25 the ships must either have 30% protective location or introduce hydrostatic loading;
- After the age of 30 all vessels must have a double hull.

This implies that all vessels in principle could sail until they are 30 without any dramatic cost increases. Costs required for meeting classification standards relative to freight rate expectations will determine which ships are scrapped.

One of the main reasons why a more radical approach did not succeed can be found in **Table X**: Age is not a good criterion for the quality of vessels. Too many good tankers would have to be scrapped much too early under the radical proposals and, since flags like Panama, Liberia, Greece, Bahamas and Malta control more than 50% of the world tanker fleet, any radical proposal had no real chance to get enough support. The interests of certain flag states played a very clear role in determining the IMO action at this stage. This demonstrates a general problem of the IMO.

11.4.7 The costs for consumers of tougher tanker market regulation

It is interesting, however, to examine what the costs for the world *would have been* in case of a more radical IMO proposal. To study this, the long term dynamic model of the tanker market as described in chapter 9 has been used. The model assumes that all investors are behaving rationally, but that they are facing fundamental demand uncertainty, which influences their investment behaviour. The model calculates theoretical correct prices that will make all investments earning a 10% on equity. Uncertainty is introduced through the oil price that can take on three levels in the model - high, medium and low. With medium and stable oil prices the underlying expected growth in trades is 4% per year. One scenario - assuming stable, medium oil prices - was used to simulate the actual result of the IMO meeting in 1992, using the data for 1991 as the starting point of reference. The model generated a simulation of the development in freight rates as indicated in **Figure 6**.

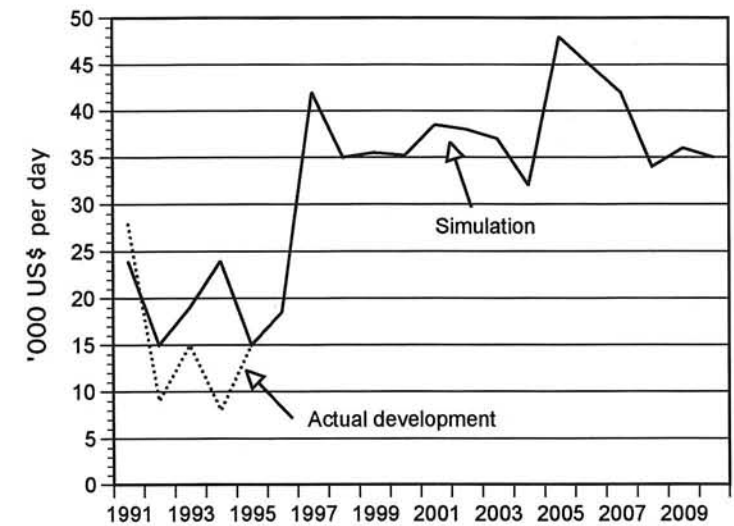

Figure 6: Freight rate simulation of the consequences of IMO regulation 1992

Compared to the actual development since 1991, the scenario is somewhat more optimistic. Since 1991 a combination of lower demand growth in tonne-miles mainly due to higher production of oil in the North Sea, has reduced average distances, and higher fleet growth than the simulation.

Figure 7 indicates the scrapping volumes and investment volumes that were the result of the simulation. These are also compared to the actual development, which shows generally higher levels of investments over these 5 last years and a somewhat different scrapping profile.

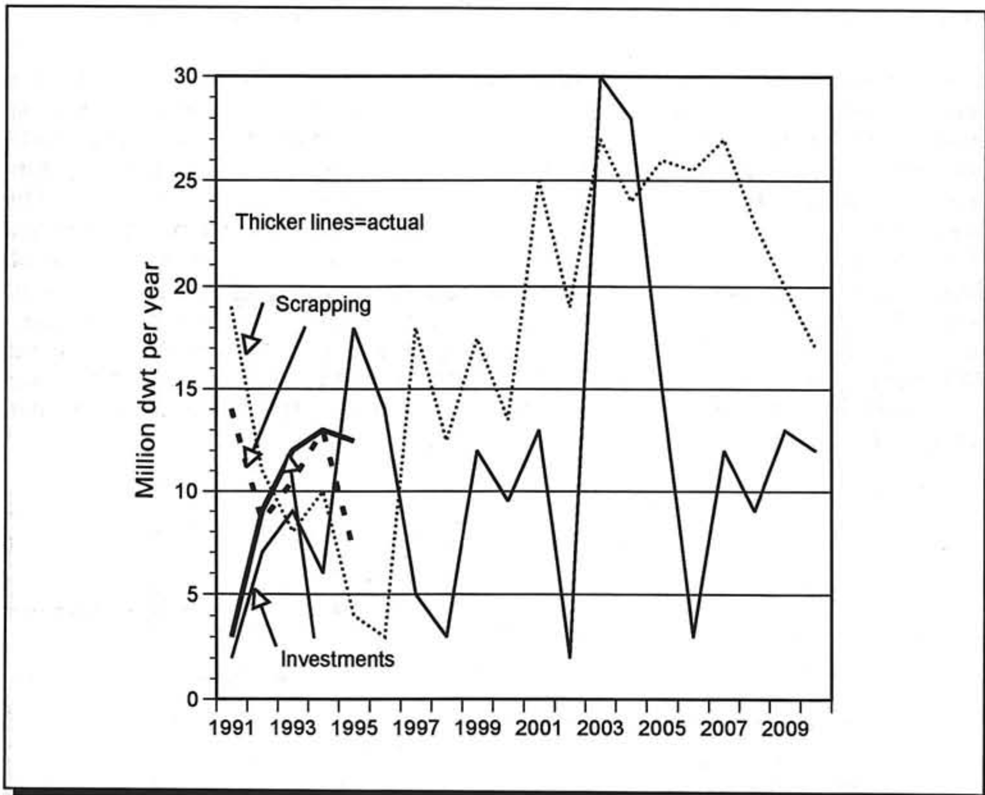

Figure 7: Scrapping and investment volumes in tankers after IMO decision in 1992

Against this base case simulation of the consequences of the IMO decisions, the Swedish-Norwegian proposal was simulated based on the following assumptions:

- Conversion to SBT for pre-MARPOL ships costs 5.7 million US$;
- Reduction of cargo capacity in case of hydrostatic loading is 22% for pre-MARPOL ships and 5% for MARPOL ships.

In this case investments in SBTs are carried out for the majority of pre-MARPOL ships when they reach the age of 22 and they are all scrapped at the age of 26. The MARPOL ships proceed with reduced cargo capacity until the age of 26 and are then scrapped. This would have given a profile of scrapping compared to the base case as indicated in **Figure 8**.

The freight rate development for this much more proactive scrapping behaviour, is illustrated in **Figure 9**. The Swedish-Norwegian proposal would have caused much higher freight rates over the period up to year 2003 and a much faster renewal of the tanker fleet. **Table XII** shows the consequences of the two alternatives.

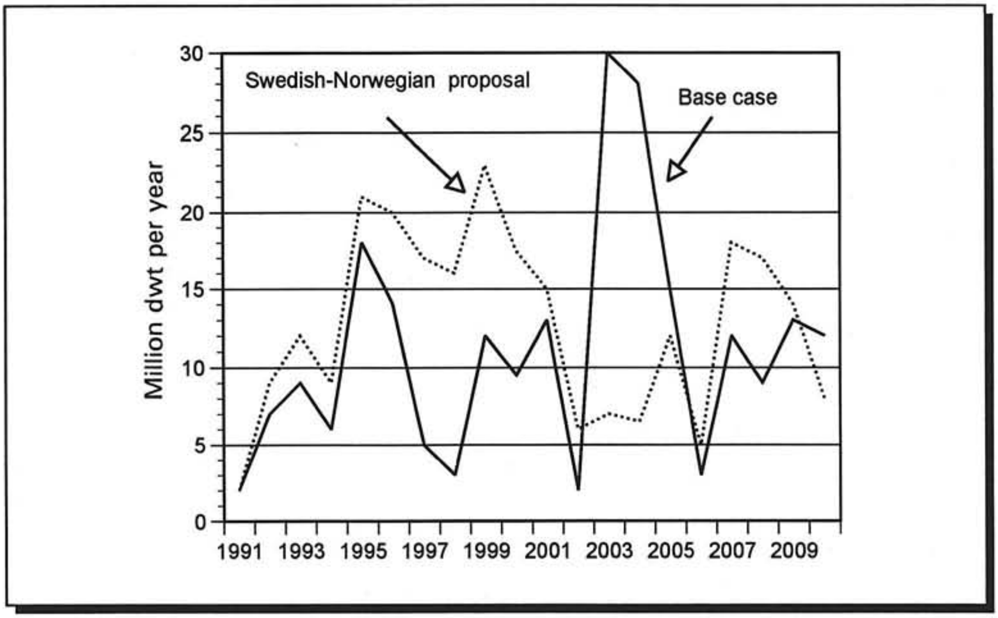

Figure 8: Scrapping behaviour comparison

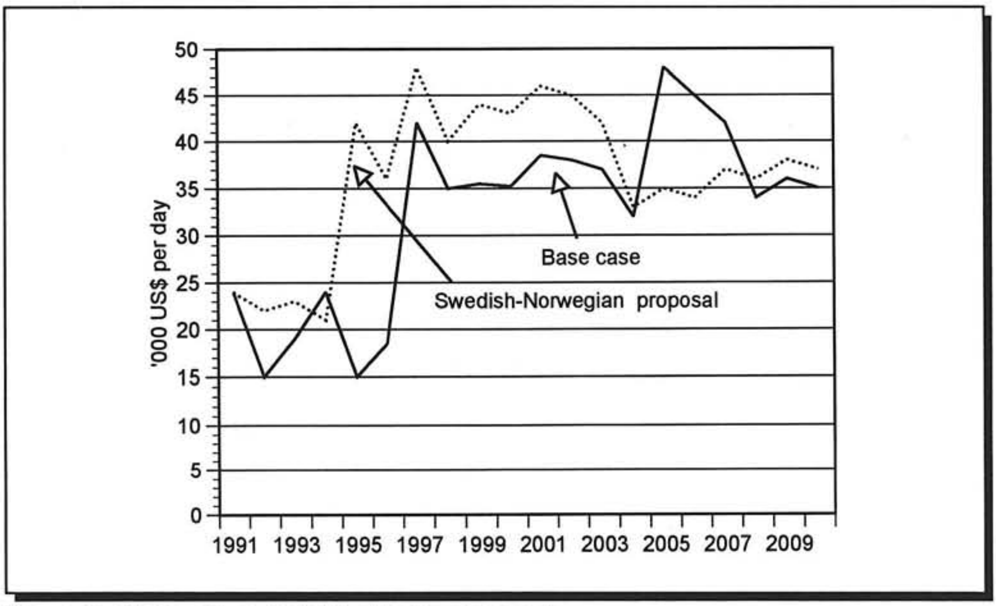

Figure 9: Comparison freight rate development

The Swedish-Norwegian proposal would clearly have led to a quicker renewal of the fleet, but also increased freight rates. The nett present value of the TC-equivalents increases by some 3.6 billion US$. This represents, however, only a

	Base case	Proposal
Fleet in 2015 million dwt	445	435
Accumulated scrapping 1992-2015 million dwt	259	293
New orders 1992-2001 (million dwt)	137.4	230.5
% of fleet older than 15 years in 2000	48%	27%
Net present 1991 value of TC-equivalents. billion US$	60.37	63.9
As % of FOB value of oil carried	3.80%	4.02%

Table XII: Comparisons of the base case vs. the Swedish-Norwegian proposal

mere 0.22% increase in the total transport bill. It can, therefore, be concluded, that the costs for the world consumers of a much tougher regulation of the tanker market are not at all dramatic. Still, this is difficult to achieve under the current regulation regime, as the incentives of the members of the IMO are connected to the current ships under operation, relative to the costs of newbuildings. The broader perspective of the image of the shipping industry and the welfare of the world as such do not enter the equation.

CHAPTER 12: ROUTING AND SCHEDULING OF SHIPS

12.1 Bulk Shipping

12.1.1 Introduction

The challenge for shipowners in the bulk trades is to maximise the utilisation of their ships, or rather to minimise the ballast voyages. This can be done by clever routing and scheduling. However, the characteristics of major commodity flows is such that no matter how much expertise is put into the effort, the ships have to sail in ballast close to fifty percent of the time.
Before the more formal routing and scheduling approaches will be discussed, it is therefore useful to have an insight into the basic flows of goods around the world.
Fearnleys in its annual report *"World Bulk Trades 1995"* shows some very clear pictures of the major world bulk trades.
Figure 1 shows the origin and destination of seaborne crude oil in the world. The total 1994 trade amounted to 1,403 million tonnes, and 7469 billion tonne-miles. It is self-evident that the dedicated crude oil tankers can only be employed in one way traffic, although the use of the Suez canal enables some tankers to reduce the ballast leg substantially on the trade to and from Europe

Figure 2 shows a similar picture for the world iron ore trades, which amounted in 1994 to 383 million tonnes and 2,165 billion tonne-miles. Although this is again more or less the same unidirectional flow as in the case of crude oil, the opportunities for the shipowner increase by the nature of the commodity iron ore. Bulk carriers that can transport this heavy commodity, have to be specially designed for it. These are ore carriers or strengthened bulk carriers. Ore carriers are able to transport other bulk commodities like coal and grain, but standard bulk carriers cannot transport iron ore.
An owner of an ore carrier can try to find employment in other dry bulk trades in order to reposition his ship back to the loading zones of iron ore, like Brazil and Australia. Two of the main flows are those of coal and grain.

Figure 3 shows the 1994 trade flows of coal, which amounted to 383 million tonnes and 2,014 billion tonne-miles. **Figure 4** shows the 1994 trade flows of grain, which amounted to 184 million tonnes and 992 billion tonne-miles. Similar pictures can be drawn for other commodities like bauxite and alumina, phosphate rock, manganese ore, cement, gypsum, nonferrous ores, potash, petroleum coke, tapioca, etc.

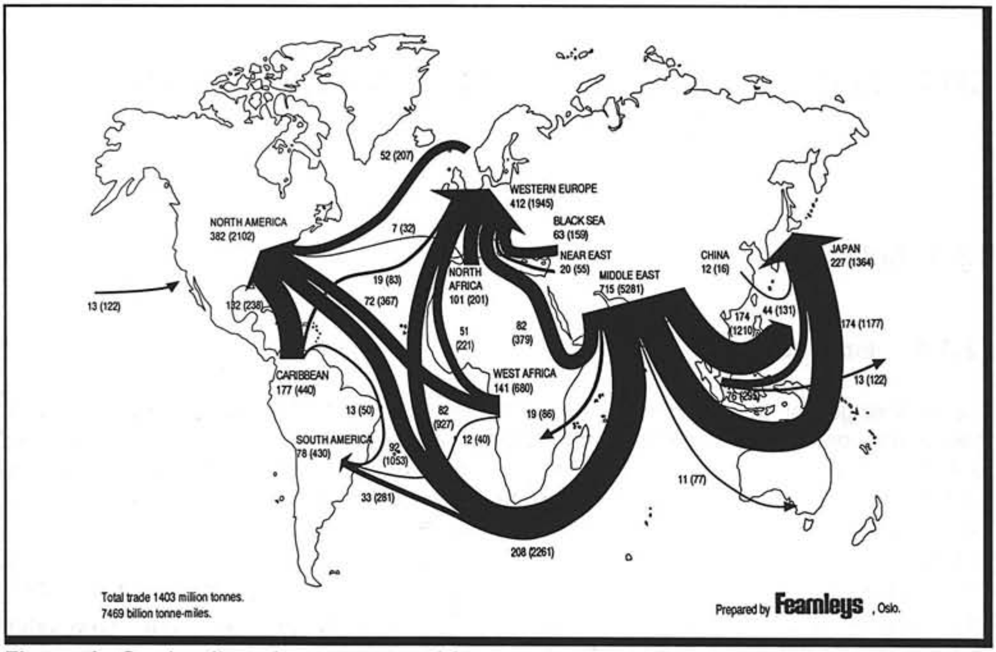

Figure 1: Crude oil seaborne trade 1994

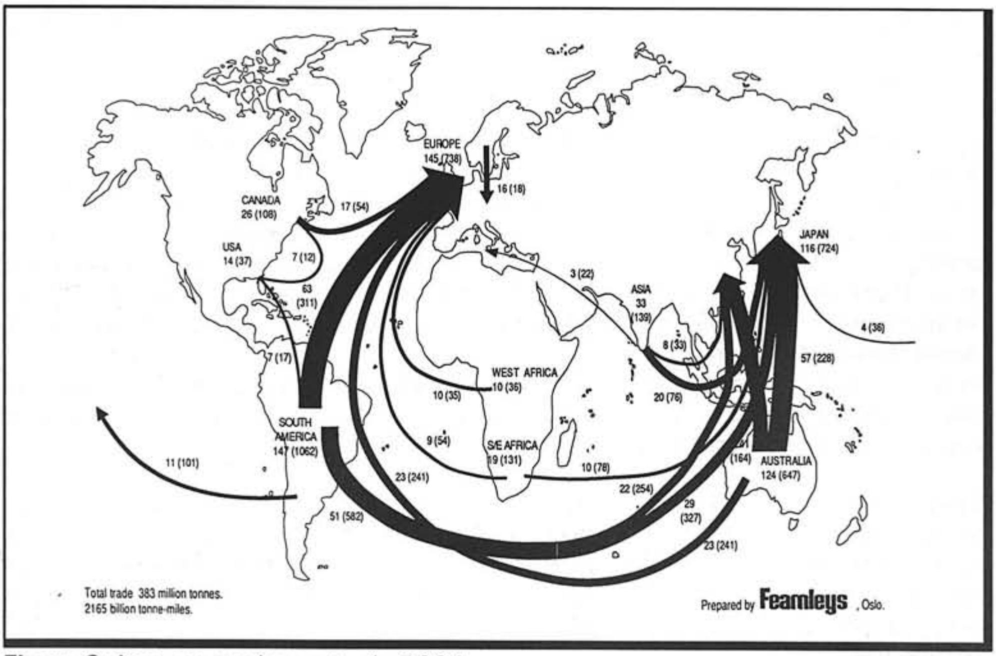

Figure 2: Iron ore seaborne trade 1994

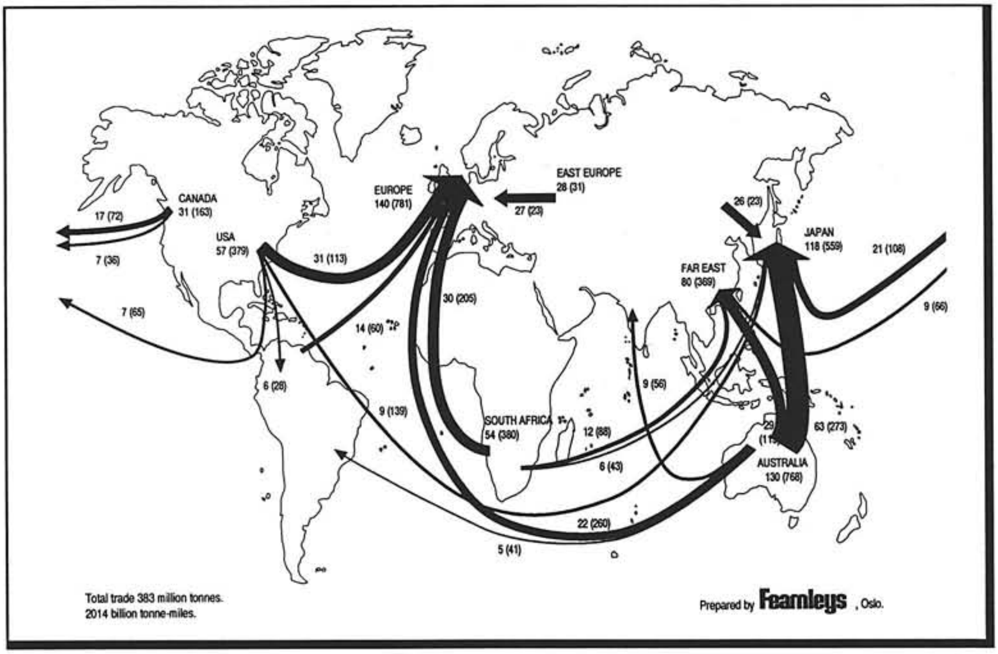

Figure 3: Coal seaborne trade 1994

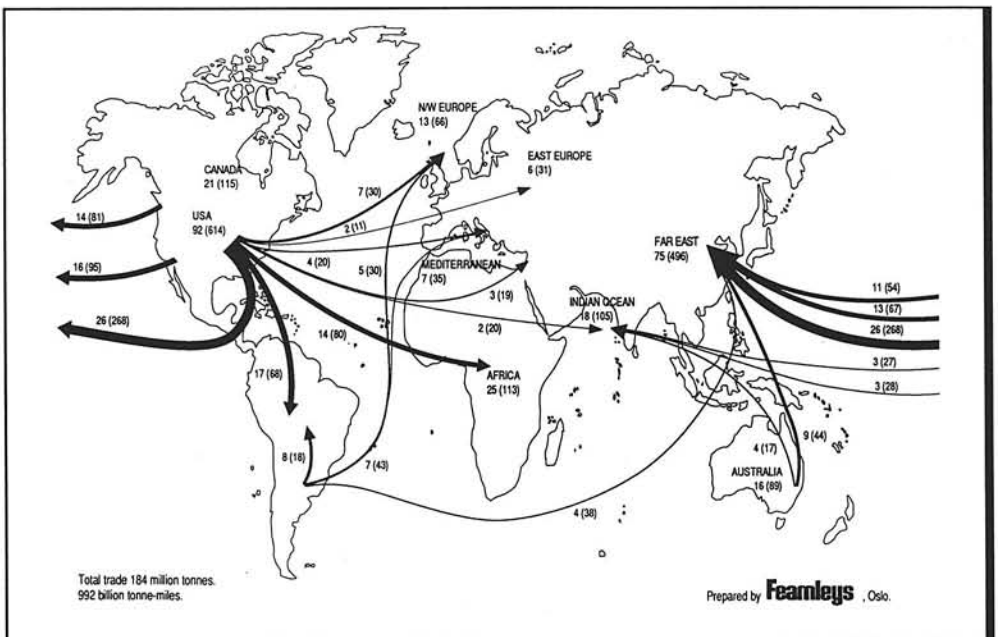

Figure 4: Grain seaborne trade 1994

The smart owner in the bulk trade tries to find combinations of successive trips for his ship in order to minimise the empty legs. An example from the shipping company Teekay will illustrate the potential of such a policy.

Figure 5 shows two cases of bulk carrier employment. The upper case, called industry practice, is the situation in which a bulk carrier loads in one port, discharges and returns in ballast to the loading port. This alternative creates a revenue for the owner of US$ 480,000 per round-trip of 40 days, or a time charter equivalent of US$ 12,000 per day.
The lower case, titled the Viking Star Backhaul, includes three extra ports of call, two for loading and one for discharging. In fact the owner creates in this case a parcel service. The time charter revenue increases to US$ 900,000 on a round-trip time of 52 days, which equates to a TC-equivalent of US$ 17,308.

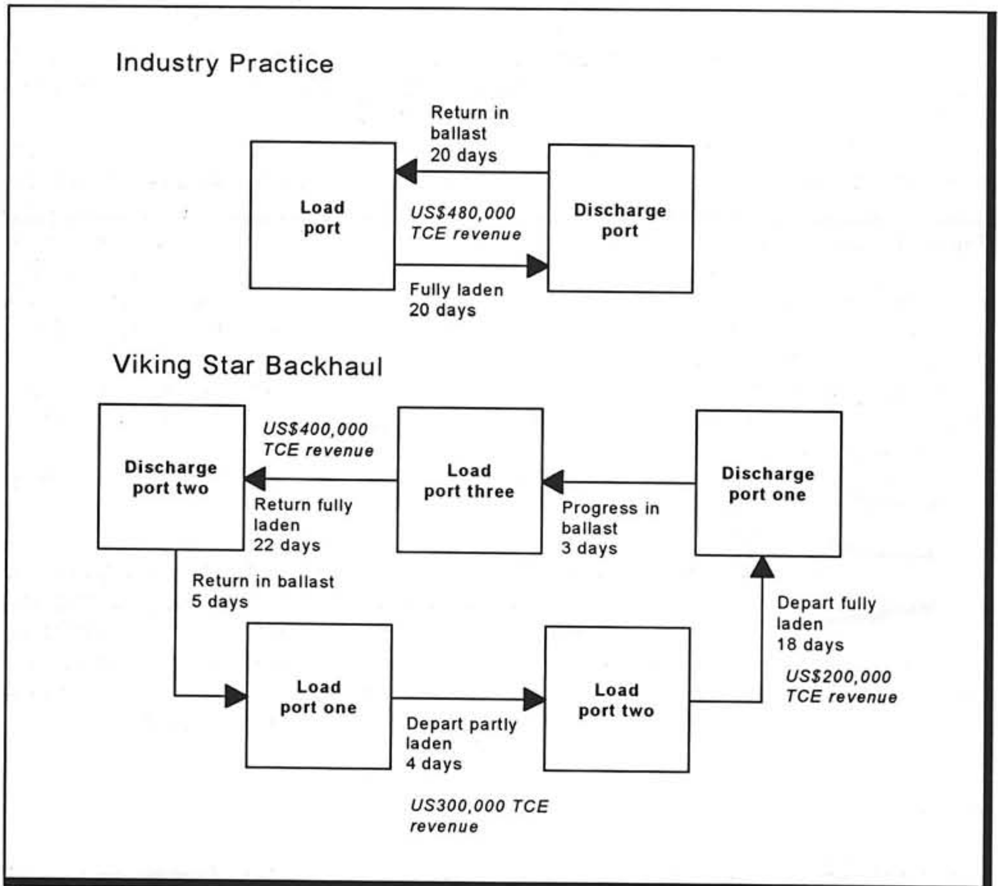

Figure 5: Two cases of bulk carrier employment

The smart shipowner tries constantly to find such a performance enhancing routing for his ship. It will be clear that there are limits to the possibilities, as commodities are not always compatible. Therefore, a special class of ships has been created that can switch over time between the different bulk markets, which is called the OBO carrier (Ore-Bulk-Oil).

The dry bulk trades discussed previously, are all deepsea trades, in which large bulk carriers are employed. The challenge of eliminating ballast voyages also exists on the shortsea trades, where smaller ships are employed. Shipowners try to design new ship types in order to cater for the special transport needs and opportunities of a region. An example of such an effort is the development of the COB vessel (container-oil-bulk) by the shipowner Van Nievelt Goudriaan at the end of the eighties, a company, which unfortunately ceased to exist.

12.1.2 Container-Oil-Bulk carrier

The COB carrier is a ship that can transport three different commodities: Containers, bulk cargoes and oil. Due to this ability a COB carrier can carry cargo when conventional bulk carriers have to sail in ballast.
Specific commodity flows often go in one direction only, e.g. forest products flows in Europe go mainly from Scandinavia to the other European countries, however not in the opposite direction. This means that forest products carriers on this route have to sail half of their time in ballast. When the ship is able to take an oil cargo on its return voyage this will increase the profit, even if this means that the ship has to sail a longer route, when the return cargo has to be loaded in a port other than the discharging port. This way the time the COB carrier sails in ballast may be reduced from 50% to 10%.
A second advantage of COB carriers is that due to their box-shaped stainless steel cargo holds, they have a smaller risk of being damaged than conventional ships and are easier to clean.
The main disadvantage is that the ships are more expensive than conventional bulk carriers.

Figure 6 shows an example of a COB carrier. Characteristic for the design of the carrier is the construction of the hatchways. One side of the hatchway is flat, the other side has vertical bulkheads in longitudinal direction. The bulkheads serve as cell guides for containers on deck. When the hatchways are turned around they can be used to reduce the free fluid surface of oil cargoes, and this way enhance the stability of the ship. The main dimensions of the ship are given in **Table I**.

Planning

When this study was made by ir. P. van Mechelen for his master thesis, the shipowner under study had a fleet of three, almost identical COB carriers, and plans to increase the number to six. The ships were deployed for contract voyages as well as for spot voyages. The contract voyages guaranteed a minimum number of voyages, spot voyages were used to fill the gaps between the separate contract voyages.

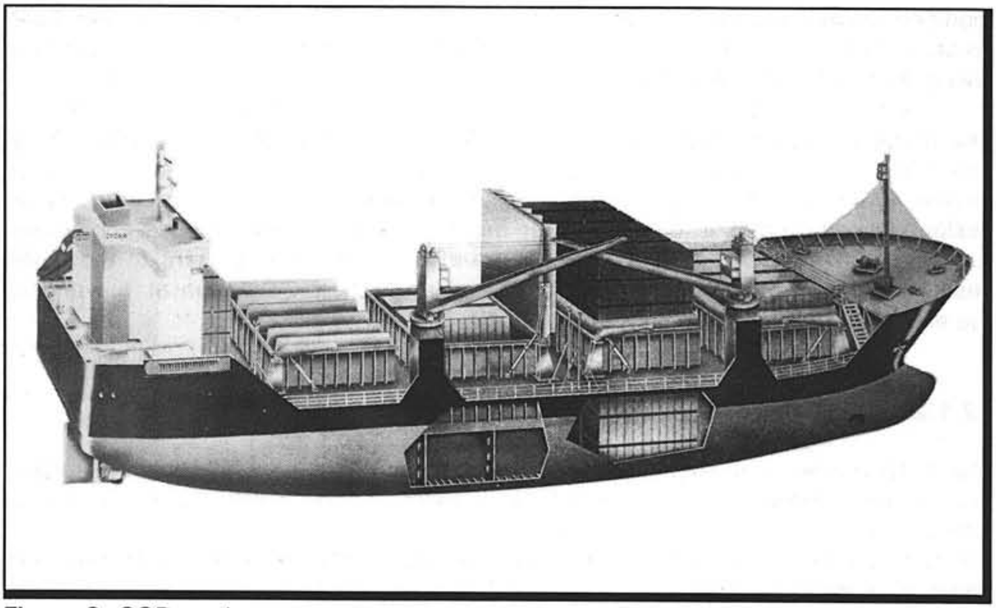

Figure 6: COB carrier

Length over all	99.80 m	Capacity	(bale)	6,800 m³
Length p.p.	93.00 m		(oil)	7,195 m³
Breadth	17.00 m	Propulsion		Bergen diesel
Depth	8.50 m	Power		3,250 kW
Draught	6.53 m	Service speed		12 knots
Deadweight	6,000 tonnes			

Table I: Main dimensions of the COB carrier

The ships transported mainly the following cargoes: Oil, wood and pulp, and were deployed on the following routes:

- Oil products from the UK (Immingham) to the west and east coast of Sweden. These journeys take about five and seven days, respectively;
- Oil products from the west coast of Sweden to the east coast of Sweden. This journey takes about five days;
- Forest products from the east coast of Sweden to the northern part of Germany or the Netherlands. This takes about 7 days;
- Spot voyages from Russia (St. Petersburg) to e.g. the ARA range (Amsterdam, Rotterdam and Antwerp).

When dry cargo is carried after carrying an oil cargo, the holds first have to be cleaned thoroughly. This was done in Gavle, a city located at the east coast of

Sweden. Cleaning takes about 20 hours, excluding the sailing time to and from Gavle.
One ship made about four round-trips a month. Every round-trip comprised a maximum number of five ports: One or two loading ports, one or two discharging ports and if necessary one cleaning port. On average, the number of ports per month was ten.
The speed depended on the route and varied between 10.5 and 11.7 knots. When a planning was made, weather conditions were not taken into account, since it is difficult to estimate its influence, only a distinction was made between the summer and the winter season, since speed can decrease significantly due to ice.

Ballast voyages were minimised and only acceptable within three areas. Between these areas the carriers should not sail without cargo. These areas are:

1. The entire area west and east of the northern part of the Netherlands;
2. West coast of Sweden and Denmark;
3. East coast of Sweden, Finland and Russia.

Further, ballast voyages were allowed between The Northern Netherlands and Northern Germany and areas 1 and 2 from the above list.

The planning was made one month in advance. Contract voyages were announced by the shipper at the end of the month before, together with the days required for loading (laycan), the loading port and sometimes the discharging port. Then, a sailing schedule was composed, in which the costs were minimised and the revenues were maximised. Sailing time was calculated on the basis of the distance between the two ports and the expected service speed. The loading and discharging time for each commodity and port are known by experience. Deviation from these times, frequently occurred, but were not taken into account for the planning.

The planning had to account with a number of restrictions. The most important restriction was that forest products and other dry cargoes often cannot be loaded and discharged on a Sunday. Another problem was the working hours of the shifts. When a ship arrives later than the starting time of a shift, the ship has to wait until the next shift starts or has to pay extra for the waiting hours of the shift between the starting time and the time the ship arrives. Bulk cargoes are not loaded or discharged during the night unless special provisions, which costs extra, are made.

The planning was also complicated by the laycans of the shipper. Often it was not possible to get an optimal productivity for the ship and also comply with the desires of the shipper. Sometimes it was possible to work out a compromise.

The sailing schedule composed contained the following information:

- ETA (Estimated time of arrival);
- ETS (Estimated time of sailing);

- Loading port;
- Discharging port;
- Cleaning port.

The general routing problem in shipping can be defined as follows: *Allocating cargo to the available ships in such a way that the revenues are maximal. All cargo under contract must be allocated and all operational restrictions must be complied with.*

Automatic routing

Making a planning is a very time-consuming activity. Therefore, the target of this study is to make a computer program that does the planning. To achieve this two existing models for similar problems have been studied and used as a starting point for the new planning program. The existing models are described in the following sections.

Model 1

Model 1 is a model, originally written for the planning of COB carriers and calculates an exact solution. This means that the solution presented is the *best* possible solution for the problem. All possible solutions are checked and evaluated. Then, all solutions are compared and the best one is selected.
The main disadvantage of this method is that, because *all* possible combinations are checked, calculation time is very high. If it is a complicated problem (many ships, many voyages), it may not even be possible to find a solution within an acceptable amount of calculation time. Depending on the number of ships and voyages the calculation time of the computer may even add up to years.

The calculation requires two types of information, which is stored in two different databases. The first database contains information on cargo, ships, ship types and canals. The information about ships and canals is fixed and only changes incidently, the information about cargo headers and cargo items changes for every planning. The second database contains information about the distances between the ports.

After the information has been entered into the program the calculation starts with three test:

- A deadweight test;
- A time windows test;
- A ship type test.

The deadweight test checks which ship can carry which cargo. The time window test looks which cargoes cannot be carried in succession. Finally, the ship type test determines whether the ships are allowed to carry the cargo, according to their IMO classification.

On the basis of the calculated distances the sailing times between the loading and discharging ports can be estimated and together with the loading and discharging time all possible round-trips can be determined. Finally, the sailing schedule with the highest nett income is selected.

The algorithm for the voyage calculation works as follows. The algorithm consists of two separate parts. The first part determines the cargo vectors (round-trips). i.e. all possible combinations of cargoes for a ship.
This cargo vector consists of two parts. The first part shows which ship is being considered. The second part shows the cargoes that have been assigned to the ship. A cargo vector is for example: (0 0 0 1 | 0 1 0 1 0). This vector shows that ship 4 carries the cargoes 2 and 4. The number of possible cargo vectors is restricted according to time, capacity and classification. Cargoes cannot be divided over more than one ship.

The second part of the algorithm contains the optimisation process. The target is to minimise costs, but can also be the maximisation of revenues. The target function is defined as follows:

$$\Sigma\ C_i\ x_i$$

Where:
- x_i = A decision variable that is 1 when vector i is selected, otherwise it is 0;
- c_i = The costs or revenues of round-trip i.

The round-trip with the lowest costs is selected.

Model 2

Model 2 is a strong simplification of the reality, and is based on heuristics. Heuristic algorithms do not have to converge to an optimal solution. Often a semi-optimal solution is selected. Due to selection procedures, the best solution may be missed. The main advantage, however, is calculation time. The calculation time of a heuristic algorithm is often considerably less than that of an exact algorithm.

The assumptions for model 2 are the following. During a specific period the direction and size of the cargo flows between a number of ports are known, as well as the time span in which the cargo has to be transported. There is only one type of goods.

Initially it is assumed that there is an unlimited number of identical ships. The capacity, speed and costs of these ships are known. The ships are assigned to the cargoes in such a way that the costs are minimal. The algorithm determines how many ships are required and which routes they should sail to transport all the cargo with minimal costs. The emphasis is on the minimisation of the costs. The revenues are fixed.

The ships should be utilised maximally. Therefore an attempt is made to make large chains of voyages. It is assumed that the starting time of each voyage is known. This means that the sequence of the voyages is fixed and determined by time.

The procedure is as follows. First, ship 1 is assigned to voyage 1. Then the next voyage is considered. When ship 1 is able to arrive in the loading port before this voyage has to start, it is assigned to ship 1 and the ship sails to the new loading port in ballast. If this is not possible the next voyage is considered, etc.

Secondly, the same procedure is repeated for ship 1, starting with voyage 2, then it is repeated for voyage 3, etc. After this procedure has been repeated for all voyages on this first level, the longest chains are selected, the other chains are rejected.
Now for each of the longest chains it is considered which voyages remain for the other ships. The procedure is repeated for ship 2 (level 2), then for ship 3 (level 3), etc. This procedure results in a tree structure as shown in **Figure 7**. From all selected chains the one with the lowest costs is selected.

The main disadvantage of this algorithm is that the target is not to find the optimal solution but an acceptable solution. Often it is better to skip a voyage, especially if a long ballast voyage is required, while another ship is much nearer.

The COBplan model

Model number 2 is best suitable as a starting point for the design of the new model, called COBplan. Model 2 provides an acceptable solution for the planning of COB carriers. The model tries to assign as many voyages to one ship as possible, which is positive because this way the ships are well utilised and other ships can be used for other voyages.
Time is the main decision criterion. This is very important for a planning model for the tramp market. Finally, calculation time is short and the required computer memory is relatively small.

The COBplan model is based on model 2, so this section mainly describes the differences between the two models. The COBplan model comprises the following steps:

1. Determine which ships are considered;

2. Determine which combination and which level is considered, this is not required for the first level;

3. Determine which voyages have not been assigned to a ship yet. Determine for every trip the first port of the voyage: Cleaning port or first loading port.

4. Determine which voyage will be considered first in the chain;

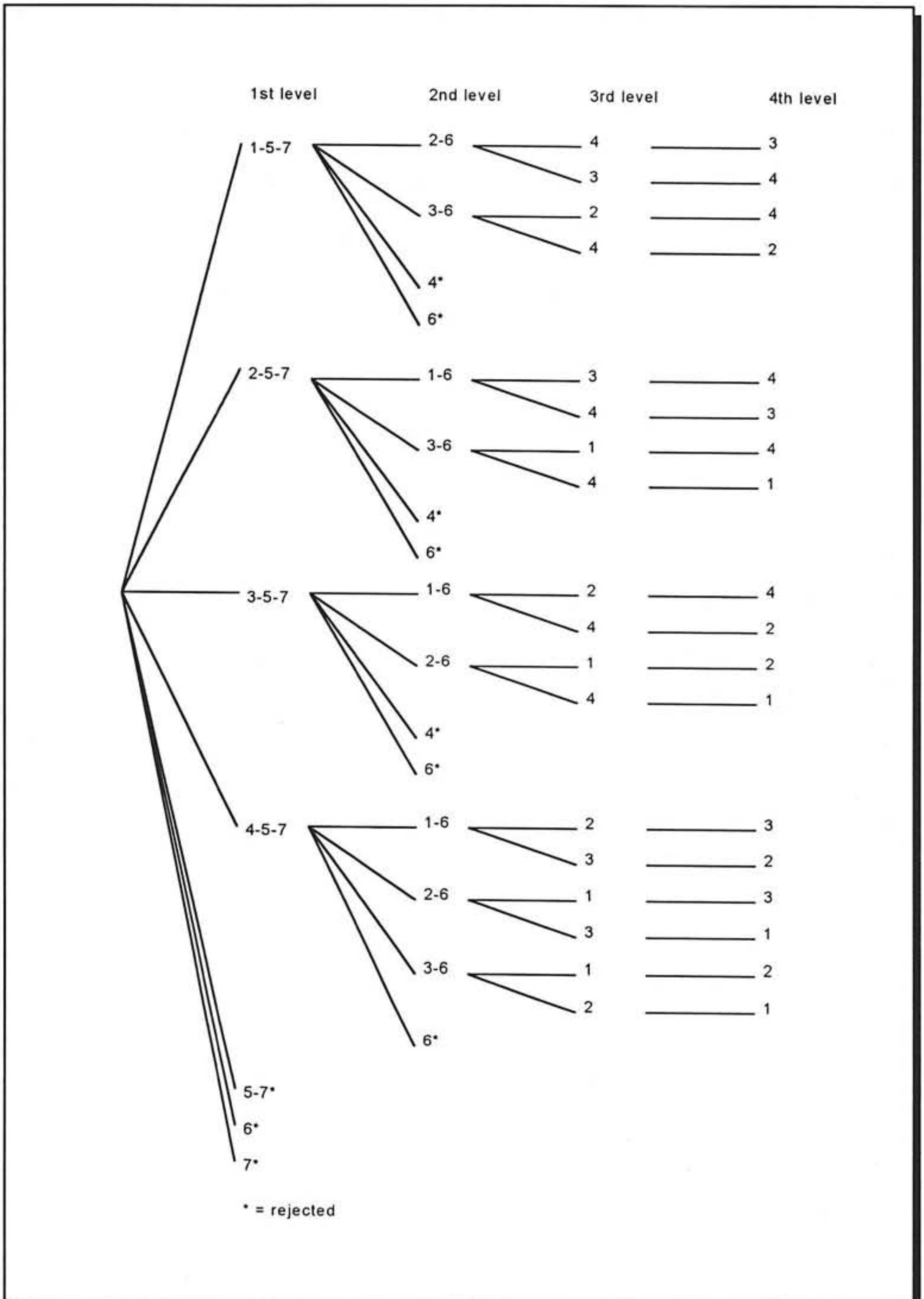

Figure 7: An example tree structure of model 2

5. Check if the ship is able to get from the starting port to the loading port of the voyage. If this is not the case, go back to step 4;

6. Assign the first voyage to the ship on the considered level;

7. Calculate the time at the end of the voyage on the basis of cleaning, loading and discharging time, and the sailing distance;

8. Determine which voyage is next after the previous voyage is finished;

9. Check if the ship is able to get from the discharging port of the previous voyage to the loading port of the next voyage? If this is not true, go back to step 8;

10. Assign the voyage to the ship on the considered level;

11. Calculate the time at the end of the voyage on the basis of cleaning, loading and discharging time, and the sailing distance;

12. Repeat from step 8, until all voyages have been assigned;

13. Determine the longest chain;

14. If the chain is the longest one on the considered level, then save it;

15. Repeat from step 4, until all voyages have been considered as the first one in the chain;

16. Determine the longest chains and save them as possible new combinations;

17. Go one level up and repeat the procedure from step 3;

18. Determine the best combination up until now on the basis of the utilisation ratio of the ships;

19 Repeat from step 2, until all possible combinations have been considered;

20. Repeat from step 1, until all possible combinations to the ships have been considered.

21. Print the best solution.

Figure 8 shows a flow diagram of the algorithm.

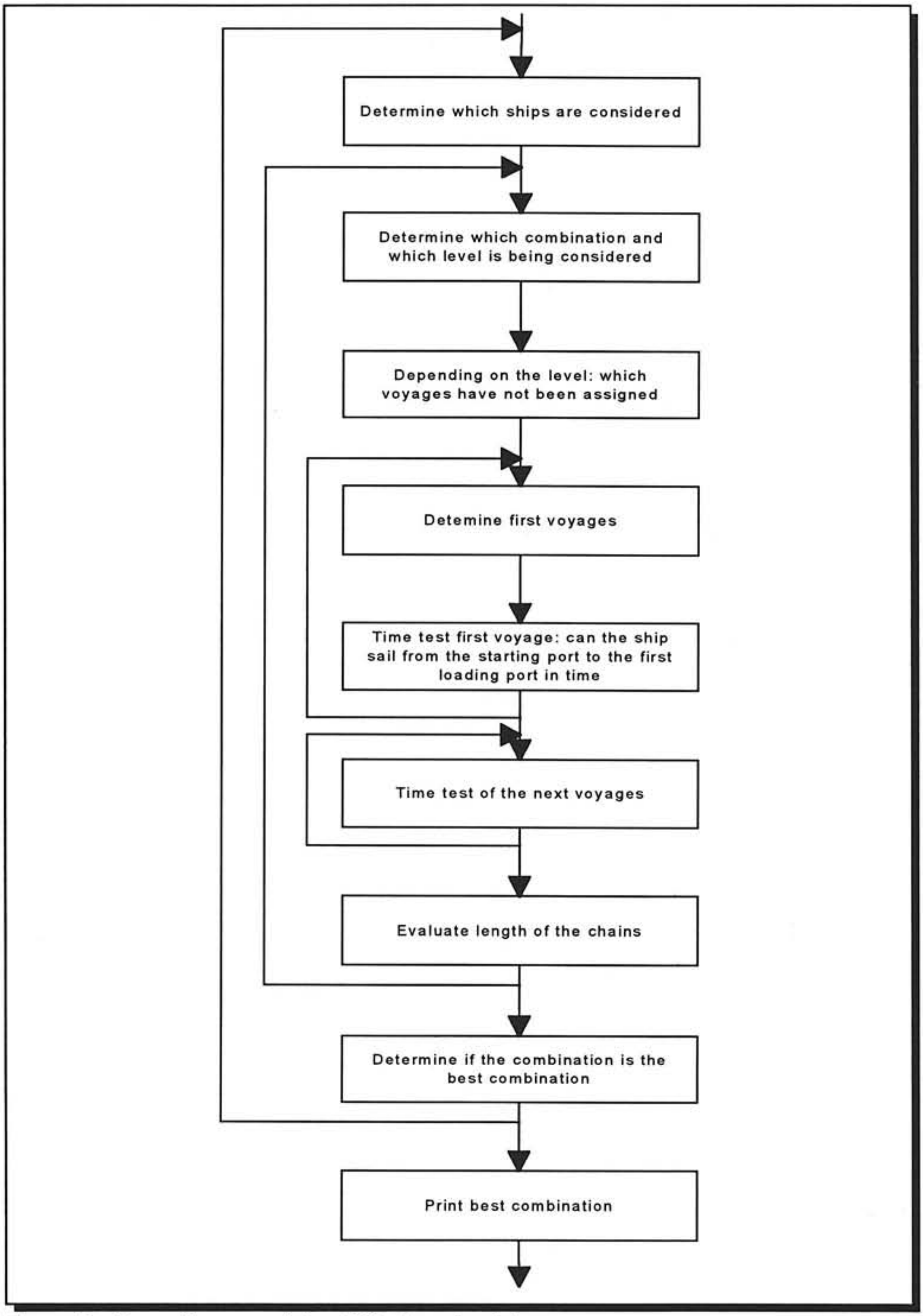

Figure 8: Flow diagram of the COBplan algorithm

Model 2 assumes that a ship is available in the loading port of the first voyage assigned to the ship. In reality, a ship will be available in a specific port and will have to wait for the next voyage that starts in that port or sail to another port in ballast. Usually the ship will not be available in the port where the first voyage starts. The COBplan model considers whether the ship can sail from the starting port to the first loading port in time. If the ship cannot arrive in the loading port in time another voyage is considered.

In the new model loading, discharging and cleaning time are fixed. They are added to the total sailing time.

It is important that there can be more than two ports in one voyage. Sometimes the ship will first have to sail to a cleaning port, before it can start a new voyage. In the COBplan model the cleaning port is considered to be the first port of the voyage. Then the distance between the ports is determined. On the basis of the distance, the speed of the ship and the loading, cleaning and cargo loading and unloading times, the total voyage time is calculated. This way it can be determined when the ship is available again. The discharging port of the voyage can be used as the starting port, after which the procedure is carried out again. This process is repeated until all voyages have been considered.

In reality often the starting time of a voyage is not fixed, but the shipper will agree on a period in between which the loading has to start, the loading window. This means that initially the exact moment of loading is not known.
The model first determines whether the departure time from the discharging port is end of the loading window of the new voyage. If so, the time to get to the new loading port is estimated. If the ship can get to the loading port before the end of the loading window, the ship can do the voyage. The ship will start loading at the start of the loading windows or at the moment on which it arrives in the loading port.

In model 2 the sequence in which the voyages are entered into the program influences the result. In the COBplan model the influence is eliminated since the voyages are sorted on the basis of the end of the loading windows.

The COBplan also takes into account that some commodities cannot be loaded on specific days. The model checks whether discharging takes place in such a period. In this case, the number of discharging hours within such a period is added to the voyage time.

Often there is more than one solution possible. The best planning is selected on the basis of the utilisation ratio. The utilisation ratio is defined as follows: *Sailing time laden + cleaning time + loading time + discharging time*, divided by *sailing time laden + cleaning time + loading time + discharging time + ballast time + waiting time*.
The utilisation ratio has been chosen as selection criterion because this reduces the required input. The solution with the minimum ballast time and waiting time will be selected. This is also the solution with the largest nett revenues.

The solution depends very much on the voyages considered. With the test data, 3 ship, 9 voyages, the program achieved a utilisation ratio of 0.806. Planning by hand resulted in a utilisation ratio of 0.761.

12.2 Liner Shipping

The routing and scheduling challenge in container shipping is quite different from that of dry bulk trades. Container ships are employed on more or less fixed routes, calling regularly at many ports. An example of the routing and scheduling challenge is provided by Nedlloyd Lines' worldwide network sailing booklet, September 1995, 32 services, sometimes with fancy acronyms, like SINBAD and SAFARI, use over two hundred vessels, and call at hundreds of ports. These services are often jointly operated with other container lines, sharing the capacity on board and the costs of operating the ships (slot charters). **Figure 9** shows some examples of the liner services of Nedlloyd Lines, and **Table II** the sailing and port schedule of the LAMCON service: Far East - East Coast South America - Far East - West Coast South America.

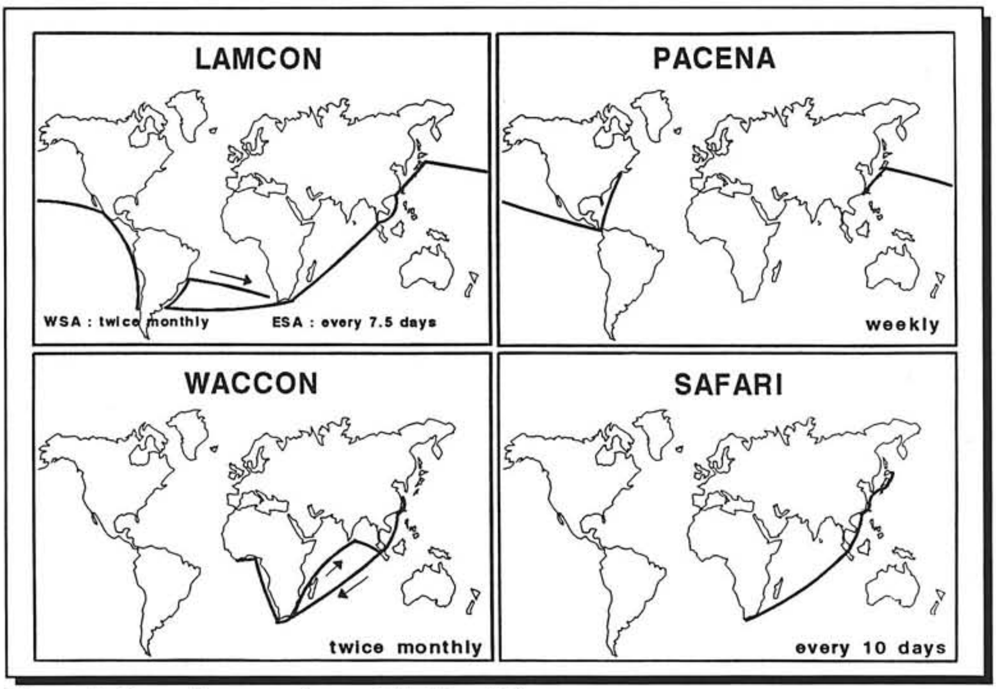

Figure 9: Some liner services of Nedlloyd Lines

Most important for Nedlloyd are the main liner vessels. These vessels transport containers between continents. Within a continent, feeders bring the containers to their final (maritime) destinations.

N. River Plate 6104A		Merid. challanger 6204A			
Iquique	04-06/May	Yokohama	22-22/Jun		
San Antonio	08-10/May	Kobe	23-23/Jun		
Arica	12-12/May	Shanghai	26-26/Jun		
Ilo	13-13/May	Hong Kong	28-29/Jun		
Callao	14-15/May	Singapore	02-03/Jul		
Manta	17-19/May	Montevideo	24-25/Jul		
Buenaventura	20-20/May	Buenos Aires	25-27/Jul		
Yokohama	08-09/Jun	Paranagua	29-31/Jul		
Magoya	10-10/Jun	Santos	31-07/Aug		
Koe	11-11/Jun	Rio de Janeiro	08-09/Aug		
Pusan	12-13/Jun				
Chi-Lung	15-16/Jun				
Hong Kong	17-17/Jun				
Singapore	21-22/Jun				
Durban	02-05/Jul				
Montevideo	17-19/Jul				
Buenos Aires	20-22/Jul				
Santos	25-29/Jul				
Sao Francisco	29-30/Jul				
Paranagua	30-31/Jul				
Vitoria	02-03/Aug	Rio Grande	11-13/Aug		
N. River Plate 6104B		**Merid. challanger 6204B**		**Sunshihne Amazon 6304C**	
Montevideo	17-19/Jul	Montevideo	24-25/Jul	Singapore	08-09/Sep
Buenos Aires	20-22/Jul	Buenos Aires	25-27/Jul	Hong Kong	12-13/Sep
Santos	25-29/Jul	Paranagua	29-31/Jul	Chi-Lung	15-15/Sep
Sao Francisco	29-30/Jul	Santos	31-07/Aug	Pusan	17-18/Sep
Paranagua	30-31/Jul	Rio de Janeiro	08-09/Aug	Kobe	19-20/Sep
Vitoria	02-03/Aug	Rio Grande	11-13/Aug	Yokohama	21-21/Sep
East London	12-13/Aug	Port Elizabeth	23-24/Aug	Buenaventura	09-10/Oct
Durban	14-14/Aug	Singapore	05-05/Sep	Manta	11-12/Oct
Singapore	27-28/Aug	Hong Kong	09-09/Sep	Callao	13-14/Oct
Hong Kong	31-01/Sep	Yokohama	11-12/Sep	Iquique	15-16/Oct
Chi-Lung	02-03/Sep	Magoya	13-13/Sep	San Antonio	18-20/Oct
Kobe	05-06/Sep				
Yokohama	07-07/Sep				
Buenaventura	25-26/Sep				
Manta	27-28/Sep				
Callao	30-30/Sep				
Iquique	02-03/Oct				
San Antonio	05-07/Oct				
Arica	09-09/Oct	Kobe	14-15/Sep	Arica	22-23/Oct

Table II: Part of the Nedlloyd Sailing Booklet, September 1995

The company decides to call at a port when it expects enough cargo to make it profitable. Together, these ports form a network, between which they create fixed services (lines). Then, they estimate the capacity required for each line on the basis of which they compose the fleet required to exploit all the liner services.

Transit time is very important. If, for example, the company can offer one day quicker transport time for a trip between Rotterdam and Singapore, this may encourage shippers to choose Nedlloyd. Although economic factors are most important for strategic problems (which port, which ship, etc.), scheduling is also very important.

Once it has been decided to create a liner service between port A en port B, this can be worked out in several ways. A main liner can sail between ports A and C and a feeder between ports C and B. Also, a main liner can sail directly between A and B. This seems rather simple but if one considers that Nedlloyd operates more than 30 lines between about 175 ports, with about 190 ships one can imagine it is very complicated.

Another complication is that a main liner may sail a round-trip in Europe followed by a trip to Asia and another round-trip over there. What should such a round-trip look like, where to start and where to finish? Is there a port where it is better to call at twice? Another solution is not to sail round-trips, but to leave that to a feeder. Should there be one or more feeders? Which route must they sail?

The company uses a database program to create a routing and scheduling tool. They consider distances, vessels, ports and bunker prices. With these parameters, port costs, sailing costs, etc., can be accounted. Forecasts of cargo and contracts lead to an estimate of revenues. The expected cargo leads to a number of moves in each port. This influences port times and port costs. With revenues and costs it is possible to optimise.

This container ship routing and scheduling is an important part of the competitive strategy of the container lines. The changes are constant, often induced by the increase in size of the ships and the expansion of trades. Recently, Nedlloyd has become part of the Global Alliance, while other lines have created the Grand Alliance. Maersk and Sea-Land have teamed up in yet another alliance, of which only recently the service structures have been disclosed. The description of the alliance in *"Lloyd's List"* of 10 January 1996, illustrates well the importance of routing and scheduling in this domain.

One of the main tasks in the creation of routes and schedules is the decision on the ship sizes to be employed.

12.3 Offshore

Routing and scheduling in the offshore industry has a completely different nature, as it is intimately linked to exploration and production processes, like the supply of drilling muds. This section briefly summarises the master thesis project of ir. F.A.J. Waals, on the routing and scheduling of supply vessels in the North Sea for the oil and gas industry.

Every country situated along the North Sea has its own continental shelf. The total area of the Dutch continental shelf is 57,131.4 square kilometres. This area contains both oil and gas. The total proven reserve in 1990 was: 12 million m^3 of oil and 17.1 billion m^3 of gas. Most production fields are situated between 50 and 125 kilometres northwest of Den Helder.

The entire process to obtain the oil and gas in the North Sea, consists of two phases: The *exploration phase* and *exploitation phase*. The exploration phase can again be subdivided into: Geological research and exploratory drillings. The exploitation phase can be subdivided into: Construction of the production unit, production period and removal of the production unit. This process is schematically shown in **Figure 10**.

12.3.1 The structure of an offshore project

Geological research

The search for oil or gas starts with geological research. Generally oil or gas has accumulated on places with specific ground structures, called traps. To find these traps, it is necessary to map the structure of the sea bottom. One instrument to do this is sonar. Sonar, however, only gives information on the bottom surface. To get information on the rocks deeper down the earth, there are a number of geophysical survey methods.

Geophysical survey methods can give a detailed image of the geological structure of the earth, but the presence of the right rock structure is not enough to prove the presence of oil or gas. This can only be proven by exploratory drillings. A hole is drilled into the earth deep enough to check the presence of oil or gas in the area under study. This requires a mobile drilling installation. The equipment is placed on a movable platform, i.e. a drilling ship, a semi submersible or a jack up. The first two are floating platforms, the third one is a platform, supported through its legs, by the sea bed.

Exploratory drillings

The drilling starts with the conductor operation, during which the first casing is piled into the ground. Then, a diverter is installed to minimise the damage in case of a blow out and the drilling starts. The hole is strengthened by pipes, called casings, which are attached to the ground formation by cement. The casings have

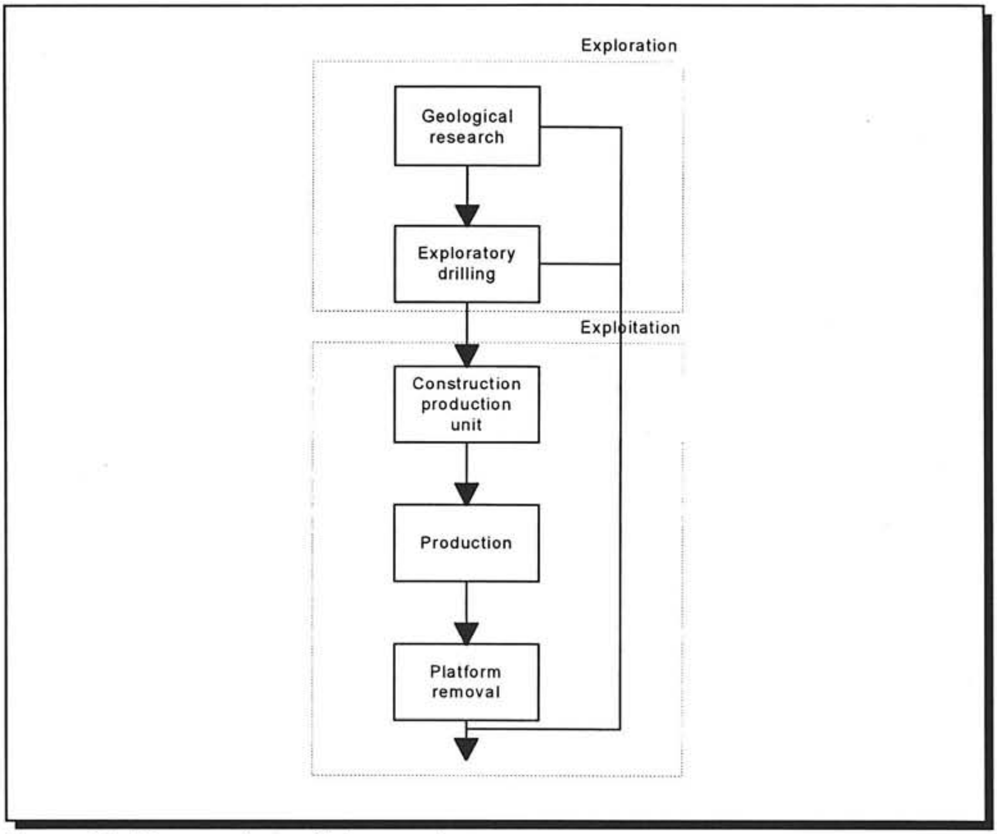

Figure 10: Phases of an offshore project

different diameters depending on the depth. When the hole is strong enough, a blow out preventer is installed.
During the drilling a liquid, called mud, is circulated through the hole. The mud removes the cuttings and provides sufficient stress in the hole to withstand the pressure of the oil and gas. The mud, of which the composition varies according to the requirements, is cleaned and used again. During the drilling, tests are carried out on the presence of oil and gas.

After the exploratory drilling the hole is closed. When there is no oil or gas the hole is closed permanently otherwise temporarily. Then, the drilling rig is removed. A drilling ship and some semi-submersibles have the ability to do this on their own power, a jack-up requires tug assistance for both anchor handling and moving of the rig.

When exploratory drillings show that the oil or gas field is profitable for production, the field is exploited. When the field is not large enough to justify the investment in an expensive fixed production platform, or when the sea is too deep, a floating production platform may be used. In shallow water usually a fixed platform is built. There are two main types of platforms: Skeleton constructions, called jackets, and gravity based constructions. Skeleton are made of steel and are fixed to the sea bottom by piles, gravity constructions are usually made of concrete, sometimes of steel, and stand stable on the sea bottom due to their own weight.

The building of a production platform

Jackets are built on land. Then they are transported to the field. They are sunk down and then the topside is installed, first the deck, then the modules.
Most gravity based platforms consist of a steel topside with concrete towers on a concrete caisson. The caisson consists of a number of cylinders, connected to each other and is used for buoyancy support during the transport of the platform, as foundation for the construction, as main weight to ensure that the platform stands stable on the sea bed and as storage capacity. The construction is built in a dry dock. When the base of the structure is ready it is floated out of the dock and transported to deeper water where the towers are built and the topside is added. The complete platform is towed to the oil or gas field and sunk down.

When the production platform is ready, the production wells can be drilled. The number of wells may add up to about 50 per platform. The drilling of production holes is very similar to exploratory drilling. The drilling speed of production holes is much higher and the planning is easier, because now the ground structure is known and less tests are required.

Production

During the production phase the main activity is getting the oil or gas out of the ground. The activities carried out during this process are: The regulation of the oil or gas flow, the treatment of the oil or gas, stimulation of the well and the maintenance of the well, platform and equipment. Before oil or gas is transported ashore, oil, gas and water are separated. On oil platforms the gas is burned. The well is stimulated by injecting chemicals, which enlarges the production.

Removal of the platform

Platforms that are put out of production cause inconvenience for navigation, fishery and environment. Therefore, after the production has ended, the platforms have to be removed.

12.3.2 Transport

During an offshore project large numbers of materials and people are required. Every material and every person required on the platform, must be transported there by ship or by helicopter. Generally, in the North Sea materials are transported by ship, people by helicopter. This imposes severe pressure on the logistics. There is always a considerable amount of time between the request for

materials or people and their arrival at the offshore unit. This especially goes for materials, since the speed of a ship is relatively low.
In some situations the waiting time is a problem, when someone or some material is needed very urgently and not available at the offshore unit. When an offshore unit cannot operate due to lack of some material, the costs can be very high. Fixed costs will continue, also when the offshore unit is not in operation. In these cases materials may be transported by helicopter, no matter what the extra costs are, but of course this can only be done for small objects.

This section mainly considers the material supply during the (exploratory and production) drilling and the production phase. These phases require a regular flow of large amounts of materials, during long periods. Reliability and costs are very important and therefore these phases are most interesting for optimisation.

The supply vessels used for the material supply are not owned by the operator of the platforms, but are chartered from specialised shipowners. Their vessels are especially designed for the supply of offshore units. They are suitable for the specific material demand of offshore units need, e.g. casings, containers, water, cement and mud, and are very fit to operate in the rough weather conditions of the North Sea. For this purpose they are equipped with a large deck and a large number of tanks in the hull. The ships have a large forecastle and their superstructure is situated in the front of the ship, the deck is situated aft.

Besides for transport, a large number of supply vessels is also equipped for other activities, i.e. rig moves, anchor handling, standby, fire fighting and oil recovery. All these activities require extra equipment, which often cost extra money. During periods in which a ship is used for one of these activities, it cannot be used for transport. This means that planning is more difficult.

The materials transported by supply vessel can be divided into three categories: Deck cargo, dry bulk and liquid bulk. The characteristics of materials for drilling are very different from the ones for production. Drilling requires the following materials:

- Deck cargo:
    - Construction materials;
    - Casings;
    - Drilling pipes;
    - Containers (5/10/20 ft);
    - Chemicals (in containers);
    - Helicopter fuel;
    - Explosives;
    - Food;
    - Spare materials;
    - Tools.

- Liquid bulk:
  - Drill water;
  - Fuel;
  - Brine;
  - Oil based mud;
  - Potable water.
- Dry bulk:
  - Cement;
  - Barite;
  - Bentonite.

Materials needed for production are:

- Deck cargo:
  - Tools;
  - Containers (5/10/20 ft);
  - Chemicals (in containers);
  - Helicopter fuel;
  - Spares.
- Liquid bulk
  - Fuel;
  - Potable water.

The quantities depend very much on the circumstances. Exploratory drillings take about three months. In this period they use an average of about 70 tonnes of materials per day. Production drillings last shorter, about 1.5 month, but have a much higher material demand, more than 100 tonnes a day. For exploratory drillings the share of deck cargo is about 25%, dry bulk 10% and liquid bulk 65%. For production drillings the share of liquid cargo is higher, about 75%. During the production phase the material demand of the platforms is much lower.

Supply vessels generally use harbours that are especially equipped for offshore purposes. This harbour is called a supply base. However, if necessary every harbour can be used. Important characteristics of harbours for the offshore sector are:

- Capacity;
- Location;
- Provisions (cranes/docks/personnel);
- Quay length;
- Provisions for supply and storage of goods.

In The Netherlands there are two offshore harbours: IJmuiden/Velzen and Den Helder. Some offshore harbours in other countries are: Invergarden, Peterhead, Aberdeen, Hull/Immingham, Great Yarmouth, Lovestoft, Stavanger/Haugesund, Bergen and Esbjerg.

All ships are chartered from specialised shipowners, for a specific period. The three most used types of charter are: Time charter, 'well to well' charter and day charter. Time charter means that a ship is chartered for a fixed period, e.g. a year, 'well to well' means that a ship is chartered for the period that it takes to drill one hole. Finally, a day charter means that a ship is chartered for a short period, often to meet peeks in the transport requirement.
When an operator charters a vessel he can decide upon the size of the ship and the special facilities of the ship. There are considerable differences between the prices of the ship, depending on the type of charter, size and facilities. In 1992 the price varied from about £ 4,000 per day for a simple supply vessel, to £ 16,000 for the largest ones, equipped for all tasks.

12.3.3 Planning

This section gives a detailed overview of all the factors that have an impact on the short and medium term planning of the employment of supply vessels. A flow diagram, **Figure 11**, shows all the activities of a supply vessel equipped with the facilities for moving rigs and anchor handling. This flow diagram is valid for the supply of drilling platforms, as well as for production platforms, except that the latter do not require *rig moves* and *anchor handling*.

The process starts with the supply vessel at the supply base, waiting for an activity. When an activity is assigned to the vessel, it can prepare for a special activity, start loading or depart for collecting cargo from the platform. When the ship is ready, it will depart and sail to its first platform, where it unloads its cargo, loads cargo, moves a rig or handles an anchor. When the activity is carried out the ship can sail to the next platform and carry out its activity and leave again. This process is repeated until all the activities are carried out. Then the ship sails back to the supply base, unloads and waits for its next assignment.

Waiting at the supply base

Due to the nature of the activities of a supply vessel, the vessel often spends a considerable amount of time waiting for its next assignment. The length of the waiting time is determined by: The type of departure schedule, the nature of material requirement of the platform, the storage capacity of the platform and the type of the platform.

The departure schedule of an operator can be organised in three ways. The first one is the *fixed departure schedule*, where the ship sails on fixed, previously determined points of time, usually at the same time every week. The ship may make more than one voyage per week. This schedule is only suitable for production platforms, where the material consumption is fairly even.
For drilling platforms this departure schedule is too rigid, due to the large variations in material requirement. Therefore, the materials are delivered *on order*. The ship sails when there are sufficient materials to fill an entire ship or when materials are needed immediately.

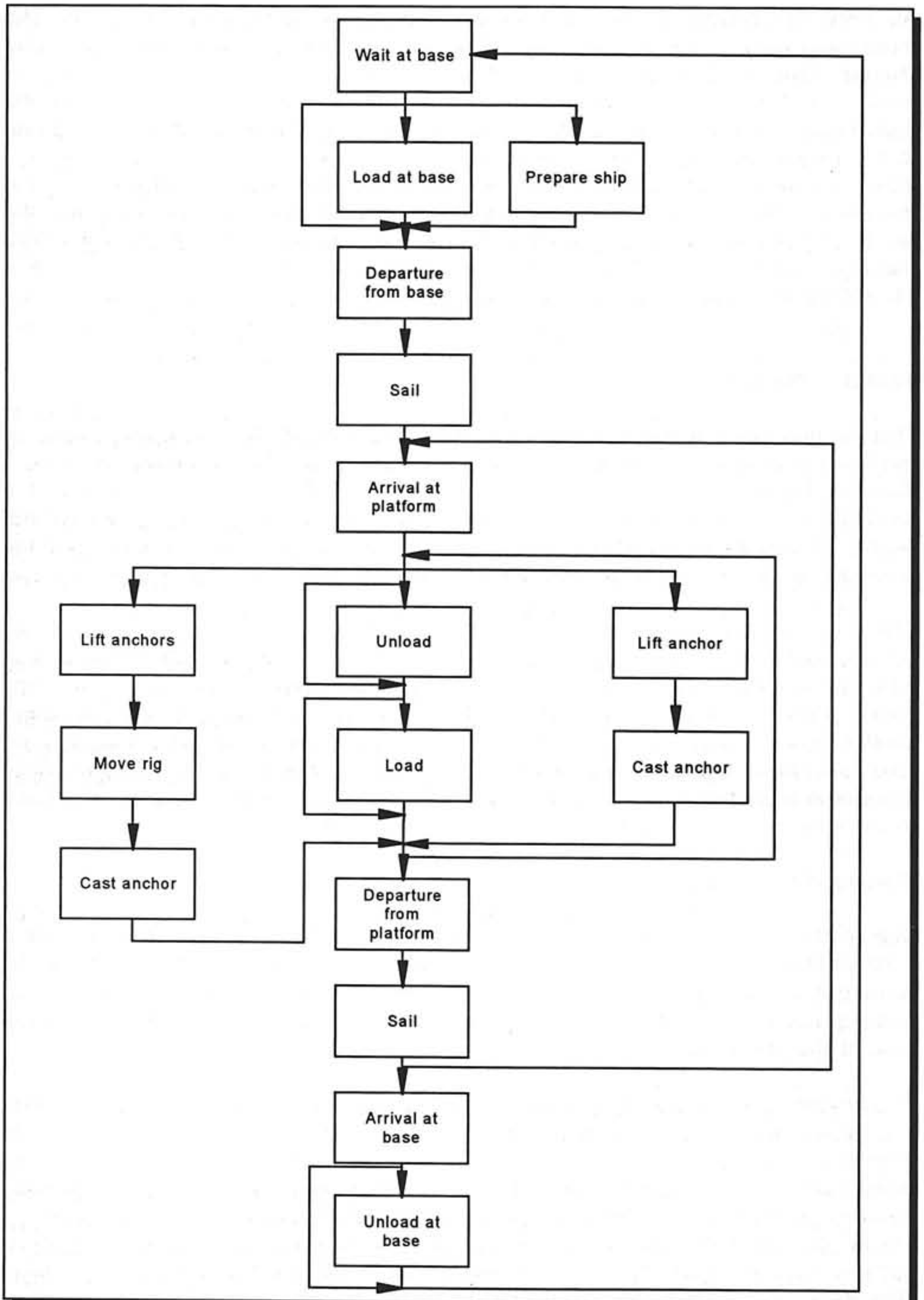

Figure 11: Activity flow diagram of a supply vessel

Sometimes a *flexible departure schedule* is used, where a fixed departure schedule is used as a basis, but whenever necessary, the time of departure can be changed and extra voyages can be made.

The type and composition of the selected supply schedule depends on the nature of the material demand. This material demand is influenced by the activities of the platform. Drilling platforms require more flexibility than production platforms.
The material demand is also influenced by the storage capacity of the platform. Large platforms can keep larger stocks than small platforms, so they require less emergency voyages.
In case supply vessels are also used for other activities, it can be difficult to fit these into a fixed schedule. Rig moves and anchor handling are required on irregular moments, which means that these activities are difficult to plan.

Waiting times at the supply base can also be caused by the unavailability of a berth, a crane or other equipment. For operators with their own berths this type of waiting time is easier to avoid, than for operators who depend on berths of others.

Sometimes extra delay is caused, when materials have not arrived at the supply base yet. If these materials are important, the supply vessel will have to wait for them, otherwise it can leave. This is most likely to happen with materials that are not used often or are very expensive and thus not kept in stock.

The choice for the moment of departure is restricted by the period in which the ship can (un)load. Production platforms often work from 7 a.m. to 7 p.m. The supply vessel can only (un)load within this period, which is called a discharge window. Drilling platforms work 24 hours a day, 7 days a week. This means that there is no discharge windows. However, it is preferred that the ship arrives at the platform during daylight because this makes (un)loading easier and safer.

Loading

The time that is required for the loading of the ship is affected by the following factors:

- Capacity of the ship;
- Amount of materials;
- Type of the materials;
- Number of pumps and cranes;
- Speed and capacity of pumps and cranes;
- Configuration of the supply vessel.

The amount of materials transported is always equal to or smaller than the capacity of the vessel, otherwise the materials will be divided over two voyages or two vessels. The time required for loading is determined by the amount loaded and the loading speed. The loading speed consists of the loading speed of deck cargo (crane speed), which for a large part depends on the size of the materials,

and the loading speeds of the dry and liquid bulk cargo, which depends on the pumping capacities. Deck cargo and bulk cargo can be loaded simultaneously.
The configuration of supply vessel also affected by the loading speed. For example, it is faster to load one large tank than two small tanks, because no changing of tanks is required.

Departure from the supply base

When the vessel is loaded, it is ready to depart. Factors that can prevent the ship from leaving are the:

- Opening hours of locks;
- Weather.

Most harbours have an open connection to the sea, which is the most favourable situation. However, some harbours are connected to the sea by locks. Some locks are closed during the night and on Sunday, or may have other restricting opening hours. Locks require extra time for locking and often extra waiting time. Especially waiting time is difficult to account with, since it will vary considerably.

The weather situation may also prevent the supply vessel from leaving the harbour. When the weather is bad, the vessel will not be able to unload at the platform. It cannot unload above a wind-force of 9 Beaufort or a wave height higher than 9 metres.
The North Sea has a rough climate, so the downtime due to the weather is very high. In the central part of the North Sea, where a lot of the Dutch platforms are situated, the downtime during the winter season is about 6 days every month (20%). **Figure 12** shows the cumulative probability distribution of the wave height in the central part of the North Sea. As one can see, the wave height is often very high.

The wave height distribution very much depends on the place where the platform is located. During the winter in the northern part of the North Sea 50% of the waves is higher than 9 metres, and the average downtime is three times as high as in the summer.
Besides the wave height, also the length of the good and bad weather periods plays a role. When the good weather period is short, the vessel cannot take advantage of it, because it will not arrive at the platform before the weather turns bad again. Weather forecasts can decrease the uncertainty for the planning, however, due to the inaccuracy of the forecasts their value is limited.

Sailing

The sailing time is determined by the distance and the speed of the vessel. The distance on its turn, is determined by the location of the platform. When more than one platform is to be visited, the total sailing distance is also influenced by the order in which they are visited.

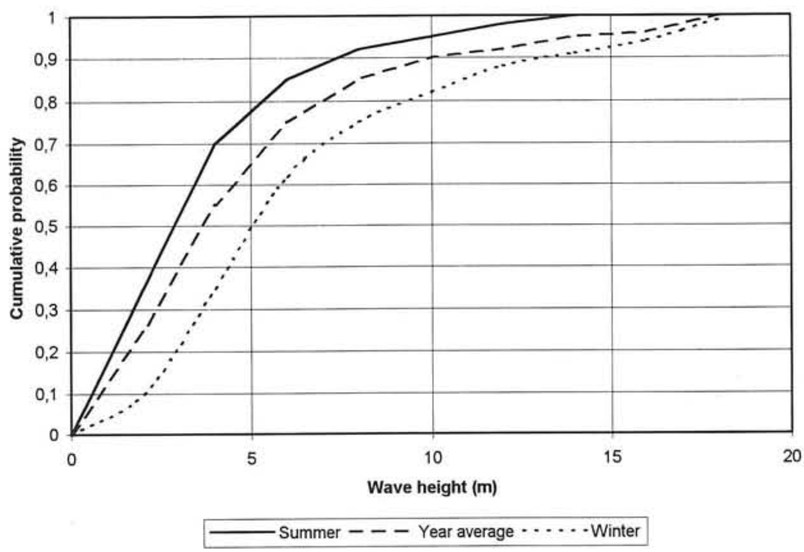

Figure 12: Cumulative probability distribution of the wave height in the North Sea

Usually the route is chosen before the vessel leaves the harbour, but if necessary it can be changed while the ship is at sea. When for some reason a ship cannot (un)load when it arrives at a platform, the ship may visit another platform first. The route is chosen on basis of the location of the platform, the urgency for the delivery of specific materials and the presence of dangerous materials. Dangerous materials must be unloaded before other platforms can be visited.
The maximum length of the route is limited by the maximum range of the vessel, which depends on the size of the fuel tanks. The vessel cannot take in fuel at the platforms. In the North Sea the maximum range hardly ever is a problem, since the platforms are located close together and distances are relatively small.

The speed of the vessel is never higher than the maximum speed, which is the highest speed a vessel can reach under the specific circumstances and depends on the following factors:

- Trial speed;
- State of maintenance;
- Weather;
- Currents;
- Amount of cargo.

The trial speed is the maximum speed the vessel is designed for and only goes for trial circumstances. When the ship is not well maintained the service speed will be considerably lower than the trial speed. The main engine may not be able to deliver its maximum power or the resistance of the ship may increase, due to marine growth on the hull. Other factors that can increase the resistance are weather, both wind and waves, and currents. The last factor that may affect the speed is the amount of cargo loaded.

To save costs the ship may not sail its maximum speed, but the most economical speed. This is the speed where the fuel costs are lower, but the vessel is still able to fulfil its duty. The higher the fuel costs are, the lower the economical speed will be. When other costs are high, the costs for fuel are relatively less important.

Activities at the platform

Activities carried out at the platform are the loading and unloading, rig moves and anchor handling. When a ship arrives at a platform there can be three reasons why the ship may not be able to (un)load:

- Another supply vessel is (un)loading on the platform, facilities are not available;
- There is a helicopter at the platform. (Un)loading while there is a helicopter at the platform is prohibited;
- Weather is bad.

In the first two cases the vessel can wait or first visit another platform, in the second case the vessel may wait until the weather clears or return to the supply base.

The time required for (un)loading comprises of the positioning of the vessel under the platform and the actual loading and unloading. The factors that affect the time for loading and unloading at the platform are similar to the time required at the supply base, though the influence of the sea may slow down the operations.

When a vessel has to carry out a rig move, this is usually known a few days in advance and can be taken into account for the planning. Sometimes an anchor breaks loose and a quick reaction is required. In this case planning is on very short term. The previously mentioned activities require an empty after deck of the supply vessel. This means that deck cargo first has to be unloaded. Therefore, it is difficult to combine special activities with material supply.

Unavailability

Sometimes supply vessels are not available for their regular activities. This happens when the vessel is used for standby services or when it is out of service for inspection, maintenance or repair.

Standby services can be planned in advance, therefore the impact on the short term planning is small. Inspection and maintenance can also be planned in advance, emergency repairs cannot. The period required for inspection, maintenance and repair, varies from several hours to several days.

12.3.4 The causal relations diagram

To acquire a good insight in the factors that affect the supply and the supply costs, **Figure 13** shows a causal relations diagram with all parameters that influence the supply and their mutual relations.

The core of the diagram is the item *total costs*, which represents the total costs for supply. For the purpose of the diagram the cost have been subdivided into three parts. These are the:

- Fixed costs;
  These costs are the charterhire that the operator pays to the shipowner and cover the capital costs and the operating costs.
- Trip costs;
  These are the costs related to the number of voyages and are the same for every voyage that the ship makes, and comprise e.g. lock costs and pilot costs.
- Sailing costs,
  These are the costs for the time that the vessel is at sea, and comprise e.g. fuel costs.

The target is to minimise the total supply costs, without damaging the performance of the supply.
This diagram is translated into a mathematical model, which allows for experimentation with different logistic planning strategies.

12.4 Reefer ship scheduling

12.4.1 Introduction

The routing and scheduling challenge in bulk shipping, container shipping and the offshore sector is again different from that of reefer shipping. Ir. H.E.M. de Jong made his master thesis project on the strategic planning and scheduling of reefer ships. This work will be summarised in this section.

The study concerns the design of a planning program for strategic planning for an operator specialised in reefer shipping. The operator takes care of the affreightment of 95 ships, varying between the size of 90,000 cu.ft. and 540,000 cu.ft. The ships are divided into two pools. Pool 1 contains the small ships, up to a size of 200,000 cu.ft., pool 2 contains the large ship, bigger than 150,000 cu.ft. The total size of the fleet is 23 million cu.ft.

The ships are not dedicated to one trade, as the sizes of the cargoes often vary by commodity. They are often employed for the same commodities on the basis of their size. These are:

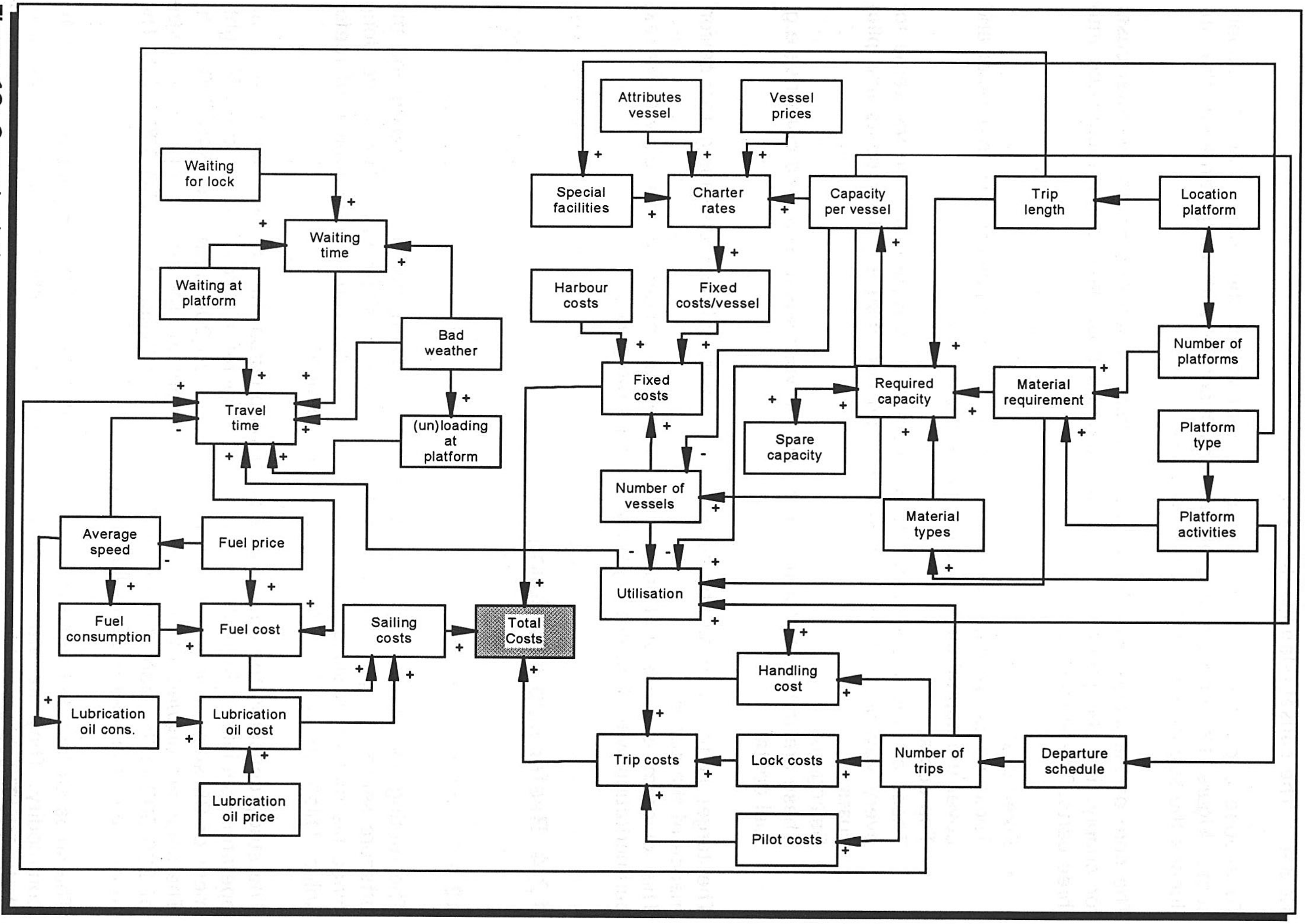

Figure 13: Causal relations diagram

- 100,000-200,000 cu.ft. Frozen cargo
- 200,000-300,000 cu.ft. Fruit and frozen cargo
- 300,000-400,000 cu.ft. Fruit
- 400,000-500,000 cu.ft. Containers and pallets
- >500,000 cu.ft. Bananas

Pool 1 contains small ships with speeds lower than 15 knots. These ships are often used by parcel services and carry mainly frozen cargo. Their cargo is often breakbulk. They make round-trips from Western Europe to South America, via Western Africa, and then back to Western Europe. Because they often carry several cargoes, they enter several loading and discharging ports along their round-trip. Because a large number of ports does not have modern equipment at their disposal, the number of port days is relatively high.

Pool 2 contains ships with a capacity larger than 150,000 cu.ft. and usually a speed over 15 knots. These ships are used for several trades and their scheduling is very flexible. The largest ships of the pool are especially designed for the transport of fruit. They are built for speed, both at sea and in port. Their service speed is about 20 knots. They are pallet friendly and designed for short loading and unloading times.

The main products for the reefer market are: Bananas, citrus fruit, fruit of broad-leaved trees, exotic fruit, meat, fish and dairy. Each of the products has its own season, origin and characteristics. The products and transport flows are shown in **Table III**. February, March and April are the busiest months.

Trade	From	To	Main season
Bananas	South America Australia	North America, Europe Southeast Asia	All year round
Citrus fruit	South America, South Africa	North America, Europe	October-March
Fruit of broad-leaved trees	South America, Africa, Australia	Europe	January-June
Kiwis	New Sealand	North America, Europe	
Avocados	Israel	North America, Europe	
Meat	New Sealand Europe North America	Europe North America, Southeast Asia Europe	All year round
Fish	Europe, Northeast Asia, North America Europe	Southeast Asia Africa	

Table III: Main reefer trades

Many cargo flows go one way. Countries that import a lot of reefer cargo, often do not export a lot. Most cargo flows run from south to north, especially fruit. Frozen cargo goes mainly from north to south. Due to this a lot of voyages are in ballast. To avoid this, sometimes non-reefer cargo, like old cars, empty pallets/containers and milk powder, is carried.

The ships are employed on contract voyages as well as on tramp voyages. The agreements of the contract voyages vary by contract. The loading and unloading port and time, the cargo, the ship, etc. may be strictly specified or undetermined. In the latter case there are strict agreements on the supply of information.

12.4.2 The planning

Presently, the short term planning is built up by the operator. The information concerning the short term is considered to be the most important, because this information is more certain. Besides, there is more time pressure on voyages that have to start in the near future.
As the planning does hardly take into account the expectations and future voyages, opportunities for the long term planning may be missed. Therefore some changes in the planning are proposed. The objectives of the new planning method are as follows:

- To improve the matching of ships and cargoes, especially when the amount of cargo is known in an early stage;
- To achieve that after their voyage the ships are in better locations to start their next voyages.

The proposed planning method should accomplish a better structure. This structure also facilitates planning by computer. The consideration of the new planning method is not to optimise one voyage per ship, but also to optimise the next voyages.

Planning takes place on three levels:

- Long term planning: Strategic planning;
- Medium term planning: Tactic planning;
- Short term planning: Operational planning.

Strategic planning

Strategic planning starts at the end of the next trip after the present one. On average, this is four to five weeks after now. The strategic planning can be divided into three stages:

- The first stage, with a planning period starting from about four weeks after now. There is already a large amount of information available and ships can be assigned to voyages;

- The second stage, in which the capacity planning is made. The contracts already give a good indication on the number of ships that is required in the near future. If necessary, new ships can be chartered for a short period;
- The third stage, in which the purchase and characteristics of new ships are considered. The next fifteen years determine the specifications of new ships.

The number of voyages known in the long term is limited. Long term contracts give an '8 week estimate'. For most voyages it is known which ship type is required, so a limited part of the fleet can be assigned.
Tramp voyages become known on a short term. They are not known for the long term planning. Sometimes the number and characteristics of ships for tramp voyages can be estimated.
In specific parts of the year large numbers of tramp voyages depart from specific regions. This can be taken into account in the planning. High and low seasons of products, weather and governmental measures, e.g. quota, show a certain regularity over the years.
Collecting these data is very time-consuming. However, when the quality is high, the information makes it easier locating the ship strategically for the long term.

Tactical planning

Tactical planning, or scheduling, raises three main questions:

- Where are the ships?
- Where do the ships go?
- Where are the ships needed?

Tactical planning runs from the end of the present voyage to the end of the next voyage. By a good planning there is a connection made between the employment of ships for the next voyages and the optimal employment of the ships in the long term.

Operational planning

The operational planning is carried out during the voyage. The objective is to ensure that the schedule is met. This, among others, means that delays have to be prevented. The operator, who is the one that has the most information on the ships, the cargo, the ports, the weather, etc. He must quickly detect and solve problems, and this way optimise the profit.

12.4.3 Model description of the strategic planning

Structure diagrams

The proposed strategic planning is described by diagrams made according to the Structured Analysis and Design Technique. The target of this analysis is the development of a planning supporting application for the long term planning of the shipowner.

Diagram A-0 (Figure 14): Strategic application SCR

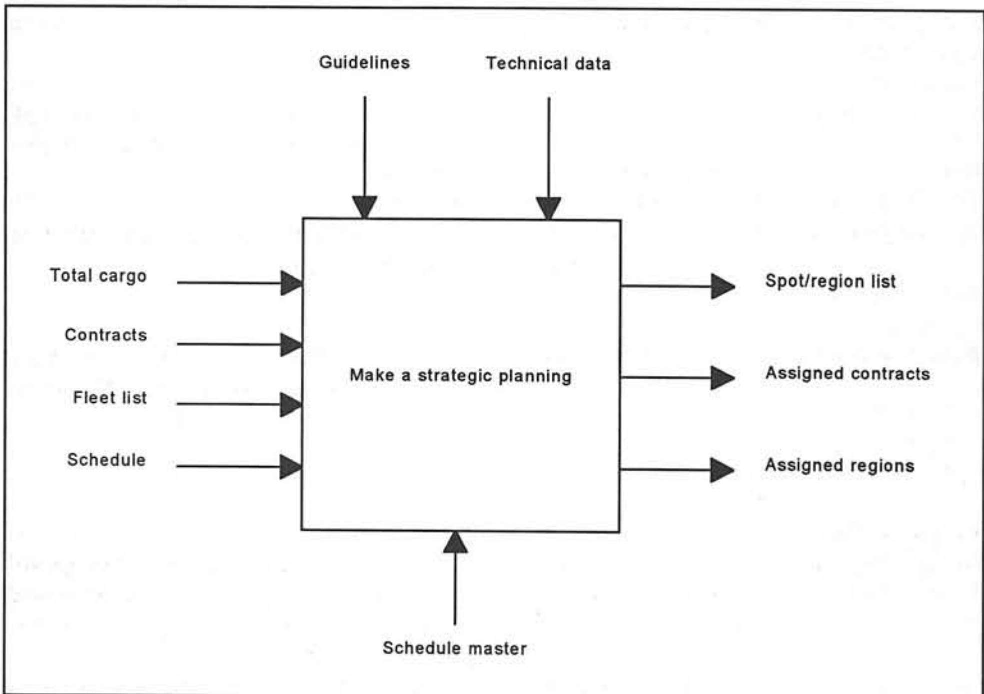

Figure 14: Diagram A-0: Strategic application SCR

Input from the environment

Total cargo: This is the most important information item. It determines where ships are required and which specifications they should meet. The information about cargo flows is obtained by market analyses and historical data of the shipowner.

Contracts: The contracts give the contract voyages that the shipowner has to carry out in the future.

Fleet list: The voyages carried out need ships that are able to these voyages.

Schedule: Because the long term planning is considered, the present schedule has little influence. Sometimes it happens that a ship is not available for a long period, because, e.g., it just started a long voyage or is out of operation. Also, the ship has to be able to arrive in the loading port in time.

Limiting conditions

Guidelines: These are the rules that indicate how the spot market analysis has to be carried out. Also, when the ships are assigned to voyages there are often extra technical and schedule criteria that have to be taken into account.

Techn. info.: Technical information hardly ever changes, e.g. the technical specifications of the ships, the dimensions of the ports and the distances between ports.

Output to the environment

Spot/region list: The result of the spot market analysis is a spot/region list. This list consists out of regions, the expected amount of cargo of a specific commodity and a period.

Assigned contr.: These are the contracts assigned to the ships.

Assigned regions: Ships that are not assigned to contract voyages, are assigned to regions where spot cargo is expected.

Executer

Schedule master: The schedule master is the most likely user of a computer planning program. If the planning is integrated into the computer system of the operator every shipper can use it.

Diagram A0: (Figure 15): Strategic planning

Activity blocks

An. spot market: Analysis spot market means that the total amount of cargo per region and per commodity is mapped for the planning period. When the contract voyages of all shipowners are deducted, this gives the regions where spot cargoes are to be expected.

Ass. contracts: Assigning contracts, gives the best way the cargoes can be assigned to the ships.

Ass. regions: Assigning regions, gives the best way the regions can be assigned to the ships that do not have contract voyages.

Internal factors

Available ships: These are the ships not assigned to contracts.

Diagram A2 (Figure 16): Assigning contract voyages

Activity blocks

Det. possibilities: Determine possibilities, checks which ships are able to carry out a specific voyage.

Assign ships: For the possible combinations the variable costs are calculated. The combination with the lowest variable costs is used.

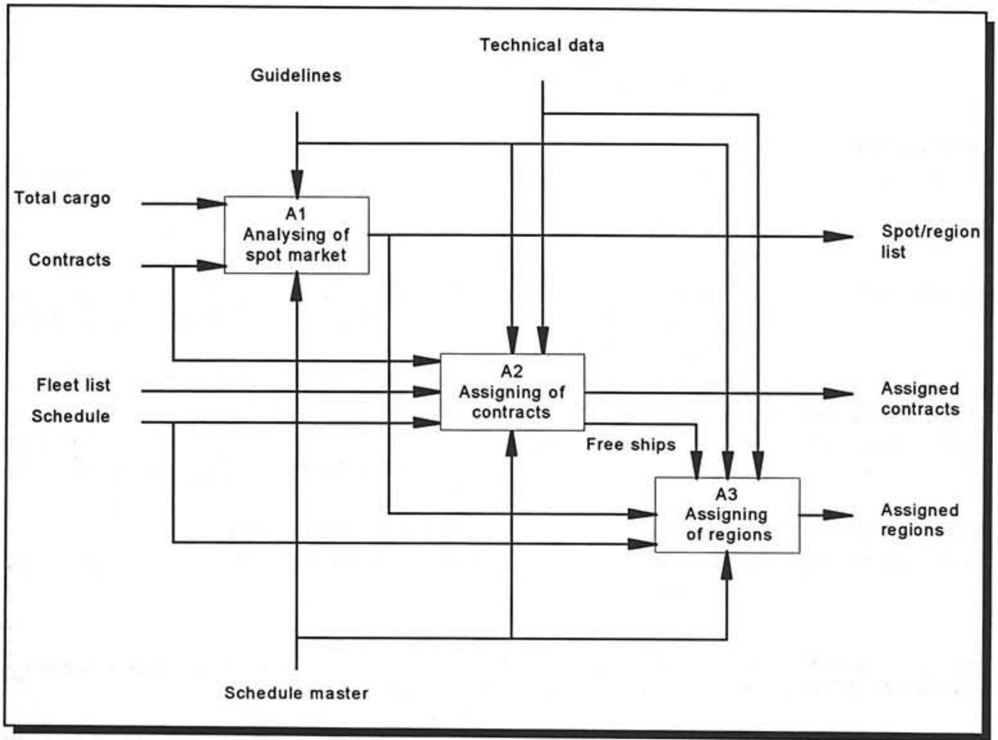

Figure 15: Diagram A0: Strategic planning

Adept. comb.: Adapting combinations. The schedule master may want to modify the list of possible combinations, according to his preferences. Then, a new optimal combination can be calculated.

Internal factors

Pos. Comb.: Possible combinations gives the list of all possible combinations of ships and voyages.

Spec. Comb: Specific combinations, are the modifications on the list of possible combinations.

Data models

The data models are considered using the identity-relationship data models.

Model 1 (Figure 17a): Check of the technical specifications

Entity blocks

Port: Dimensions of the ports.

Voyage: Information on the voyage, e.g. cargo attributes, ports and starting date.

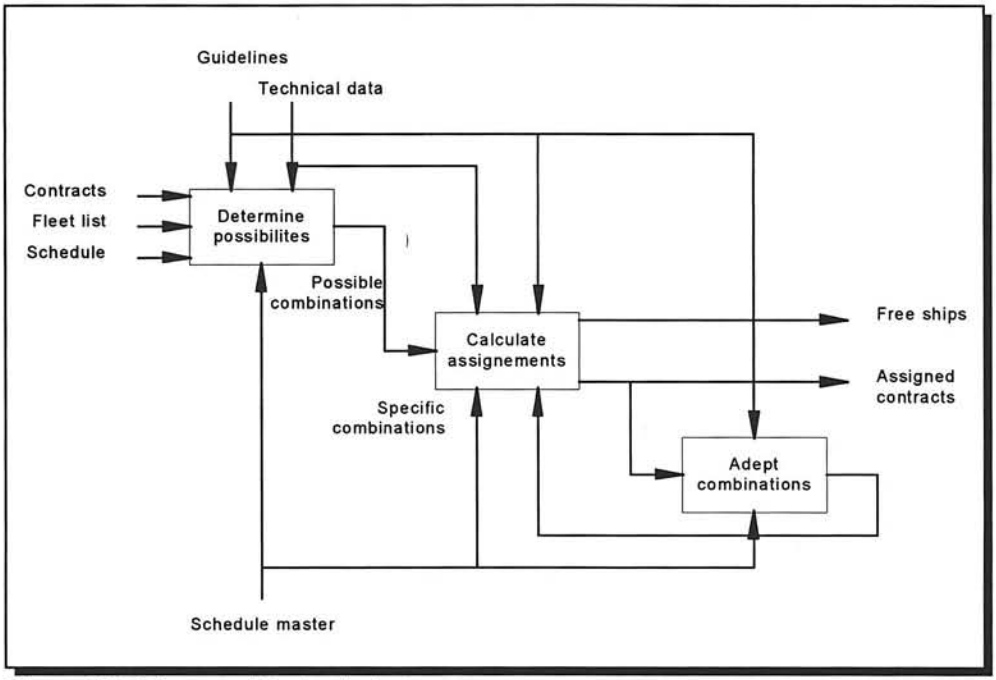

Figure 16: Diagram A2: Assigning contract voyages

ShipTec	Technical information of the ship types.

Association blocks

VoyPort	Departure and arrival ports of the voyage.
DepVoyP	Information on the departure port of the voyage.
ArrVoyP	Information on the arrival port of the voyage.
ChkPortS	The ships that are able to enter the considered ports.
ChkCargoS	The ships that can carry the cargo.
ChkTec	The ships that can do the voyage.

Model 2 (Figure 17b): Check of the schedule specifications

Entity blocks

Voyage	Information on the voyage, e.g. cargo attributes, ports and starting date.
ShipSch	Information on the present situation of the ship.
Distances	Distances between 2 ports.
ShipTec	Technical information on the ship types.

Association blocks

Ports	The ports where the ship becomes available and the port where it is going to be loaded.
Distance	The distance between the two ports.

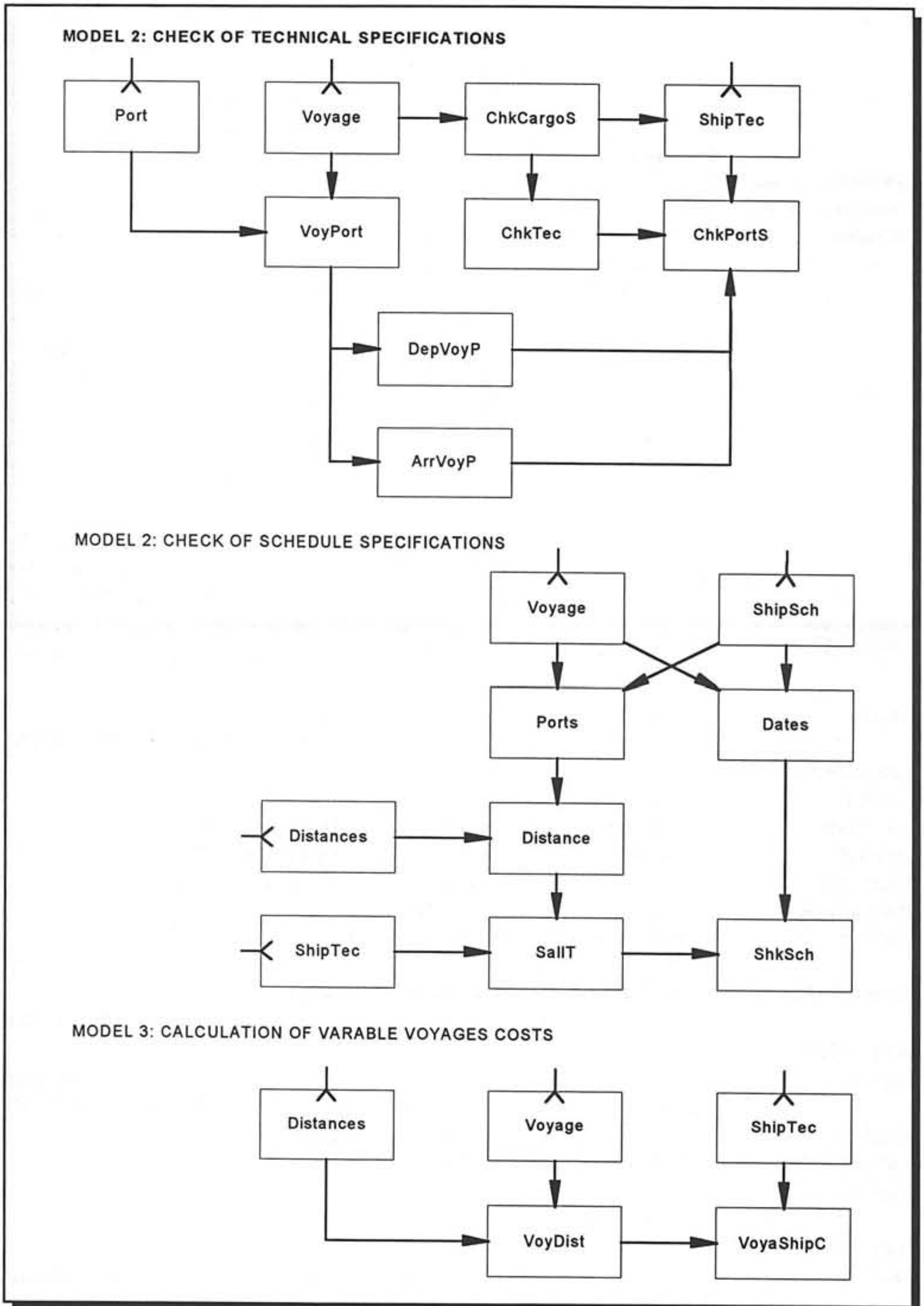

Figure 17: Data models

Dates	The date on which the ship becomes available, the date on which the loading starts and the number of days in between.
SailT	The sailing time between the two ports.
ChkSch	The ships that are able to arrive in loading port in time.

Model 3 (Figure 17c): Calculation of the variable costs

Entity blocks

Voyage	Information on the voyage, e.g. cargo attributes, the ports and the starting date.
Distances	Distances between two ports.
ShipTec	Technical information on the ship types.

Association blocks

VoyDist	The distance between departure and arrival port.
VoyShipC	Variable voyage costs.

Mathematical description

The problem is described as an allocation problem. In an allocation problem the number of resources is equal to the number of tasks. This means that for the solution the number of voyages has to be equal to the number of ships. When the number of voyages is smaller than the number of ships, dummy voyages have to be added. When a dummy voyage is assigned to a ship, this means the ship is not used in the planning.

There are a number of limiting restrictions that determine whether a voyage/ship combination is possible. These are the following:

- $v_j > v_i$, volume holds ship is bigger than required volume holds;
- $f_j > f_i$, floor area ship is bigger than required floor area cargo;
- $f_j > h_i$, deck height is higher than required deck height;
- $s_j > s_i$, speed is higher than required speed;
- $pd_i > d_j$, depth port is bigger than draught ship;
- $pl_i > l_j$, length port is bigger than length ship;
- $pb_i > b_j$, width port is bigger than breadth ship;
- $dd_i > do_j$, start date of voyage i is later than the date the ship arrives in the loading port;
- $dd_i > (do_j + \frac{dist}{s_j})$, where *dist* is the distance between the port where the ship is available and the loading port.

The assignment problem can be defined as follows:

Target function

Minimise: $Z = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}X_{ij}$

Limiting conditions

- Every voyage is assigned to exactly one ship.
- Every ship is assigned to exactly one voyage.

Cost calculation

$$C_{ij} = \frac{dist}{s_i * 24} * bunk_j * bunkprice$$

, sailing time multiplied by the fuel consumption multiplied by the fuel price

C_{ij} costs when ship j carries out voyage i

where:

m	=	Number of voyages
n	=	Number of ships
s_j	=	Speed of ship j
$dist_i$	=	Distance between the ports of voyage i
$bunk_j$	=	Bunker costs per day of ship i

12.4.4 The computer program

Using the previously described techniques a computer program was written to support the strategic planning. The program assigns ships to voyages that will start four weeks after now. The planning horizon is chosen to be from week five up to and including week eight. This concerns the voyages that have their starting date in this period.

When making a planning for a long term period, there is a large degree of uncertainty. There is little information on a large number of factors that influence the planning. Soft restrictions that influence the planning and considered using intuition and experience, cannot be used in the program. For the data that can be used as input for the program, the following conditions apply:

- The information must be available well in time;
- Hardly any changes must occur to the information;
- They must be a selection criterion.

The following parameters have been chosen

- Voyage: Departure port, arrival port, starting date, cargo volume, cargo area, deck height, speed;
- Ship (technical): Volume, deck area, deck height, speed;
- Ship (location/time): Port, date;
- Ports: Length, breadth, depth;
- Distances.

The optimisation is made on the basis of minimal costs. The user can choose wether the costs consist of bunker cost or charter cost. The first one is the cost for bunkers during the time that the ship is at sea. The second one is the time charter price during the length of the voyage.

The program consists of four phases:

1. Checking and formatting of the input;
2. Running of checking functions and calculation of the costs;
3. Calculation of the optimal combination;
4. Evaluation of the solution and possibly improving it.

Improvement of the solution does not mean that the solution the algorithm presents is not optimal, but there may be other considerations, which are no part of the program. Therefore, improving means that a part of the solution may be enforced by the user. The program offers four options for improvement:

- The user can make that a specific combination of a trip and a voyage does not take place;
- The user can make that a combination of a trip and a specific ship type does not happen;
- The user can enforce that a specific ship is assigned to a specific voyage;
- The user can enforce that a specific ship type assigned to a specific voyage.

CHAPTER 13: MARITIME LOGISTICS

13.1 Introduction

The maritime sector is a key-component of international logistics. Without maritime transport, the major international seaborne trade flows would be physically impossible, and world trade and the world economy would look quite different from what we see today.
Logistics, as a concept, is usually defined in terms of logistics management: The process of planning, implementing and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods, and related information from point-of-origin to point-of-consumption for the purpose of conforming to customer requirements.
The management of the goods and information flow can also be considered as: Enabling the corporate management to provide a profitable level of distribution service to customers through the effective planning, organising and controlling of activities that facilitate production flow.
The organising of the distribution channels and the concept of logistics evolution are two issues that will be discussed briefly and are based on L.M. Ojala's, *"Logistics Management in Finnish Foreign Trade Transport"* (1995).

Logistics operations and the overall logistics awareness have developed from a state of fragmentation to an evolving integration of logistics activities. This is illustrated in **Figure 1**. The logistics evolution has also affected the product channel logistics, as is illustrated by **Figure 2**. In this figure, six different channel solutions are identified, which can be classed on the basis of the lead time (short vs. long), and volume (small vs. big), each combination has its specified requirements, see **Table I**.

Logistics costs can be divided into direct and indirect costs. The direct costs, such as freight and inventory handling are tangible costs, while indirect costs, such as customer service level and information management are intangible costs elements. **Figure 3** illustrates this division.

Logistics concepts take many forms and are promoted under various names, such as Just-In-Time, Total Quality Management, Materials Resource Planning, Efficient Customer Response, Supply Chain Management. An interesting overview can be found in *"Fysieke distributie: Denken in toegevoegde waarde"*, written in Dutch.
The subject of logistics warrants a book by itself. This introductory text on shipping, will only highlight the specific role of ships in logistics management.

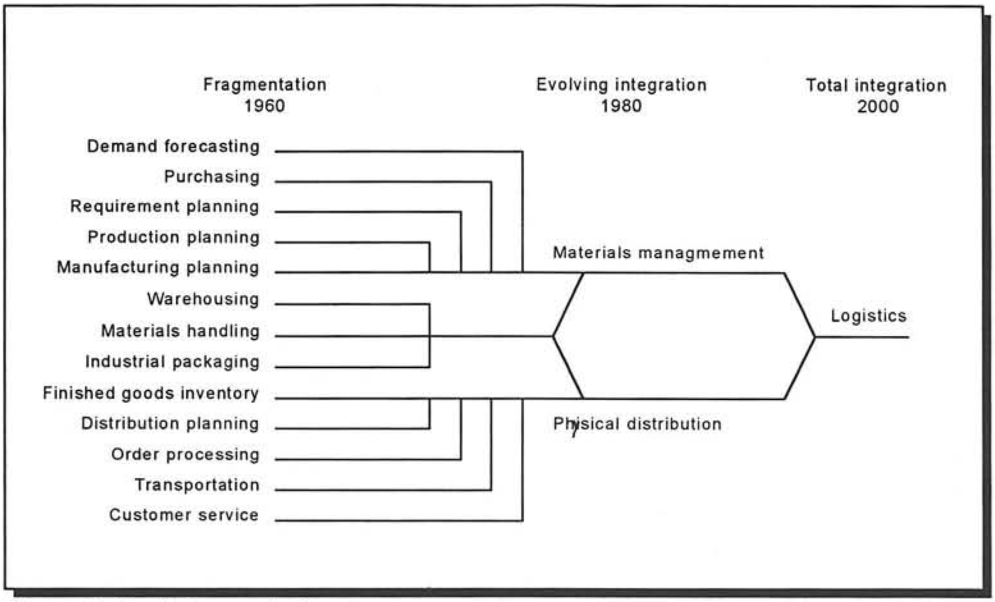

Figure 1: Logistics evolution

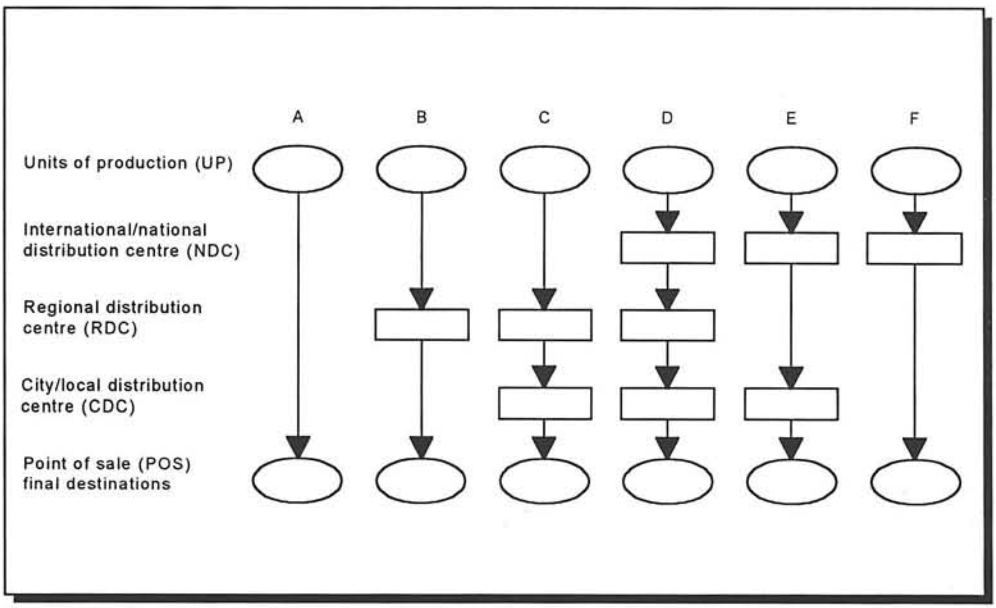

Figure 2: Five types of logistics distribution channels

	Short lead time	Long lead time
Small volume	▸ Heterogeneous markets characterised by specific lead times - (economic) necessity for consolidation of goods in distribution centres near points of scale (POS)	▸ Heterogeneous markets and economic necessity for consolidation of flows - groupage in (inter)national distribution centres, - groupage in regional (and sometimes national) distribution channels
Big volume	▸ Homogenous and concentrated markets - direct supply and distribution - consolidation in (inter)national centres	▸ Concentrated markets with low competition - direct supply and distribution

Table I: A typology of product channels logistics networks

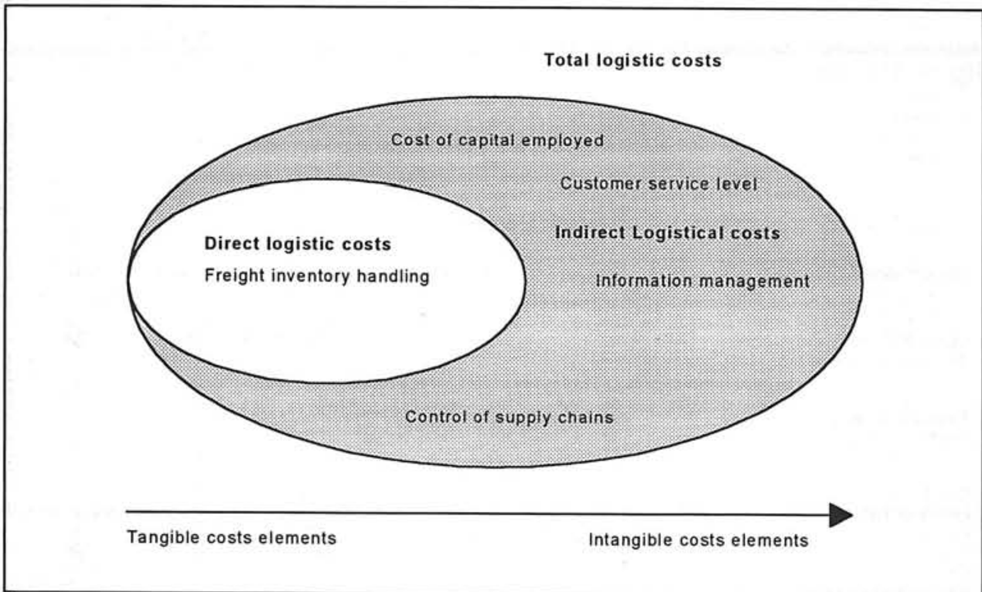

Figure 3: Exemplification of logistic costs

The maritime transport chain can be schematically represented by the model in **Figure 4**. The commodity flows from producer, via transport to the port, stevedoring, shipping, stevedoring, and transport to the receiver. The commodity can be characterised by its physical form: Dry bulk, liquid bulk, neo-bulk, general cargo, container, ro-ro. The transport chain can be controlled by separate entities, such as shipper/receiver, freight forwarder, stevedore, shipowner/operator.

The functions may also be integrated by one company. Examples of the latter case are the car manufacturer Nissan, the grain trader Cargill, the chemicals shipping company Stolt Nielsen, or the container shipping companies Bell Lines or Nedlloyd.

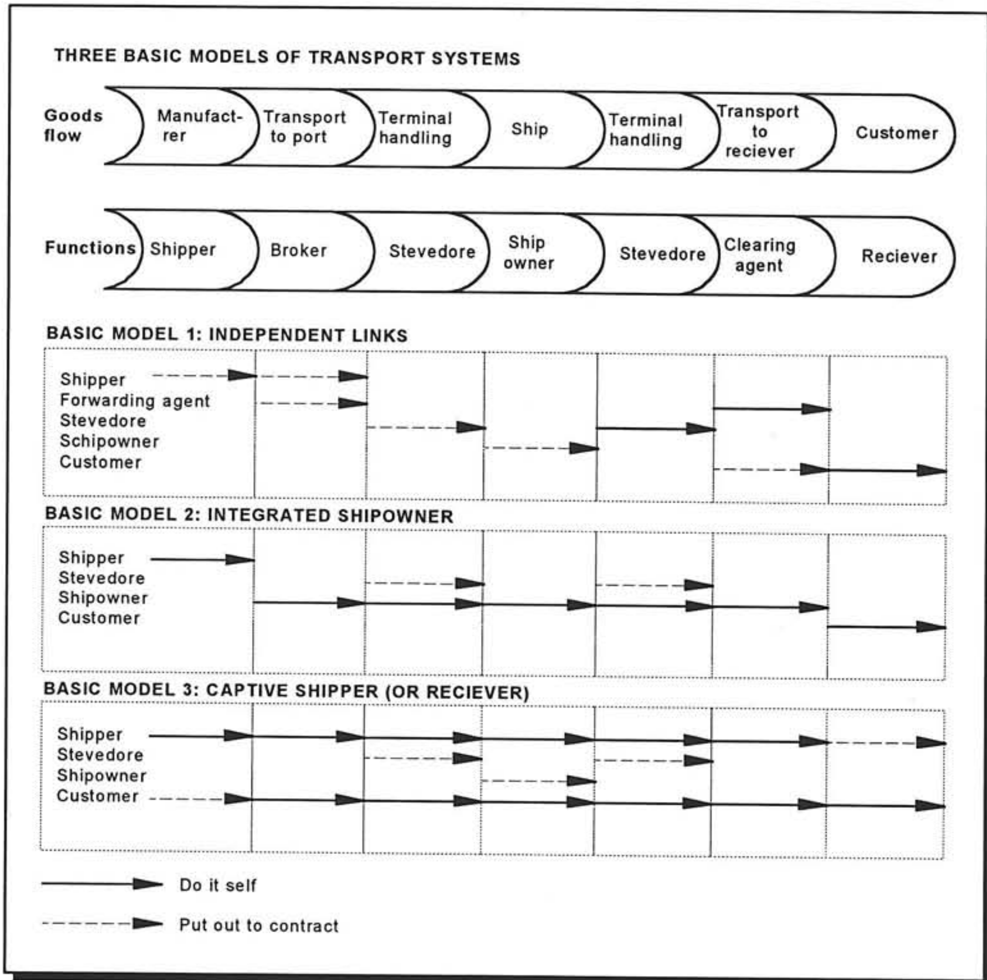

Figure 4: Basic models of transport systems

Chemicals shipping

In 1995 A.T. Kearney did research to find out the state of the art in logistics on international basis. This study included 76, among others, chemical companies and 178 logistics service suppliers. It was published in *"Strategic Partnerships in Logistics: A Key to Competitive Advantage"*

A.T. Kearney defines eight key dimensions in order to assess logistics performance. The key variables used by the approached companies to plan and manage the logistics process, are assessed. These key variables are:

1. Customer orientation/partnership;
2. Integrated long-range planning;
3. Supplier partnership;
4. Cross-functional operations planning;
5. Continuous improvements;
6. Employee empowerment
7. Integrated IT systems;
8. Measurement comparison and action.

The framework comprises three stages of development, ranging from poor performance (stage I), through average performance (stage II) to excellent performance (stage III). The outcome of the scores on each of the eight dimensions defines how well-prepared a company is to meet the challenge of achieving logistics excellence.

The evaluation model emphasises the importance of partnerships with both customers and suppliers, including service suppliers and internal and external integration. The results proved that in the chemical industry in particular, those companies that succeed in achieving logistics excellence are more than rewarded for their efforts. Leaders in logistics management create competitive advantage in many respects.

Figure 5 shows the gap in performance between the overall performers and the chemical companies that can be qualified as leaders in logistics. The leaders excel in all eight dimensions of logistics excellence and are amply rewarded for it. The responses were clustered into three performance factors: Service failures, order cycle time in days, and costs as a percentage of revenue. For each factor, leading companies gains superior results.

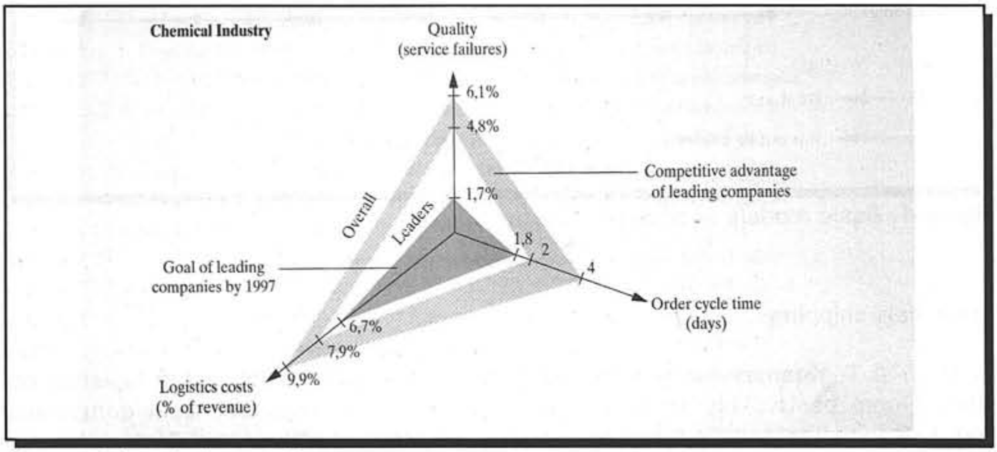

Figure 5: Leader's excellence

Striving for higher service levels, shorter cycle times and lower are not isolated objectives. Stage III companies show that these goals are interdependent, one

upon the other. Leading companies can exploit their costs advantage to gain further advantage on the dimensions of quality and order cycle time.
In fact, faster cycle times and lower costs are just some of the steps in gaining logistics excellence. The real benefit is that only a Stage III company in logistics can provide total supply quality. And only total supply quality creates total customer satisfaction.

Many significant service and costs improvements have been achieved over the past few years in the sector of logistics service suppliers. Most of the achievements, however, originate from traditional, internally-oriented improvements actions, such as:

- Transportation improvements through using more specialised equipment to transport truck loads, to coordinate and optimise reverse loads and to control routings and dispatches to really minimise distances;

- Storage improvements through using engineering analyses of storage, training personnel in handling methods and using automated storage methods.

Further significant improvements in cost and service are not possible without a move towards externally-oriented actions. The focus here is on adding value to the supply chain. Rendering services that reduce the customer's costs and improve the customer's downstream services are key in this respect.

The survey findings show three major opportunities for logistics service suppliers:

- *Making a strategic choice*. Logistics service suppliers should choose which services and markets they want to be in. They need to make a choice between delivering average, low cost services through expansion or cooperation, or offering unique services in niche markets;
- *Integrating with customers*. Logistics service suppliers should offer a broad range of tailor made, value adding services, which optimise the client's supply chain, develop long term partnerships and provide a consistent process to improve quality and productivity;
- *Innovating and investing in experience and know how*. Logistics service suppliers should make long term investments in the key system of the future that generate added value and guarantee twinning partners. One such key system is an information system that not only automates the user's own operations, but also adds value to customer service. Another type is networks and joint opportunities for optimising and clustering the goods flows. A third type is capital management through sound management of the supply chain aimed at decreasing inventories.

A climate survey revealed an increased focus on the part of both chemical companies and logistics service suppliers on specialisation, economies of scale and the need for closer cooperation in order to satisfy the demands of the end customer. Wherever there were country-based distribution systems, large companies serving the European market often used to work with large number of logistics service

suppliers. Today, centralisation and rationalisation, both on a regional and European level are causing the situation to change.
Chemical industry's requirements of its carriers are changing dramatically. With focus resting on higher performance at lower costs, they tend to work with a smaller number of carriers that are larger in size and more international in nature.

In the ocean-going and *coastal markets* for bulk movements, carrier reduction is already evident. Nowadays, most chemical shippers are linked to one major producer through 'evergreen' contracts.
The world of *tank storage* also shows a clear trend towards concentration, partly due to scale enlargement and globalisation on the part of the customer. Further centralisation of stocks is taking place at the same time. Smaller terminal companies are looking for cooperation with larger counterparts, while companies with terminals as a secondary activity are disposing them, as the degree of investment needed in these activities to keep up the market standard is becoming too high. Total required storage-capacity will not increase, due to a trend towards smaller stocks with a faster turnaround.

In addition to purely operational cost reductions, several other factors also result in consolidation:

- Lack of necessary investment or scale potential on the part of some logistics service suppliers;
- Strict safety and quality audits;
- High costs associated with transition or simply entering into contracts and managing relations with a large number of carriers;
- Expense and difficulty of developing information systems and electronic mail or electronic data interchange.

In turn, one can see an increased number of alliances among logistics service suppliers. Their goals are to make better use of each other's capacity, to increase scale effects, to increase geographical coverage and to combine logistics modes.

The number of partnerships per chemical industry company has dramatically increased over the last five years. The concentration in logistics service suppliers makes a closer working relation between companies and their individual service supplier not simply a desirable option but an absolute necessity. The development of a partner relationship becomes ever more important as the individual logistics service provider strives towards higher volume, better services and larger market share.

The role of both parties is changing. The chemical industry is better off taking decisions together with the few preferred individual logistics service suppliers. More intensive cooperation can then be achieved in service, cost and safety improvement right up the end customer.

The US-based Stolt Tankers & Terminals company, offers a *Through Transportation Services* concept to the shippers of chemicals. This service comprises all the elements, of the transport chain, such as maritime transport, tank containers, inland transport via tanker barge, tank rail car, tank truck, storage at tank terminals under one through bill of lading. This offers the shipper or receiver of chemicals a guarantee that the expensive product is handled within one system, with only one responsible party, and with reliable delivery dates.

A case-study on sea-river chemical tankers (in *"Innovation in Chemicals Shipping"*), contains a detailed analysis of the transport chain alternatives in the transport of chemicals between Germany and the United Kingdom. **Figure 6** summarises the alternatives. Each route and origin-destination has a different cost-structure. The intermodal logistics of chemicals transport are clearly illustrated by this case-study.

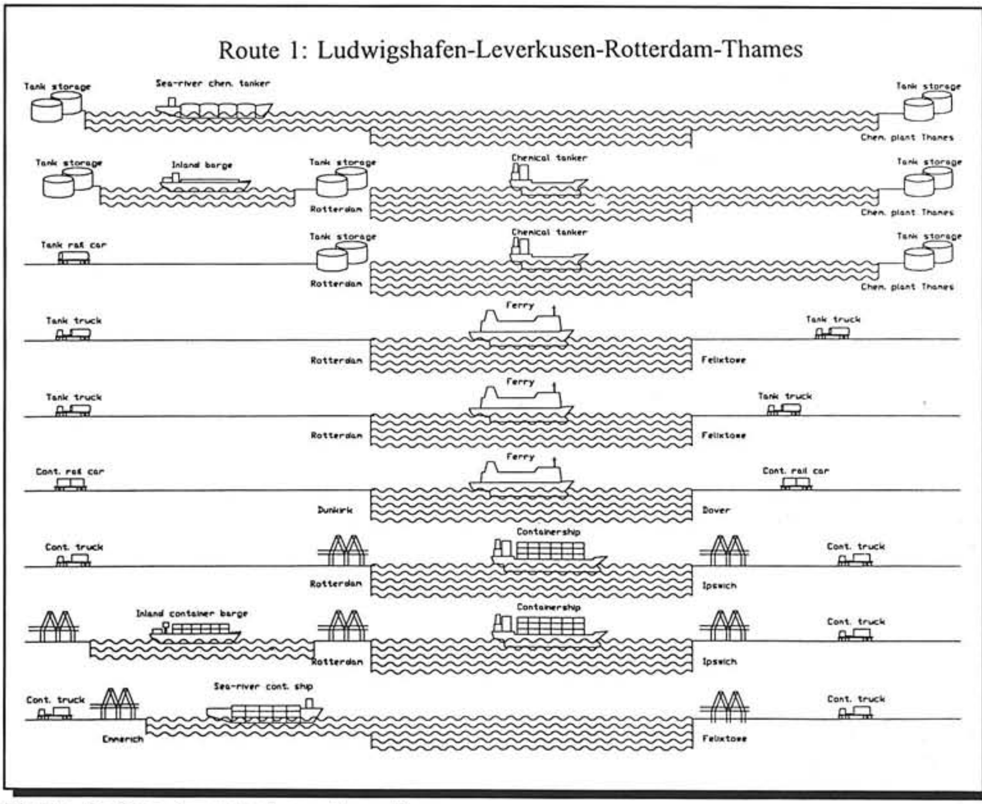

Figure 6: Sea-river tanker alternatives

Intermodal transport

Logistics management is at the basis of the concept of intermodalism, which has been called by different names: Through transport, combined transport, multi-modal transport. Intermodalism means door-to-door movement by containers and has its roots in the container revolution and in the emergence of the science of logistics management. The container revolution had four essential parts:

- *Handling*: Containers protect the cargo, are quick to handle on and off the container ship, which has very short turnaround times in port.
- *Scale*: Break-bulk general cargo ships had to be limited to 15,000-18,000 dwt in order to maintain reasonable port times. Container ships can become much larger 70,000 dwt, and maintain short port times, and thus create phenomenal economies of scale at sea.
- *Computer control*: Scale has brought bigger operators, handling more volume. Containers have to be monitored through the system and positioned around the world. Commercial documentation has to keep up with faster transit times. All this is achieved by computer control, more broader defined as information processing.
- *Door-to-door movement*: The ability of operators to transfer the container between modes and deliver the goods at the receivers premises, with a short transit time and at low cost.

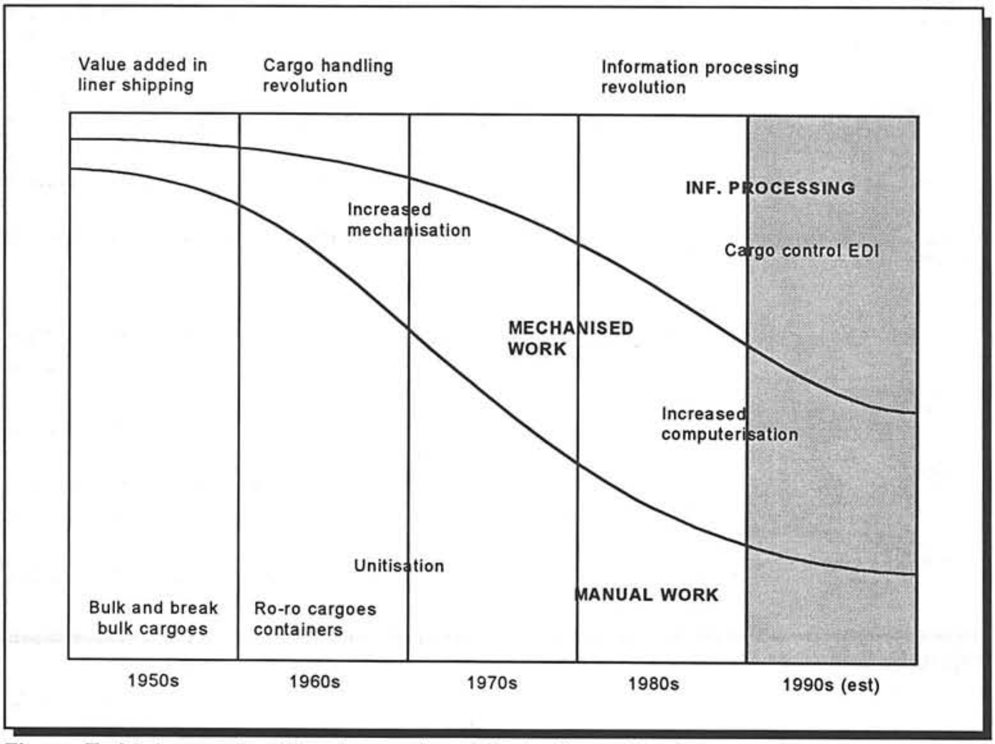

Figure 7: Main trends affecting productivity in liner shipping

In Lloyd's of London Press' *"Effective Intermodalism"*, an intermodal model is presented that gives a concise picture of the six facets or faces of intermodalism, (**Figure 8**):

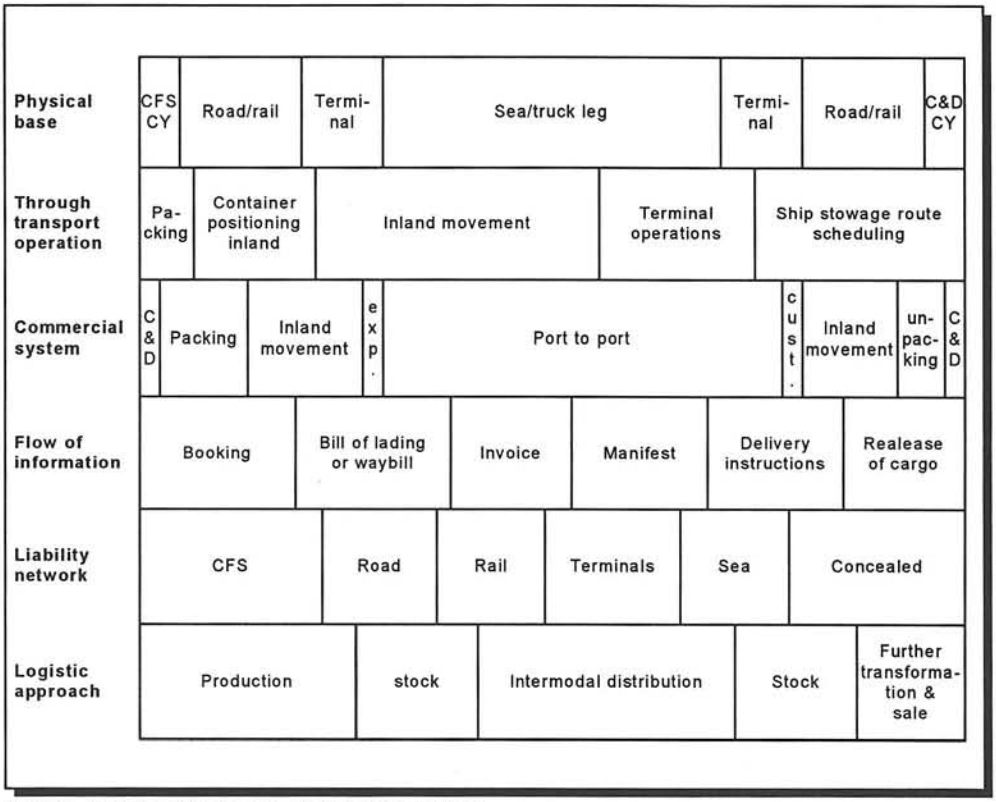

Figure 8: The six faces of intermodalism

- *The physical base*, which is provided by the modal carriers and handlers, and consists of road hauliers, railway companies, barge operators, terminals, and shipping lines;
- *The through-transport operation*, which relates to the design and control of the system as exercised by the intermodal operator;
- *The commercial system*, which mainly concerns the marketing of the service, the conditions of carriage attached to the through-journey and levels of pricing;
- *The flow of information*, which deals with the management of necessary commercial, operational and financial data;
- *The liability network*, which deals with the commercial rules and practises governing cargo liability;
- *The logistical approach*, which concerns the application of the principle of logistics management to intermodal transport.

The relative importance of each component in any one face may vary according to the actual circumstances. The 'bottom line' of all this is a reduction of the logistics costs for the end users of the transport service, e.g. shippers and receivers/consumers. An example of an intermodal deepsea container operator is Nedlloyd Lines, which introduced its Flowmaster concept early January 1996. According to *"Nedlloyd Parade"*, the Flowmaster manager coordinates the work of existing Nedlloyd services in the field of transport and distribution, in order to create an added value for the customers. The logistical objectives of the Nedlloyd Lines organisation can be summarised as follows:

- Optimisation of integrated logistics chains, as the clients know from comparison that it can be done cheaper, faster and better;
- The ability to grow with the clients in new, emerging markets, like in Eastern Europe and China;
- Create a pro-innovation corporate culture, which requires a propensity to change;
- The innovative qualities of Nedlloyd should be used for the benefit of the client, who needs innovation in logistical networks in order to stay ahead of competition;
- Nedlloyd's ability to successfully manage and operate networks, buildings, ships, trucks and warehouses;
- The control and application of integrated information-technology solutions;
- A leading role in the creation of a united European logistical market;
- Environmental consciousness, linked to special competence in product and environmental knowledge, in order to create a competitive advantage.

From this Nedlloyd statement of objectives, it may be clear that an intermodal transport company is quite different from the shipping line from the sixties. Logistics and information technology play a key-role. This is also the case for ports. The port of Rotterdam has been engaged for a decade in a large number of initiatives in order to promote the use of the most advanced technology by the users of the port. It is their believe that the invisible activities will or have already become more important than the physical activities of handling and storage.
In the report *"The Silent Force of a Worldport; Mainport on the Electronic Highway"*, the initiatives on information technology are summarised. The actors in this information network are schematically shown in **Figure 9**.

The emphasis of Rotterdam on EDI (electronic data interchange) and IT (information technology) is to create new sources of added value, in order to compensate for the declining revenues from the physical port activities through the continuous efficiency improvements.
In another report, *"Meer weten van de Keten"*, yet another diagram is presented (**Figure 10**) which shows the desirable transformation of the port-related services in Rotterdam towards value added services. The fundamental change in port and intermodal logistics and information technology requires a higher level of education from the work force. The maritime and logistics engineer are particularly equipped for these type of jobs.

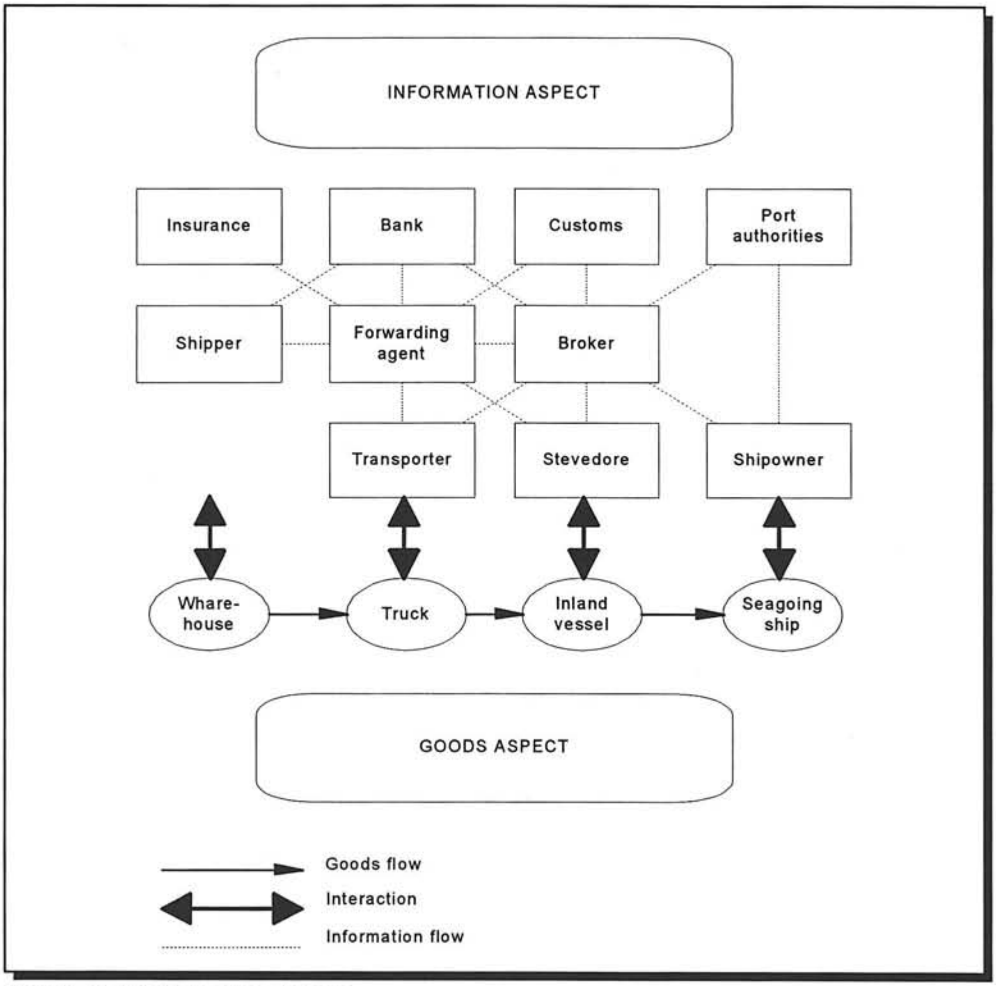

Figure 9: Chain management

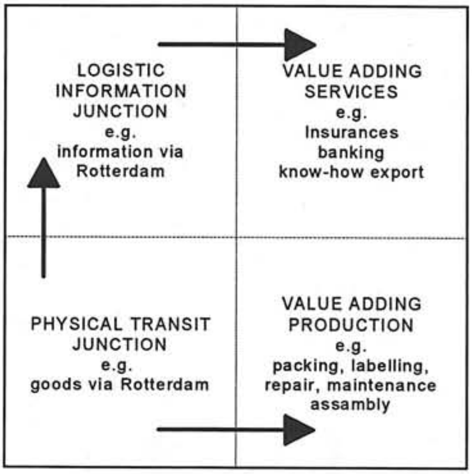

Figure 10: Significance of the Rotterdam area

13.2 The optimum size of ship and the impact of user costs[1]

13.2.1 Introduction

In the planning of shipping services, the choice of the size of the ship is very important. In the assessment of the optimum ship size, not only direct quay to quay shipping costs, but also the other costs in the door to door logistic chain, including costs of pre- and on carriage and storage of cargo, play a significant role. This section shows how user costs can be incorporated in the assessment of optimum size of ships of a liner shipping service.
In the following section a model is developed with shipping costs of a liner shipping service as a function of ship size. A quantitative example, using realistic orders of magnitude of cost and operational data, shows that as ship size increases shipping costs per unit of service decrease continuously for ship sizes up to 4000 TEU and more.
Surveys among shippers show that quality of service aspects such as transit time and frequency of service are of great importance, because of their effects on inventory costs of shippers and receivers. A model is therefore developed expressing inventory costs as a function of transit time and frequency of service, and

[1]This section was written by S. Veldman from MERC, and published under the title *"The optimum size of ship and the impact of user costs - an application to container shipping"*, in *"Current Issues in maritime economics"* , Kluwer Academic publishers, Dordrecht, 1993

thus also of ship size, showing inventory costs rising as a function of ship size. When the two models are combined, the sensitivity of the outcome to changes in the major inventory determining factors, such as commodity value, stock out risks, daily demand of goods for customer/cargo combinations and level of trade, can be investigated.

Even this combined model, however, fails adequately to account for network effects or to deal with issues as main line/feeder line transport. Therefore, the final section outlines how the service choice function, (the function indicating the preference of a shipping service for potential users), can be incorporated in a model to assess market shares of competing shipping services within one coast to coast liner shipping route. This model can be used to answer questions of the type of "*what will happen with the market of a liner service, if e.g. larger ships are allocated*", and thus can provide answers with respect to questions on the optimal size of ships for a route.

13.2.2 Cost Structure of a Liner Shipping Service

The costs of liner shipping services

This section gives a brief description of a shipping cost model, where total costs of a shipping service are a function of ship size (S). Other variables are sailing speed (V) and multi-porting variables M_1 and M_2.

The logistic costs of shippers consist of the following items: Purchase costs, order and handling costs, transport costs, capital carrying and storage costs and stock out costs[1]. The costs considered here, concern 'quay-to-quay' shipping costs, as charged to shippers using a liner shipping service.

$$C = C_s + C_t + C_i + C_b \qquad \textbf{(50)}$$

Liner shipping costs (C_s) can be written as a function of the above named variables and consist of the product of the total number of trips per year, from coast line to coast line (N_c), times the product of time and related daily costs.

$$C_s = N_c * T_r * [G_c(S,V) + G_t(S)] + N_c * [T_{rs} * G_{fm}(S,V) + (T_{rh} + T_{ra}) * G_{fa}(S)] \qquad \textbf{(51)}$$

The number of round-trips to be made between both coastlines (N_c) depends on the total amount of cargo carried and is determined by coastline 1 generating cost cargo amounting to E_c. In the opposite direction an amount of $b*E_c$ of cargo is carried, where b is the ratio of backhaul to linehaul cargo, which varies from 0 to 1. The annual number of trips (N_c) thus equals the amount of cargo (E_c), divided by the amount of cargo carried per trip, which is equal to the size of the ships (S) times the maximum load factor 1.

[1]Roberts, P.O. and Kullman, B.C. Urban goods movements: Behavioral demand forecasting procedures. Contribution as chapter 25 to *"Behavioral travel modelling"* Croom Helm, 1979

$$N_c = \frac{E_c}{l * s} \tag{52}$$

The coast to coast cargo flow pattern consists of flows between M_{c1} ports along coast 1 and M_{c2} ports along coast 2. Thus, there are M_{c1} times M_{c2} flows from coastline 1 to coastline 2 each being equal to E_p, while the same number of flows goes into the opposite direction, each flow amounting to $b*E_p$. E_p is given so that E_c can be calculated from E_p.

$$E_c = E_p * M_{cl} * M_{c2} \tag{53}$$

Sailing patterns serving this coast to coast trade are supposed to be built up of different sets of itineraries of which at each trip respectively M_1 and M_2 ports are called at in such a way that all cargo of the route is carried. These itineraries thus range form a variant where only one port is called at ($M_1 = M_2 = 1$), to a variant where at the maximum number of ports are called ($M_1 = M_{c1}$ and $M_2 = M_{c2}$).
The round-trip time (T_r) consists of three components: The time spent at sea (T_{rs}), the time spent for preparation of cargo handling and berthing/unberthing (T_{ra}), and the time used for the cargo handling (T_{rh}).

$$T_r = T_{rs} + T_{ra} + T_{rh} \tag{54}$$

The vessel's service speed can be considered as an exogenous variable or as a function of ship size. A statistical analysis of container ships built since 1985 shows that there exists a positive relation between ship size and service speed. The parameters of a multiplicative relation were estimated with regression analysis. The resulting elasticity of design service speed with respect to ship size (in TEU) amounts to about 0.147[1].

$$V(S) = \kappa_0 * S^{\kappa_1} \tag{55}$$

The cargo handling speed (HS) is a function of ship size, for which generally a multiplicative relation is used. There is evidence that the elasticity of cargo handling speed with respect to ship size is in the range of 0.20 to 0.30.

$$H(S) = \lambda_0 * S^{\lambda_1} \tag{56}$$

Once the time per round-trip is established, shipping costs (C_s) can be assessed by multiplying time and production factor costs per unit of time according to equation 2. Capital and labour costs apply to total round-trip time, fuel costs for the main engine apply to the time spent at sea, while fuel costs related to auxiliary engines apply to the time spent waiting and on cargo handling. The resulting daily costs per production factor are all calculated according to a multiplicative relationship with respect to ship size and sailing speed.

[1]A sample of 161 fully cellular ships built since 1985 was taken from Lloyd's Register Book data available on magnetic tape. Loglinear regression gave a value for the elasticity with respect to ship size of 0.147 and a corresponding T-value of 15.69. The coefficient of determination (r-square) gave a value of 0.61, showing that a great part of the variation of design vessel speed is not explained by ship size.

Total shipping costs (C_s) can be established by substituting the various components into equation 2.

A quantitative example

A hypothetical example is worked out for a container shipping route connecting two coastlines. The trade pattern is simplified and assumed to consist of a flow of containers between 10 ports on each coastline leading to a total of 10*10 = 100 port to port flows on the outgoing leg, each amounting to 1,500 TEU and thus leading to 150,000 TEU from coastline 1 to coastline 2. Backhaul cargo amounts to 50 percent of this flow.
The geography of both coastlines is assumed to be such that the coast to coast distance amounts to 8,000 nm, while the distance between the consecutive ports of call along a coastline amounts to 200 nm.
Production factor input costs consist of:

- Capital related costs: Depreciation, interest, insurance and repair and maintenance costs, which all can be assumed to be proportionally related to a ship's value. These inputs are the same for the time spent at sea and in port;
- Labour costs: The crew's wages and related travel expenses etc. These inputs are the same for the time spent at sea and in port;
- Fuel costs: Fuel consumption of the ship's main engine and fuel consumption of auxiliaries;
- Overhead cost: Given as a flat rate per year.

The resulting daily costs of each category of container ship size classes varying from 400 to 4000 TEU, are given in **Table II**.

Ship size (TEU)	Capital costs	Labour costs	Fuel main engine	Fuel aux. engine	Administration costs
400	6,264	4,300	1,982	349	6,049
800	10,056	4,300	3,803	445	6,719
1200	13,264	4,300	5,568	513	7,144
1600	16,143	4,300	7,298	567	7,462
2000	18,800	4,300	9,001	613	7,718
2400	21,293	4,300	10,684	654	7,934
2800	23,656	4,300	12,350	690	8,122
3200	25,915	4,300	14,002	723	8,288
2600	28,085	4,300	15,641	753	8,437
4000	30,180	4,300	17,270	781	8,572

Table II: Daily costs per main category as function of ship size (US$)

The numbers of ports called at on each coast line, is put at $M_1 = M_2 = 5$ at this stage. The types of roundups being made to carry all the cargo between the 10 ports on each coastline, can vary from one extreme with one port of call at each coastline to the other extreme with all (ten) ports of call at each coastline. In the former case there need to be made 100 different one-port-to-one-port type of itineraries, whilst in the latter case there exists only one type of itinerary. In between, all types of itineraries can be considered which fit together into one type of shipping service. The advantage of the former case is that overall sailing distance and transitory time is less, whilst the advantage of the latter is that it leads to a high service frequency between port pairs[1].

Time spent at sea, in port and transitory time can be assessed. The various operational data and resulting shipping costs per TEU as a function of ship size, are given in **Table III**. Time spent at sea is decreasing as a function of ship size, whilst time spent in port is increasing, leading to a decreasing share of steaming time from 90 percent for the 400 TEU ship to 68 percent for the 4000 TEU ship. The combined effect leads to a decrease of round-trip time, turning into an increase with 2000 TEU. The number of roundups needed to carry all cargo decreases inversely with ship size, from 104 to 10 roundups for the range of ships considered.

Size (TEU)	Speed (knots)	Handling rate (TEU/day)	Round -trip (days)	Time at sea (%)	Round -trips/ year	Inter arrival time (days)	Transit time (days	Shipping cost (US$/TEU)
400	17.4	716	46.7	90	104.2	3.5	22.5	1593
800	19.3	851	43.9	87	52.1	7.0	20.6	994
1200	20.5	942	42.9	83	34.7	10.5	19.6	781
1600	21.3	1012	42.6	81	26.0	14.0	19.0	668
2000	22.0	1070	42.5	78	20.8	17.5	18.6	598
2400	22.6	1120	42.6	76	17.4	21.0	18.2	550
2800	23.2	1164	42.8	74	14.9	24.5	17.9	514
3200	23.6	1203	43.1	72	13.0	28.1	17.7	487
3600	24.0	1239	43.5	70	11.6	31.5	17.6	465
4000	24.4	1272	43.9	68	10.4	35.1	17.4	448

Table III: Main operational data as a function of ship size

It appears clearly that total shipping costs keep decreasing with the employment of larger ships. If the decrease in shipping costs per TEU is expressed as a (loglinear) function of size, the elasticity with respect to size arrives are about -0.543, meaning that a doubling of ship size leads to a reduction in costs per TEU carried of 31 per cent.

The functions and values chosen are of a broad nature, while other studies using another sample of data and sources of costs would certainly produce different costs. The main conclusion, however, would remain the same. For liner shipping

[1]The frequency of service for a port pair N_r is proportionally related to the number of ports of call on each coastline.

routes connecting the world industrialised areas, use of large ships, if unconstrained by cargo availability, would lead to lower costs[1].

13.2.3 User and producer costs as a function of ship size

How users regard shipping services

Cargo delivery standards are becoming increasingly important as shippers judge their seaborne logistics management as part of their overall logistics management, including inventory carrying and pre- and on-carriage. In a recent survey of European shipowners (as quoted by Peters[2]) and a similar survey of American shippers[3] the same message, that 'quality' is very important, emerged.
More specific in respect to the quality of service are the results of a study by Collison[4], who investigated the existence of liner service attributes, their individual importance and how categories of customers differ on the importance of those service attributes. For the US domestic route Pacific Northwest-Central Alaska, 50 major and a number of minor customers were surveyed and 26 different attributes were identified and aggregated in 5 main groups:

a. Timeliness of service;
b. Facilities and equipment;
c. Traffic services;
d. Pricing and rates;
e. Marketing services.

The study reinforces the primary importance of the timeliness-of-service attributes to the shipper: Overall transit time, frequency of sailing, schedule reliability and convenience of access to port facilities. The rate attributes were less important to the respondents. Collison gave as explanation to this the fact that companies tended to quote the same rates for the same shipments.
For assessment of the optimum size of ships the attributes of timeliness-of-services and freight rates are of primary interest. The other attributes, although important for the success of a liner shipping service, have a neutral impact on the outcome. The importance of the various attributes is demonstrated through the ranking and segmentation, and is useful for the segmentation of liner shipping

[1]Talley, W.K., *"Optimal containership size"*, *"Maritime Policy and Management"*, Vol. 17, no. 3, pp. 165-175, 1990. This study produces a curious exception and comes at an optimum ship size for containers on the North Atlantic route. The study makes use of a translog function requiring more inputs than the rather simple multiplicative functions used here. Surprisingly, it uses fixed capital costs per dwt, which is presumably the explanation of the fact that the optimum size is achieved for rather small sizes of ships while disregarding user costs.

[2]Peters, H.J., *"Seatrade, logistics and transport"*, Policy and research series, The world bank, 1989

[3]*"Buzzword for the '90's"*, *"American Shipper"* 1990

[4]Collison, F.M., *"Market segmetns for marine liner service"*, Transportation Journal, Vol. 24, pp. 40-45

services for demand choice models. The outcome does not tell how to translate this knowledge into a liner service structure. To that end a mathematical model is developed, which puts the various attributes at a common footing.

A model of user and producer costs

General

The costs treated so far concern quay-to-quay shipping costs. Other shipping costs not yet included, concern port charges, cargo handling charges and costs of pre- and on-carriage. Port charges show a wide variation per port and it is not clear, whether they work overall in favour of large ships or not. Cargo handling charges and also port charges as far as related to the amounts of cargo handled are charged on the amount of cargo handled and this works neutral. Costs of pre- and on-carriage work neutral. Therefore the above items of costs are disregarded.

Inventory costs discussed here, consist of:

a. Interest costs of cargo in transit;
b. Inter-arrival stock costs;
c. Safety stock costs.

Cargo in transit

Interest costs of cargo in transit (C_t) equal the product of all cargo carried $(1+b)*E_c$, times the average transit time per consignment (T_t), times the cargo's value (V), times the opportunity cost of capital i divided by 365.

$$C_t = \frac{(1+b)*E_c*T_t*V*i}{365} \tag{57}$$

Safety stock

Shippers carry a safety stock in order to allow for fluctuations in demand. The assessment of the safety stock concerns trading off the costs of risks of running out of stock against stock carrying costs. Safety stock is calculated according to the 'single item static model', see Taha[1] and depends on the variance of daily demand of customers of liner services (Q), the duration of the lead time period (T_t+T_i) and the accepted risk of running out of stock (P). It is assumed that daily demand is Poisson distributed, in accordance with the approach of Jansson and Shneerson.

Safety stock carrying costs (C_b) can be assessed by multiplying the buffer stock of a shipper (S_b), times the total number of shippers (equal to the total volume carried from coast to coast ($E_c*(1+b)$, divided by the average annual demand per

[1]Taha, H.A., *"Operations Research"*, third edition, MacMillan Publishing Co. Inc., Newyork, 1984. On p. 499-500 Taha criticises the use of the model for purposes as here and proposes better, but more complicated alternatives.

shipper $Q*365*S_b$), times the interest and warehousing cost per shipper. ($V*i+W$).

$$C_b = \frac{E_c}{Q} + (1+b) * \frac{S_b * (V*i+W)}{365} \tag{58}$$

The safety stock per shipper is equal to the square root of daily demand per shipper, times the sum of transit time and inter-arrival time ($T_r + T_i$), divided by twice the accepted risk of running out of stock.

$$S_b = \sqrt{\frac{Q*(T+T_i)}{2*P}} \tag{59}$$

Inter arrival stock

The amounts of stocks being carried, concern an amount being equal to the demand over half the period elapsing between two consecutive calls ('inter arrival' stock). Thus it is implicitly assumed that the stock is carried by either consignors or consignees and is counted once per consignment. The cost of carrying the inter-arrival stock C_1 is equal to the inter-arrival stock, times the stock carrying cost per unit of time.

$$C_i = S_i * (V*i+W) \tag{60}$$

The inter-arrival stock S_i equals the total amount of cargo carried $(1 + b) * E_c$, times the time span between two consecutive arrivals T_1.

$$C_i = \frac{T_i}{365} * E_c(1+b) \tag{61}$$

A quantitative example

According to the equations given above user costs consist of interest cost of cargo in transit, and interest and inventory carrying costs related to carrying of inter-arrival stock and of a safety stock. The following values are used: interest rate i = 0.08 average commodity value V = 10000 US$ per TEU and warehousing cost W = 2500 US$ per TEU per year. Safety stock depends on an average daily demand Q = 1 per commodity/customer (i.e. one TEU per day) and the accepted risk of running out of stock P = 0.03.
Producer or shipping costs decrease as a function of ship size for the whole range of ships from 400 to 4000 TEU. Costs of cargo in transit are relatively low and vary slightly as a function of ship size: Transit time for the average consignment for the range of ships considered, decreases from 22.5 to 17.4 days. Inter-arrival time ranges from 3.5 days for a 400 TEU ship to 35 days for a 4000 TEU ship. The costs of the inter-arrival stock increase proportionally with ship size from a negligible level for the smallest sizes of ships to a considerable amount for the largest one. The costs of safety stocks are considerable and increase with ship size, but much less steep than with the inter arrival stock, as the safety stock is

related proportionally to the square root of the sum of inter-arrival and transit time.
The decrease of producer costs as a function of ship size being combined with an increase in user costs leads to a U-shaped curve of total costs with an optimum around 3200 TEU.

TEU	Total costs	Shipping cost	Inventory costs		
			in transit	inter-arrival	safety
400	1868	1593	58	16	201
800	1286	994	53	32	207
1200	1094	781	51	48	215
1600	1005	668	50	63	224
2000	959	598	49	79	233
2400	935	550	48	95	242
2800	924	514	48	111	251
3200	920	487	47	127	260
3600	923	465	47	143	268
4000	929	448	46	158	277

Table IV: Shipping and inventory costs in US$ per TEU as a function of ship size

Sensitivity to major inputs

The sensitivity analysis focuses on variables of routing and trade. The impact of variables as route distances, cost and productivity levels and related elasticities with respect to ships size are therefore left aside.

Multi-porting options

Main particulars of the shipping route are the multi-porting options M_1 and M_2 and the coast to coast distance D_c. A greater distance leads to a relative greater importance of the sea time component, and thus works in favour of large ships. This aspect is treated in literature frequently and therefore left aside. The impact of multi-porting options is less straightforward.
Variation of M_1 and M_2 has a great impact on the time elapsing between two consecutive calls, and thus on the inter-arrival stock carrying costs. Varying the number of ports of call at each coastline from one to 10, means that per port pair the number trips being made increases with a factor 10*10=100, so that inter-arrival stock carrying costs decrease to 1/100 of the initial level. Safety stock carrying costs depend on the sum of inter-arrival time (T_i) and transit time (T_t), of which T_t, is increasing due to longer round-trip distances. The combined effect is that total costs decrease quickly for the first step from (1:1) to (3:3) and remain practically the same for the changes up to (10:10). The optimum size of ships

increases from 800 to 1600 TEU to 3200 TEU and for values up to (10:10), see **Figure 11**.

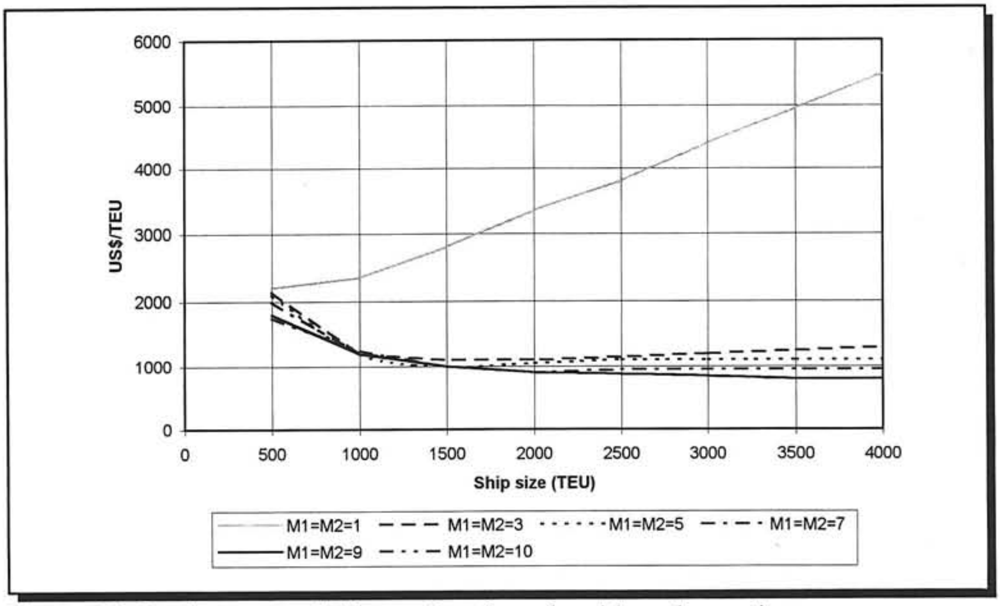

Figure 11: Total cost per TEU as a function of multi-porting options

Commodity value and warehousing cost

Trade particulars, such as daily demand per shipper, the accepted probability of running out of stock, the value of cargo and warehousing costs and also the level of port to port cargo flows have an important impact on inventory carrying costs. Varying the commodity price from 5,000 US$ per TEU to respectively 10,000, 15,000, 20,000 and 25,000 US$ per TEU, while at the same time varying warehousing costs per TEU per year from 1,250 to respectively 2,500, 3,750, 5,000 and 6,250 US$, thus maintaining a constant ratio between both, implies a proportional change of all stock carrying costs. As a consequence, total costs per TEU increase and the optimum size of ships shifts to the smaller ones (**Figure 12**).

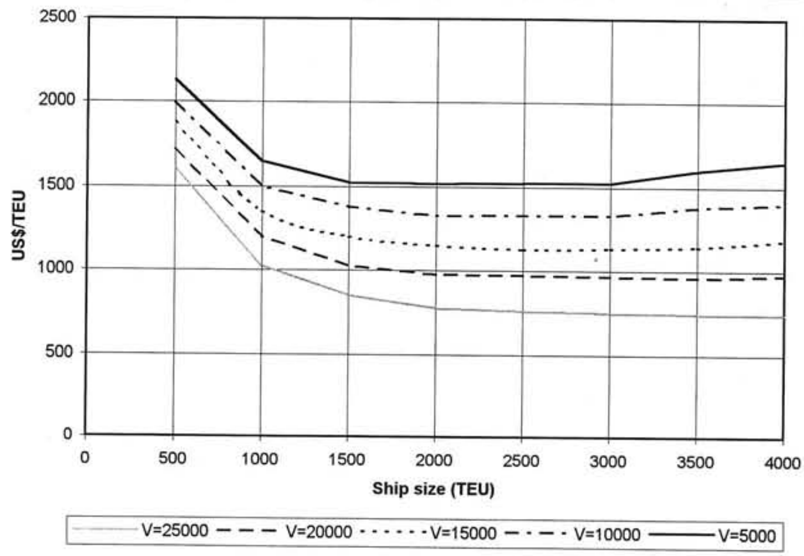

Figure 12: Total cost/TEU as a function of commodity price and warehousing

Daily demand per customer per commodity

Safety stock carrying is influenced by the level of daily demand per article/commodity combined with individual shipper/customer and by the accepted risk of running out. Both values are difficult to establish for a multitude of consignors and consignees. Varying average daily demand for all shippers from 0.5 to respectively 0.75, 1, 1.25 TEU per day, leads to a decrease in safety stock carrying costs and to an increase in the optimum size of ships, as shown in **Figure 13.**

Accepted risk of running out of stock

A similar effect can be seen with respect to the assumed values for the accepted risk of running out of stock. Increasing the probabilities from 1 percent to respectively 2, 3, 4 and 5 percent, leads to an increase of buffer stock carrying costs, while the optimum size of ships shifts to the smaller ones, see **Figure 14.**

Cargo flow level

The cargo flow level determines the sailing frequency and thus the inter-arrival time. Inter-arrival stock carrying costs thus decrease proportionally with the inverse of the cargo flow level, while they have a smaller impact on the safety stock carrying costs[1]. Increasing port to port cargo flows from 500 TEU per year

[1]Thus it is implicitly assumed that the cargo flow level is independent of other variables determining safety stock carrying. There are reasons to assume that the average daily demand per commodity/customer is positively related to overall port to port demand E_p. Adapting both simultaneously would

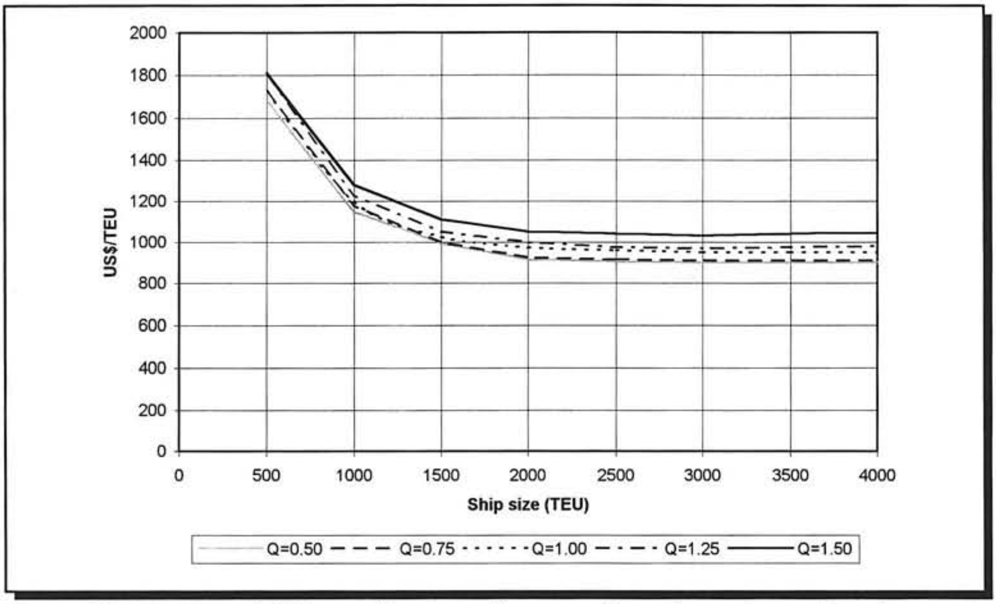

Figure 13: Total cost/TEU as a functon of commodity price and warehousing cost

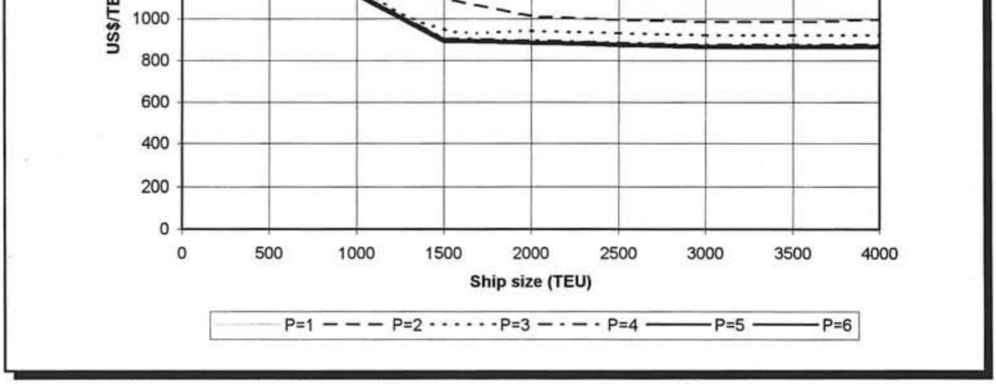

Figure 14: Total cost/TEU as a function of demand per shipper

to respectively 1000, 1500, 2000 and 2500 TEU shows a considerable decrease in total costs per TEU, see **Figure 15, Figure 16.**

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lead to lower safety stock levels with higher trade levels and thus to greater economies of scale.

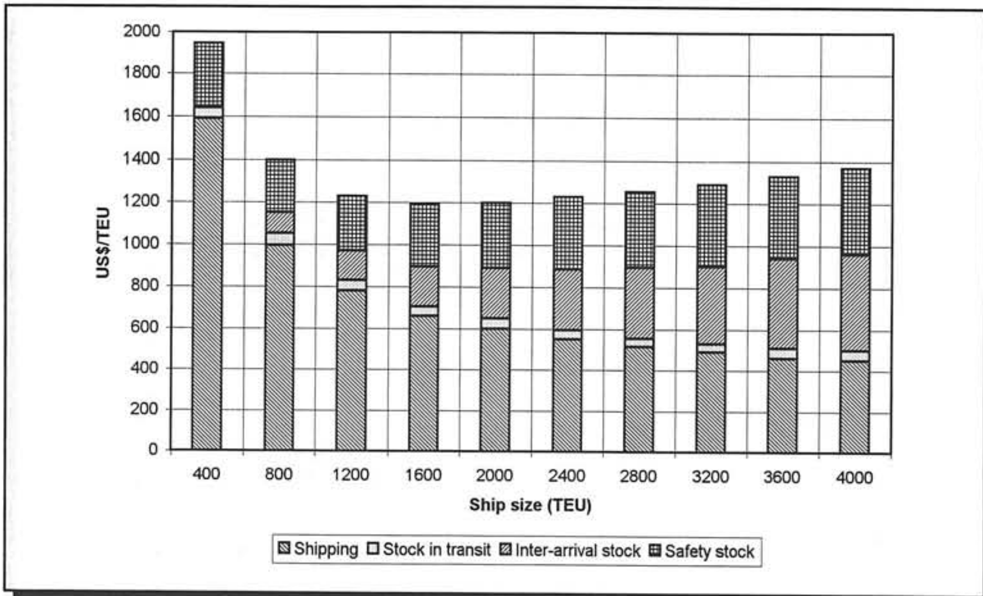

Figure 15: Total cost/TEU as function of the accepted risk of running out of stock

With the lowest level of port trade (Ep = 500) inter-arrival costs increase enormously and are for the optimal size of ships of the same order of magnitude as direct shipping costs, see **Figure 16**.

Concluding remarks

One of the major conclusions is that producer costs tend to decrease for the interval of ship sizes up to about 6,000 TEU. If the set of the input variables related to shipping costs is changed in favour to larger ships through e.g. (not too much differing) values of port productivity and scale factors with respect to daily costs and port productivity (equation 2), shipping costs per TEU keep decreasing for quite a range of sizes of ships. Combining port-to-port trades through multi-porting appears to be an effectieve means to reduce inter-arrival inventory costs, as the inter-arrival time develops proportionally with the inverse of the product of the number of ports of call at each coastline and thus disappears quickly.

Data on customars and commodities appear to have a great impact on the optimum size: see variations in warehousing costs combined with commodity value, in the demand per customer and in the accepted risk of running out of stock. The great variation in plausibly looking values of the variables, emphasizes the need to apply segmentation with respect to customers and cargoes.

The cargo flow level itself becomes an important determinant of ship size through its impact on inter-arrival stocks. This effect can also be measured statistically. Assume that the average size of ships S employed on a container route depends on the coast to coast distance D and trade level L as major explanatory variables according to the following relation:

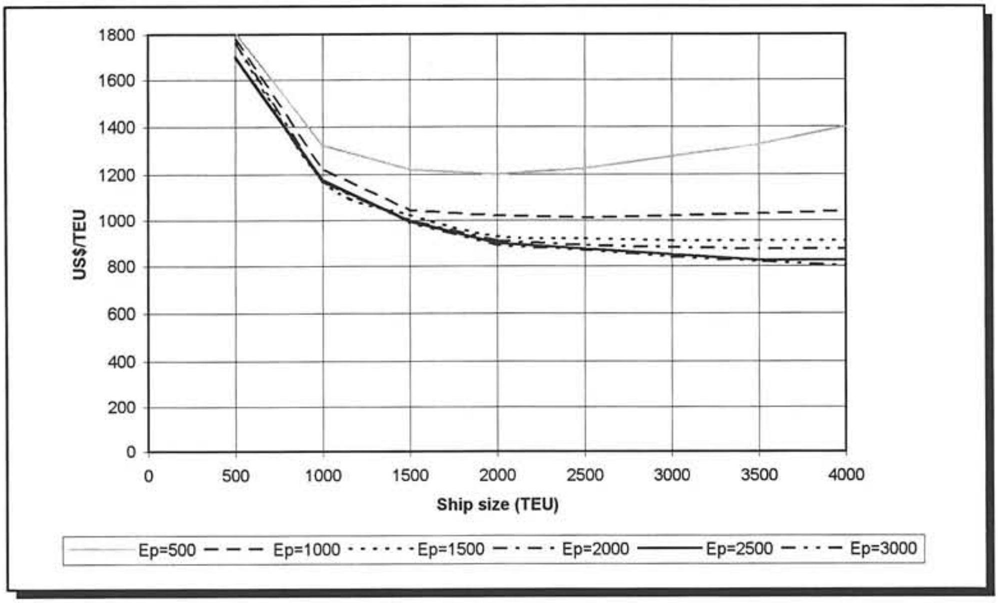

Figure 16: Total cost per TEU as a function of cargo flow level

$$S = \alpha_0 \, D^{\alpha_1} \, L^{\alpha_2}$$

For a sample of 29 container routes connecting world regions and selected on the basis of characteristics as being 'end-to-end' routes and having a minimum number of trips made by fully cellular ships, statistically significant values were estimated. The elasticity with respect to cargo flow level amounts to 0.145 indicating that a doubling of the trade leads to a 10.6 percent increase of the average size of ships employed.
A comparison of the observed average size of ships with the ones calculated according to the above equation, shows that TransPacific and TransAtlantic routes fit in quite well, but that the Europe Far East route shows a considerable higher calculated deadweight than average size of ships, see **Figure 17**.

The following items require more attention:

- Routing: the competitive position of ship size classes is considered for identical routes only, while transhipment practices are difficult to include;
- Network: some shipping routes cannot be analysed without considering other routes of the worldwide network;
- What choices are being faced? Do shippers select a particular service at a consignment per consignment basis or, do they choose for a period of time?
- Inventory carrying: the information on inventory behaviour is a compilation of assumptions averaged for a wide range of cargo/customer combinations.

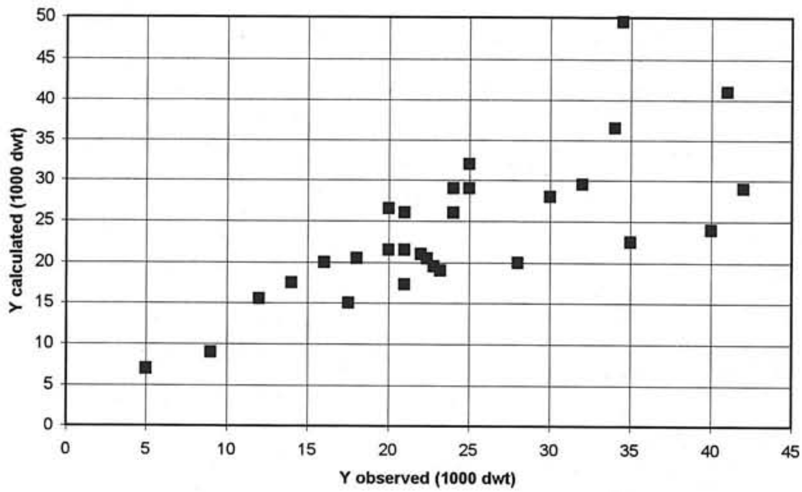

Figure 17: Average size of fully cellular container ships

13.3 Logistics cases

Ships are very flexible assets, which can be adapted to almost any circumstance. Most shipowners constantly look for new ways of solving logistical problems and thus hope to create a competitive advantage, and make money. In this section a number of logistical case-studies will be discussed. In this introduction some examples of everyday shipping news will illustrate the sort of thinking that drives the successful entrepreneurs in this sector.

Northern Sea Route

The shortest route from Europe to the Far East is via the northern sea route (NSR), passing between Russia and the Arctic Ocean (**Figure 18**). The duration of the navigation season does not usually exceed six months and depends on climatic conditions. The total fleet of nuclear and diesel ice breakers and ice strengthened cargo vessels during the season is about 60 ships. Some types of Russian ice breakers are able to crush and split up to 4 metres of ice.

The total length of the NSR between cape of Dezhnev (Bering Strait) in the east and mid of Scandinavia in the west is about 3,900 nm. In comparison, the distance between Tokyo and London via the conventional route through the Suez Canal is 4300 nm longer.

Figure 18: Northern Sea Route

Sailing through ice requires a special bow design of the vessel. However, this bow is inefficient in open waters. This has prompted the shipbuilder Kværner to develop a design that is efficient in both conditions. The design (of a tanker) uses of the anomaly that vessels often move better through ice when traveling stern first. The problem of overcoming steering difficulties with bow propellers, particularly in Arctic ice, have been overcome by the creation of the Azipod drive. The electrical propulsion unit, which rotates about its vertical axis, offers high manoeuvrability from beneath the vessel's stern. In tests, the system has proven that ice resistance when running astern was 40 percent less than when running ahead. Vessels fitted with the unit can also cope with ice four times as thick, without icebreaker assistance.

Air bag for bulk carriers

Self-unloading bulk carriers are innovative ships. Suppliers of marine equipment constantly look for ways to improve the cargo handling technology onboard these ships. There are two challenges for the designer of such equipment: To improve the cargo capacity in the hold and to accept less than free-flowing commodities.
Most self-unloaders are equipped with one or more hoppers in the hold in order to direct the bulk cargo onto the conveying system. A hopper must always has to have a slope, which reduces the cargo capacity of the ship.
Self-unloaders can only handle commodities that have a certain degree of free flowing, although the Kværner cargoscooper concept can scrap the cargo out of the hold.
The company Cirrus markets an innovative air bag as an alternative for the conventional hopper (**Figure 19**). The air bags in the hold require minimal space when deflated and work as a protective coating between the cargo and the interior. Blowers powered by electric engines inflate the bags to match the discharge speed and when unloading is completed, the process is reversed to deflate the bags. The air bags are made of a durable fabric with high tensile strength. **Figure 23** shows four cross-sections of the hold of a typical operational sequence with a bottom chain conveyor.

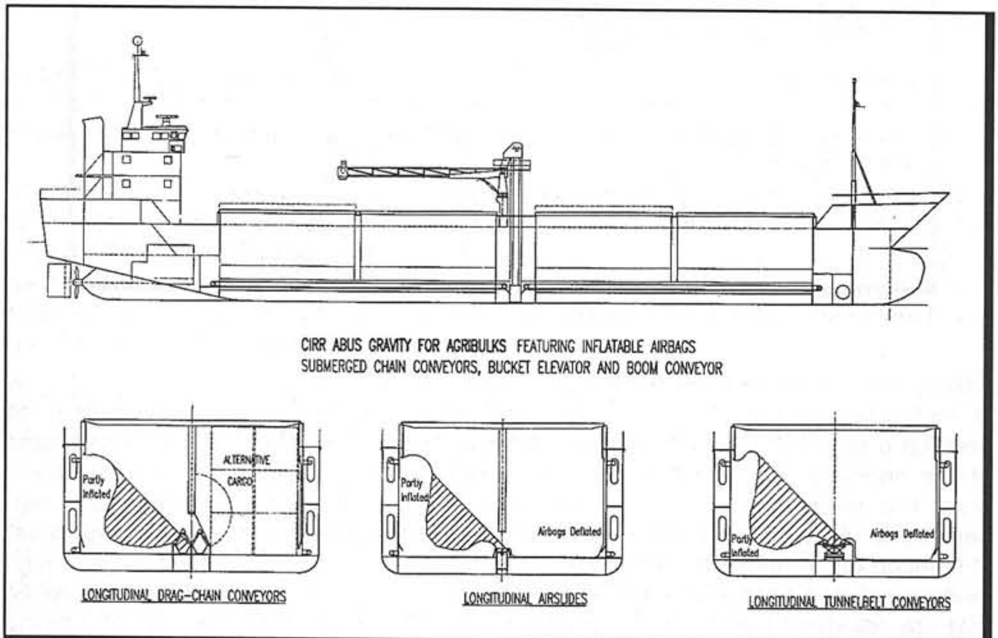

Figure 19: Air bag self-unloading system

This air bag concept can improve the economics of self-unloading bulk carriers, and enlarge the commodity ranges in which they can be used. This in turn may open up new markets and routes.

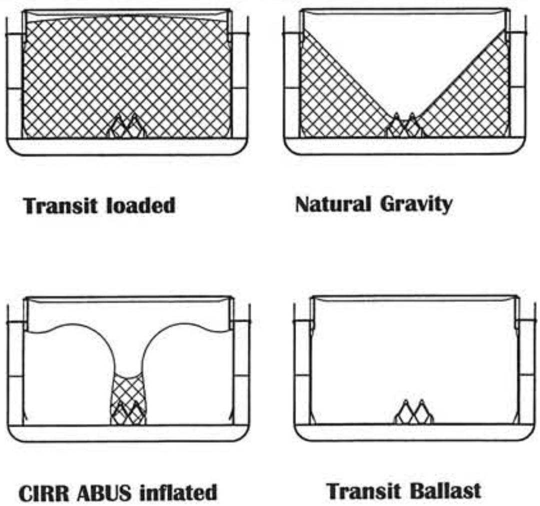

Figure 20: Cross-sections air bag self-unloading tanker

Tankers to Tangiers

The half-million population of Tangiers in Morocco has been getting their summer drinking water from four 30,000 m^3 tankers. A paradoxical situation since Ta,n-giers has abundant rainfall, but the local geology is not suitable for the natural storage of this water.
Because a dry winter followed the severe drought in 1992/1993, the levels in the public water reservoirs lowered dramatically. The Moroccan authorities looked at various alternatives for bringing water to the inhabitants of Tangiers. Building a desalination plant was too slow and costly, supply by road tankers needed at least 1000 vehicles, rail tank cars could only deliver 10,000 m^3/day, and diverting water from another reservoir would require the construction of a new 80 km pipeline and two pump stations.
It was eventually decided that the quickest and cheapest means was shipping water by tanker from a far away reservoir (400 km) to the coast and load it on-board the tankers (**Figure 21**).

Four tankers operating from the port of Jorf El Asfar shuttled 30,000 m^3/day for four months to meet the minimum needs, in a rescue operation that called for new, short pipelines at the ports of departure and arrival: A 3 km gravity line for loading the ships and a 6.3 km pumped line from Tangiers harbour to a reservoir. The sea-leg took 24 hours, the costs per cubic metre was approximately 60 dirhams, as against a national average of 4.60 dirhams.

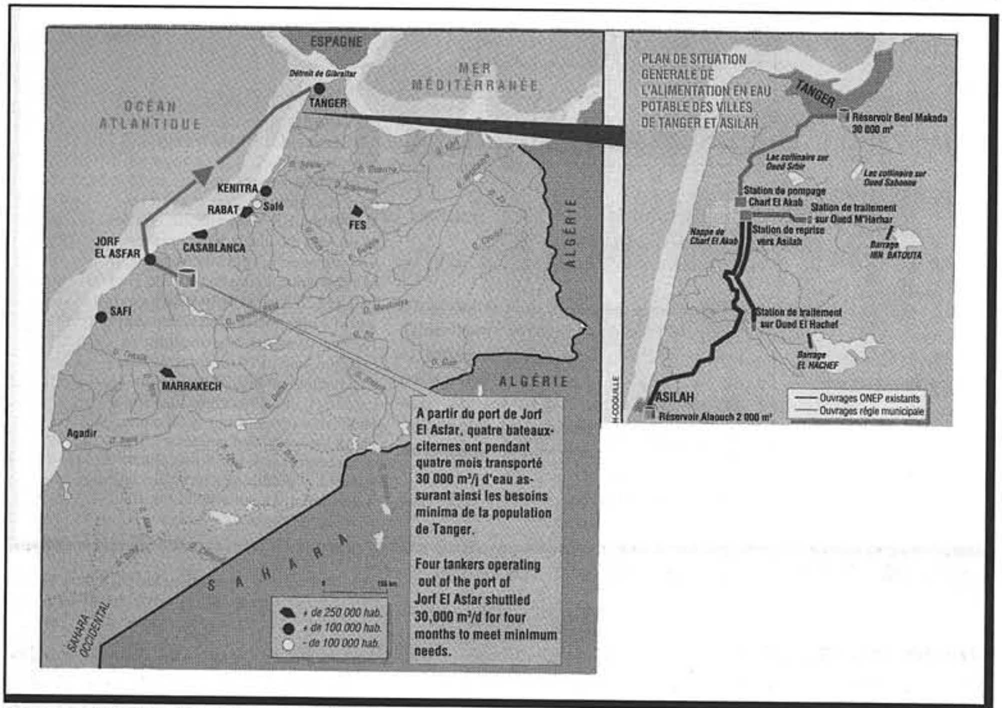

Figure 21: Water transport in Morocco

13.4 Fast ships

Speed not only fascinates people, but also creates logistical opportunities in passenger and freight transport. Ships are, compared to the land modes, relatively slow, although, modern container ships have service speeds of 24 knots or 44 km/hr. Faster ships, with service speeds up to 50 knots (approximately 90 km/hr), may create a new logistical niche in passenger and freight transport.

The *Japanese Techno-Superliner* development project aims on developing fast ship concepts that can fill in the gap that exists between air and surface transport. The demand for logistical services from fast freight ships is schematically represented by **Figure 22.** Conventional air and marine cargo carriers differ widely in speed and capacity. An intermediate transport mode with a speed and capacity midway between those of aircrafts and ships, has long been sought. In Japan, trucking has served as such an intermediate transport mode, but road haulage has suffered from traffic congestion and a shortage of drivers. A possible solution to these problems would be a modal shift from land to sea transportation. This idea lead in 1989 to the start of the project, which aimed to develop new fast vessels with a range of 500 nm, with exceptional seaworthiness, allowing it to navigate safely in high seas. Once in service, the Techno-Superliner will be able to provide approximately half-day freight services between Tokyo and Hokkaido and Kyushu. Apart from this coastal services, the liner could provide one or two day services connecting Japan and neighbouring countries.

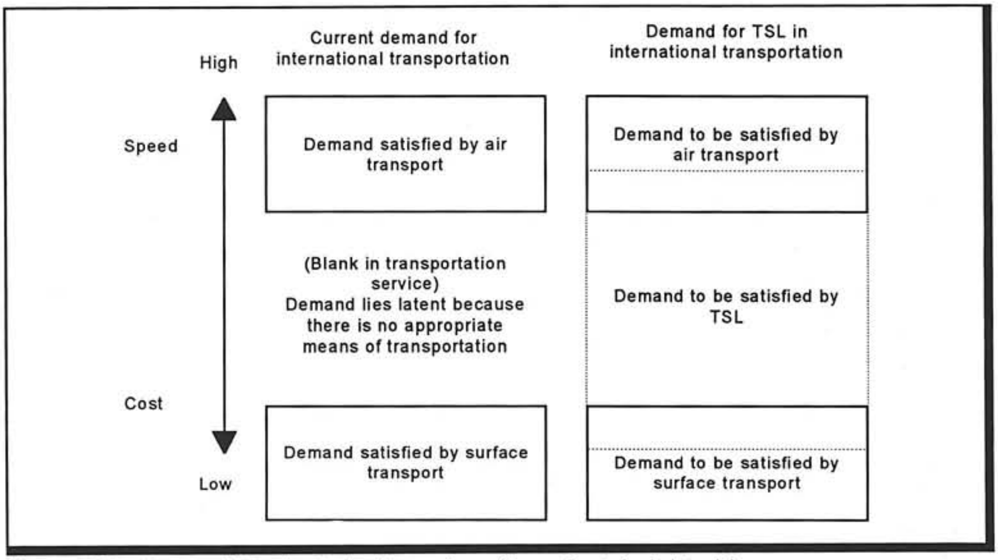

Figure 22: Demand for logistical services form fast freight ships

The conceptual design of the fast ships can be placed against the lift triangle, with on the three corners the basic lifting principles: Buoyance support, airlift, dynamic lift (**Figure 23**). Two ship concepts have been selected as most promising: Hydrofoil type hybrid hull, and air-cushion type hybrid hull.
The Techno-Superliner project will be part of an integral logistics system, which also requires high speed terminal handling. One such system is based on the conveyor side loader (**Figure 24**).

The Finnish ship designer Kværner Masa-Yards Technology has also developed revolutionary fast freight ships, based on the principle of buoyance support. The rather odd looking monohull (**Figure 25**), with a reclining bow, can develop a high speed and at the same time have a rather high payload.

When the speed of a vessel is increased the hull form must be changed. The block coefficient decreases and the slenderness ratio increases. The block coefficient of a typical cruise vessel is 0.55 to 0.60 and the slenderness ratio is 6.0 to 6.5. The Kværner Masa design has a block coefficient of 0.48 and a slenderness ratio of 8.9.

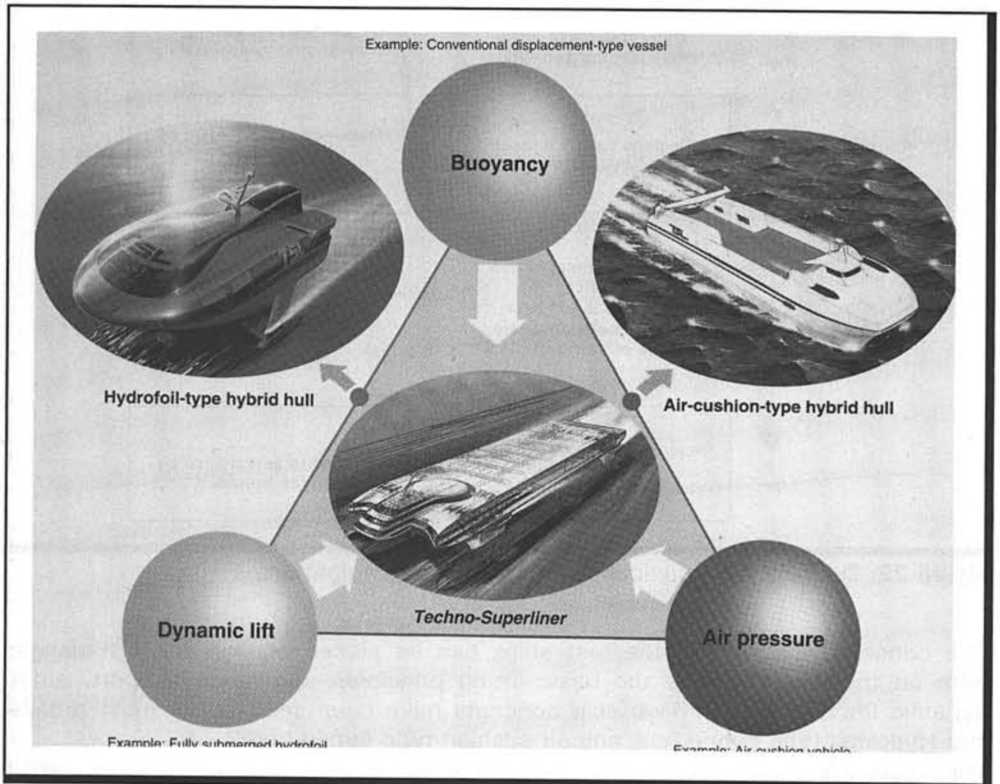

Figure 23: Lift triangle

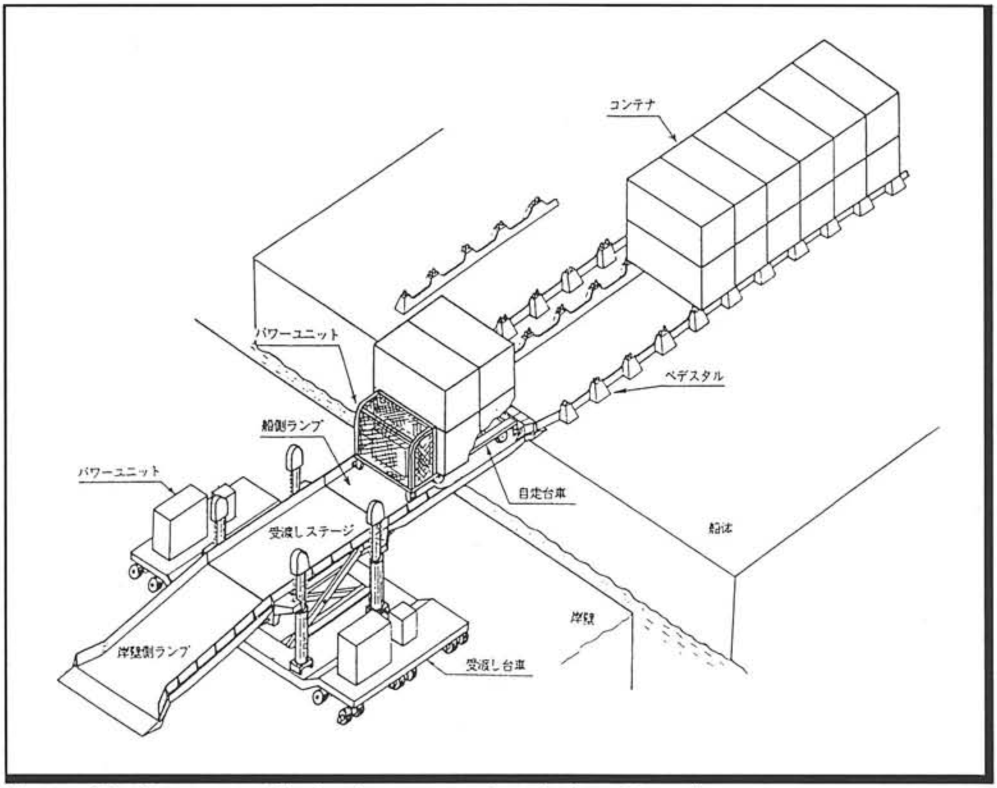

Figure 24: Conveyor side loader system for Techno Superliner

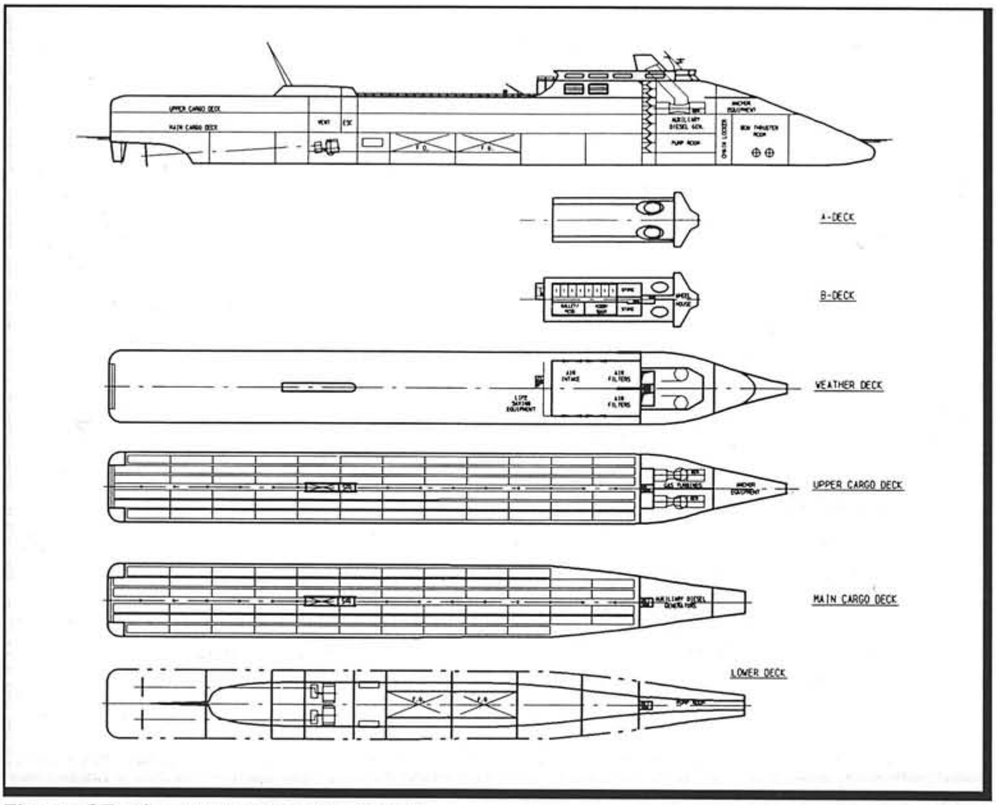

Figure 25: Kværner fast ship design

In order to gain information on resistance and seekeeping of slender monohulls model tests were done varying the hull form. Slenderness ratios of 8, 10 and 12 were selected with a wave piercing bow. Stern lines for both conventional propellers and waterjet propulsion were included in the test. A slenderness ratio of 12 gives a very long and narrow hull form with little stability. To effectively apply such a slender hull form it must be used in a catamaran or trimaran.

The model tests show that for the same displacement the propulsion power decreases with higher slenderness ratio. But a catamaran or trimaran has a higher power demand than the mono-hull with the similar slenderness ratio. The catamaran or trimaran can, however offer other benefits, such as larger deck area of better stability.

Figure 26 shows the delivered power of high speed ships as a function of their speed. The graphs shows the power for three slender monohulls, a catamaran and a trimaran. The slender mono-hull with a slenderness ratio of 10 or more require less power than the catamaran and the trimaran.

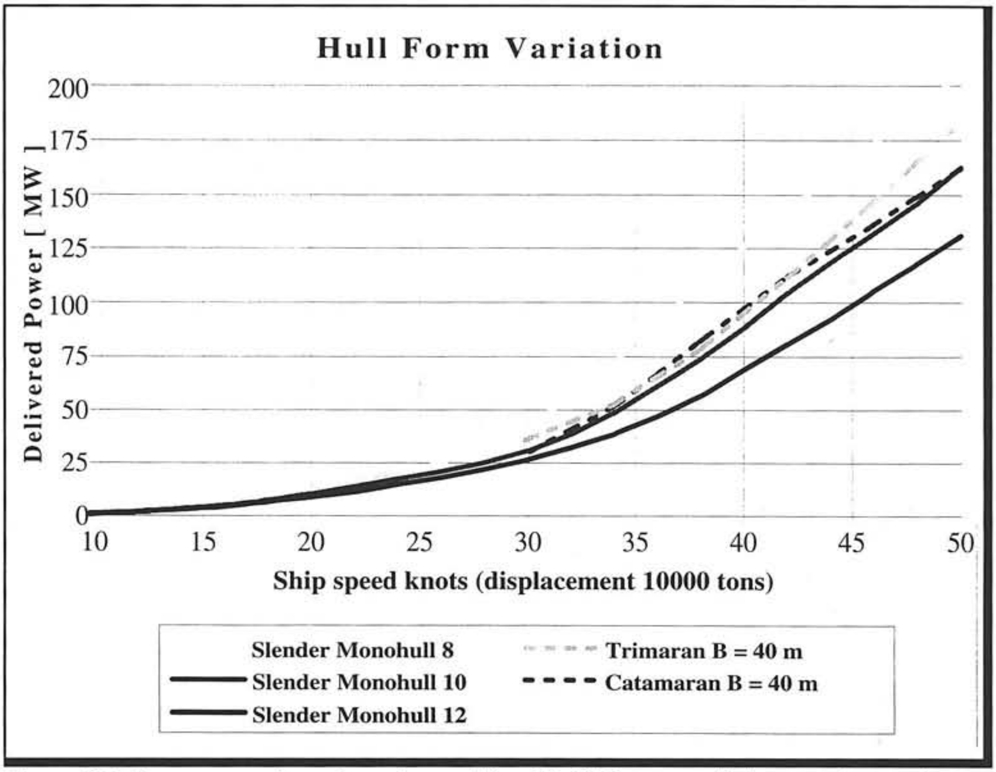

Figure 26: Power as a function of speed for 10,000 tonnes high speed vessels

Both the resistance/weight ratio and payload weight/weight ratio are strongly influenced by the size of the vessel. The Froude number is depending on the speed and waterline length of the vessel. For Froude numbers below 0.35 the vessel is in displacement mode, for values above 0.70 in the planing mode. In the displacement mode the resistance is strongly influenced by the slenderness ratio. Most ships performing speeds over 30 knots have hull lines with a slenderness ratio around 7. By increasing the slenderness ratio above 7, the vessel can pass through the hull length speed barrier at Froude number 0.35.

Length, displacement and speed are the main parameters when calculating the necessary propulsion power. For the displacement mode of operation, the power is proportional to the displacement$^{2/3}$. This reflects the wetted surface of the ship. The power demand of hydrofoils on the one hand and air cushion vehicles on the other hand, is directly proportional to the displacement.

When the displacement increases above 3,000 tonnes, vehicles operating in the displacement mode start to need less power than alternative solutions. For bigger vessels the displacement type of hull form becomes increasingly superior, see **Figure 27**.

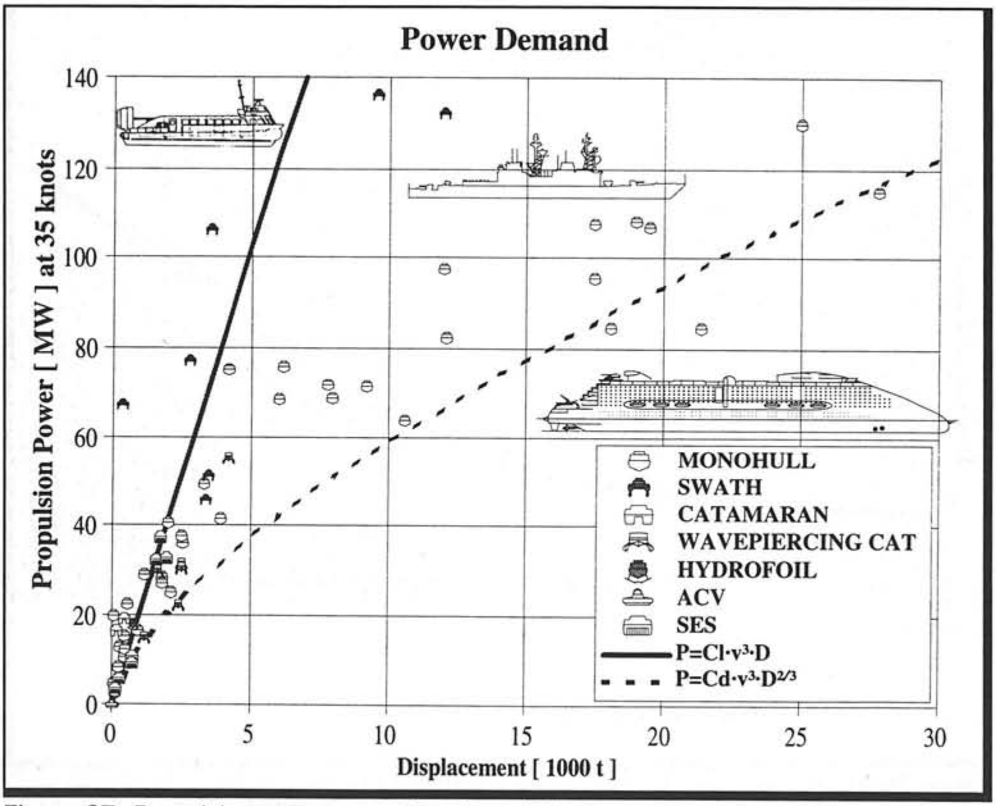

Figure 27: Propulsion power as a function of displacement

One of the first high capacity fast ships, in service since May 1996, is the Stena HSS (Highspeed Sea Service), see **Figure 28**. This vessel is able to maintain a 40 knots service speed, produced by 78 MW engines. The economics of this service are difficult to establish for an outsider, although, one ship replaces two conventional ferries on the Irish Sea route, thus achieving major savings in manning costs.

The ferry transports passengers with cars during the day, and trucks during the night. In the summer, the speed will be higher, as demand is higher. This capacity flexibility is an important extra advantage of fast ferries.

In order to get an insight into the economics of fast freight transportation and the comparison with the existing modes and modal split, two examples will be discussed from the passenger/car market and the freight-only market.

Figure 28: Stena HSS design

Fast passenger/car ship economics

The European ferry market grew steadily over the period 1980-1990, which is illustrated by **Figure 29**. The Italian shipyard Fincantieri Navali Italiani developed, like many other yards, designs for fast passenger/car ships, an example of which is shown in **Figure 30**. This ship fulfills the design and operational requirements of fast ferries, which the yard defined as:

- High service speed;
- Relatively low fuel consumption;
- High comfort on board (noise and seakeeping);
- High level of automation;
- Daily transport services;
- Reduced embarking and disembarking time;
- Limited length of routes;
- Relatively small ships.

Table V summarises the main input data for the financial feasibility calculation. The investment in one fast ferry amounts to US$ 25.2 million. The calculation results in an annual profit of US$ 629,708. The costs breakdown is shown in **Figure 31**; the capital costs make up 46% of the total costs. Tuel almost 30%. Crew costs are relatively small, 6.9%, which is a marked difference from the traditional ferry operations.

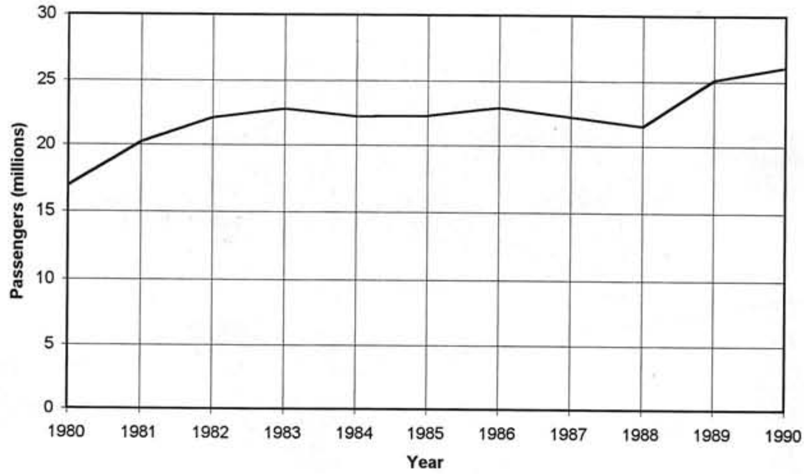

Figure 29: European ferry market

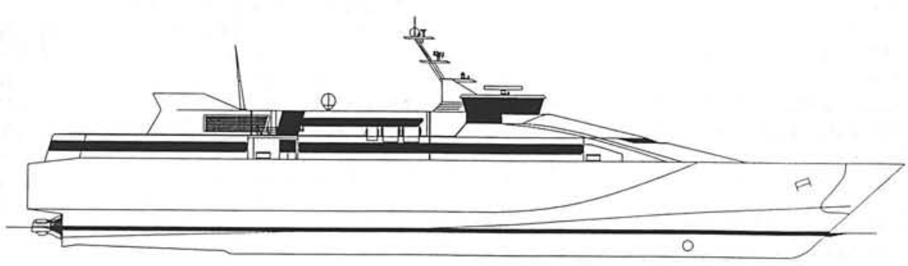

Figure 30: Fast ship design of Fincantieri Navali Italiani

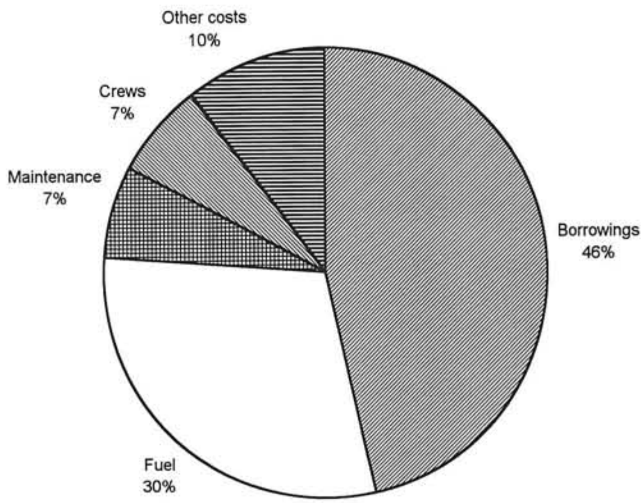

Figure 31: Cost breakdown

Fast ferries input data		**Operational input data**	
- Number of cars	142	- Utilisation factor high season	0.9
- Number of lorries	0	- Utilisation factor medium season	0.500
- Number of passengers	550	- Utilisation factor low season	0.250
- Crew	12	- High season days	90
- Fuel consumption (kg/nm)	145	- Medium season days	180
- Contractual price (US$)	25,200,00	- Low season days	90
- Subsidies percentage to owner	17	- Daily runs per ship, high season	4
- Range of route (nm)	119	- Daily runs per ship, medium season	2
- Number of ships	1	- Daily runs per ship, low season	2
- Crews per ship, high season	2		
- Crews per ship, medium season	1	**Costs input data**	
- Crews per ship, low season	1	- Maintenance costs (US$/nm)	5
		- Fuel costs (US$/kg)	0.15
Fares input data		- Average monthly salary (US$)	3,000
- Car fares ratio (M.S./H.S)	0.8	- Interest rate (%)	6.6
- Car fares ratio (L.S./H.S)	0.66	- Borrowing period (years)	10
- Passenger fares ratio (M.S./H.S.)	0.8		
- Passenger fares ratio (M.S./H.S.)	0.66		
- Car/passenger fares ratio	4		

Table V: Main input data for the financial feasibility calculation

Fast freight ships

Fast ships are frequently used for passenger transport, but, though there are many initiatives, they are not yet used for freight transport. This section shows a framework for a fast freight service between The Netherlands (Scheveningen) and Ireland (Dublin). This route is a good alternative for the land route, which comprises two ferries (Rotterdam-Felixtowe and UK-Dublin) and a large distance by road through the UK.

The sea route has the following advantages (compared to the land route):

- A high speed vessel allows for a 24-hour schedule;
- The trip saves time, due to the high speed;
- The cargo will be handled only two times, instead of four times;
- The distance between Scheveningen and Dublin is large enough to fully utilise the high speed of the vessel.

Ship design

The route will be operated by a fast ship with a displacement of 2,000 tonnes and equipped for the transport of unitloads. Because the vessel will be operating on a fixed schedule, speed is very important. The distance of 680 nm requires a minimum speed of 31 knots, allowing 45 minutes for manoeuvring and 1.2 hours for unloading and loading (based on a (un)loading speed of 800 tonnes per hour).

Important parameters for fast ships are the block coefficient and the slenderness ratio. They are respectively chosen at 0.40 and 8.5. For these values the optimal length is 106 m., the breadth is 15.10 m. and the draught is 2.90 m. The breadth is relatively large, because:

- A large metacentric height provides for great stability;
- A large breadth allows for a wide ramp, which facilitates fast (un)loading via the stern (ramp);
- It gives a large deck area. No tweendecks, and therefore no internal or external ramps, are required.

The service speed of 31 knots requires a power of 23,500 kW, the total installed power is 28,000 kW. The payload of the ship depends on the light ship weight and the speed of the ship. Extra speed requires extra bunker capacity and extra machinery weight. The maximum payload for a maximum speed of 31 knots, is 960 tonnes and a trailer capacity of 35.
Because the required power cannot be delivered by one high speed diesel engine a configuration of a gas turbine and two high speed diesel engines is used. The gas turbine will produce the main part of the power and will only be used at sea. It is placed in the centre of the machinery room and is connected to a booster jet. The remaining power is delivered by the diesel engines. During manoeuvring only the

diesel engines will be used. These engines are connected to steerable waterjets and they will be located at each side of the ship, see **Figure 32**.

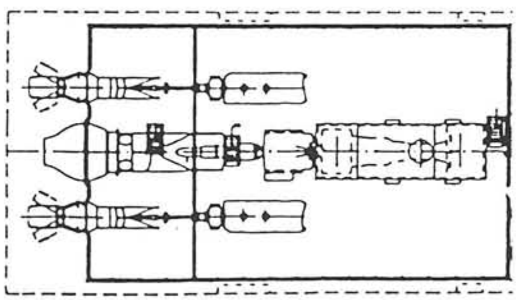

Figure 32: Propulsion unit configuration

The deck layout was selected according to the following considerations:

- The breadth of the deck is restricted by the breadth of the ship. Within these restrictions the deck must be as wide as possible;
- Efficient cargo handling is improved by straight lanes and parallel ramp;
- The payload increases by decreasing light ship and machinery weight. Extra equipment or increasing main dimensions cause a reduction of the payload.

After an evaluation of different ship types, the layout shown in **Figure 33** was selected. The ship is of ro-ro design. The simplicity of the cargo hold and ramp allows for efficient cargo handling. The maximum payload is large and the investment costs are relatively low.
The accommodation is positioned in the front of the ship, which enables a low accommodation without obstructing the view. A low accommodation is good for the ship's stability and wind resistance.

Speed keeping

It is important for fast ships that they are able to keep in service and maintain their speed during bad weather conditions. Therefore, the resistance of the ship in waves is of major importance.
The resistance is calculated in two parts, first a fixed part called still water resistance and then a variable part called added resistance. The *still water resistance* is the resistance of the ship in water without waves and varies according to the speed. For a speed of 31 knots the still water resistance is 840 kN.
The *added resistance* is the resistance caused by the waves and varies according to the speed of the ship, the significant wave height and the direction of the waves. **Figure 34** shows the added resistance for a speed of 31 knots for three different wave angles, as a function of the wave height.

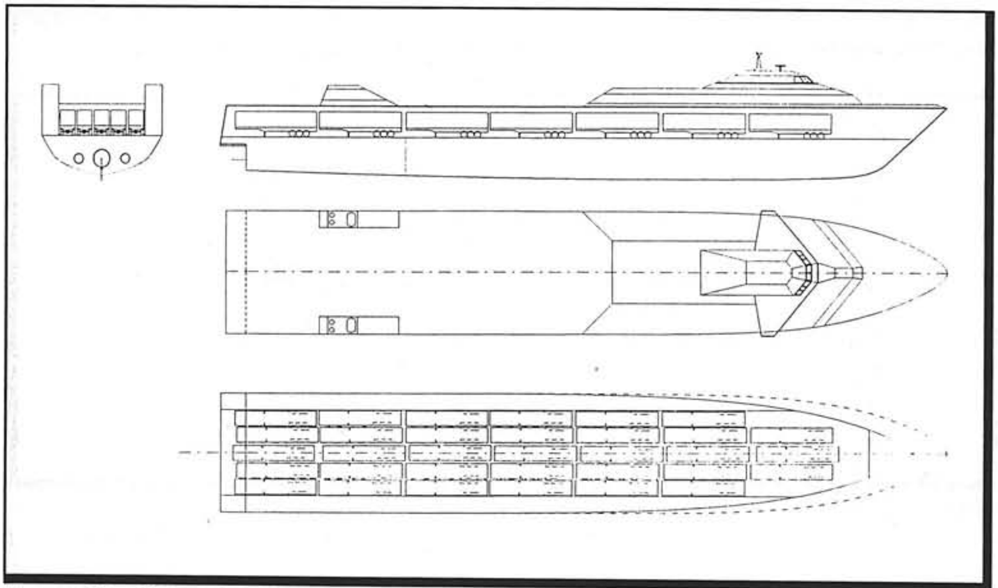

Figure 33: General arrangement of the fast freight ship

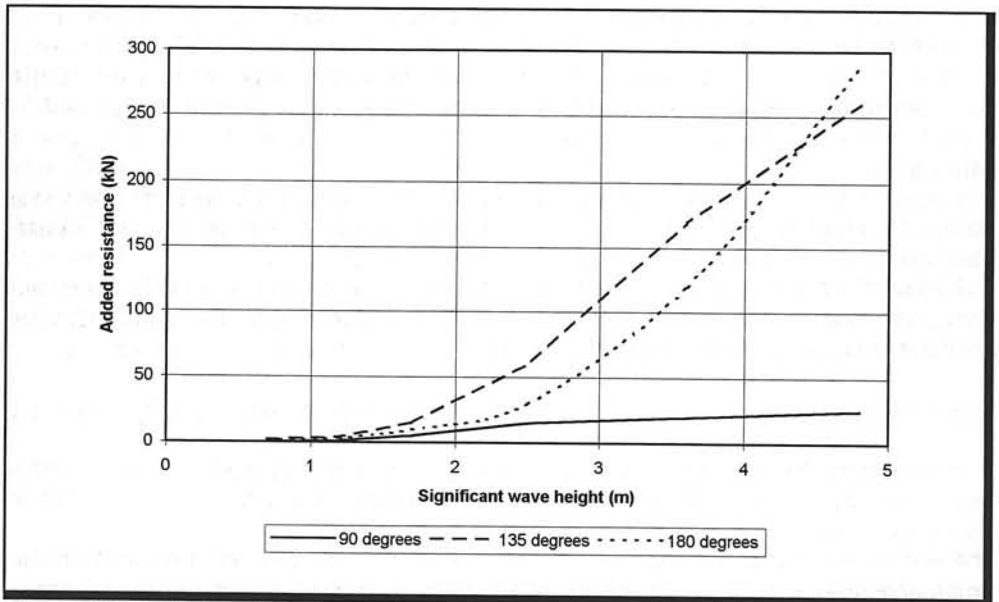

Figure 34: Added resistance at a speed of 31 knots

With the help of the wave spectra of the areas in which the ship will sail an estimate of the speed loss can be made. **Figure 35** shows the cumulative probability diagram of the significant wave height in six areas that the ship will cross.

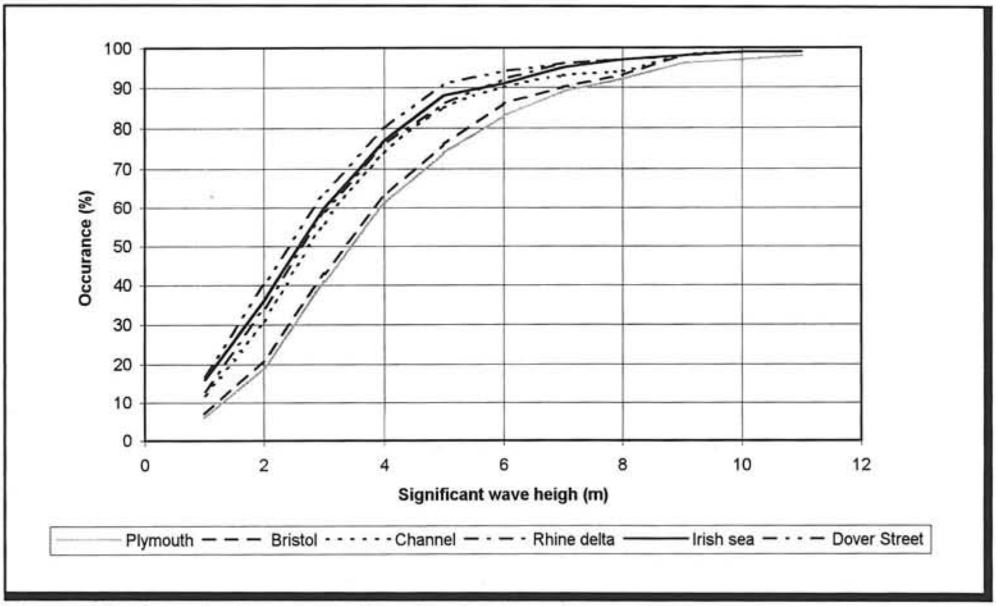

Figure 35: Cumulative probability distribution of the significant wave height

It is assumed that 2% delayed trips is acceptable. Then, the cumulative wave spectra show that the service speed of 31 knots has to be maintained in waves up to a significant wave height of 4.9 m. In the worst case (head waves) the added resistance is 295 kN. However, because the ship will not always sail in head waves the extra resistance is overestimated. This is why also another case is considered.

It is assumed that the propulsion unit is laid out to maintain the service speed in a significant wave height of 3.7 m. The added resistance in head waves is 170 kN. Together with the still water resistance of 840 kN, this gives a total resistance of 1010 kN. With a waterjet efficiency of 63% and a reduction of 5% by transmission, the required brake power is 27,000 kW. Assume that the ship, with an installed brake power of 27,000 kW is operated under the following conditions:

- The waves come from the South-West, this means that the ship has head waves during 2/3 of the trip;
- The ship makes a one-way trip from Scheveningen to Dublin;
- The significant wave height during the whole trip is 4.9 m.

The trip is calculated in two parts. The first part comprises the first 2/3 of the route. The speed on this part is calculated to be 30 knots in 4.85 m. head waves. On the second part the added resistance is zero, which gives the ship a speed of 33.5 knots. The total sailing time is calculated to be 21.9 hours, which gives sufficient time for manoeuvring, loading and unloading.

Economics

The cost per year of the ship are as follows:

- Operating cost 3,310,000 US$/year
- Voyage cost 6,690,000 US$/year
- Capital cost 4,140,000 US$/year
- Total costs 14,140,000 US$/year

For utilisation ratios of 90% and 70% of the payload this means a required freight rate of 49.6 US$/tonne and 63.7 US$/tonne, respectively.
The capacity of the ship is 35 trailers. The total cost per trip are 42,800 US$. For an average utilisation ratio of 90% of the ship's capacity and a cargo handling cost of 50$ per trailer per terminal, the required freight rate per trailer, including cargo handling cost, is 1460 US$. The required freight rate of the truck by road and ferry is 1910 US$/trailer. This means that the costs of fast cargo transportation are lower than the costs of transport by road and ferry.

CHAPTER 14: RISK MANAGEMENT

Several times in previous chapters the focus has been on the volatility of shipping markets. This chapter will deal with volatility, or *risk* as it is also called. Risk is a term that often is associated with the probability of losing money. High risk implies thus a high probability of losing money. Sometimes the word risk is also used for cases where the possibility exists of losing a substantial *amount* of money, even if the probability might be very low. If the word risk is used in this way, the term becomes fairly vague.

14.1 Definition of risk

In modern investment analysis the term risk is defined as the distribution of possible outcomes of an investment, i.e. risk is associated with possible positive (upside) and negative (downside) deviations from an expected value of the outcome. The measurement of risk is, therefore, a matter of finding a statistical measure of spread around a mean. By characterising an investment, or an ongoing economic activity, by the expected return of that investment (or activity) and the variance of this return, an operative statistical measure of risk is obtained.

The use of the variance as a relevant measure of deviation is only appropriate if the outcomes are normally distributed. The use of the normal distribution is essential in risk management, and the distribution has a number of properties that make it useful.

14.2 The normal distribution

The curve of the normal distribution is symmetric and the area under the curve is equal to one. It is characterised by two parameters only, the mean value and the standard deviation. The area under the curve between any two values represents the probability that the random variable lies between those two values. Roughly, the following is characterising the normal distribution:

- The mean ± 2/3 of a standard deviation will contain 50% of the values;
- The mean ± 1 standard deviation will contain 68% of the values;
- The mean ± 2 standard deviations will contain 95% of the values;
- The mean ± 3 standard deviations will contain 99% of the values.

In **Figure 1**, three normal distributions are shown for three potential investment projects. The project with the lowest expected mean rate of return, has also the lowest standard deviation and the project with the highest expected rate of return has the highest standard deviation. This is what one normally would expect to find in practise - those projects with the highest rate of returns also are more risky, i.e. the distribution of possible outcomes has a higher variation.

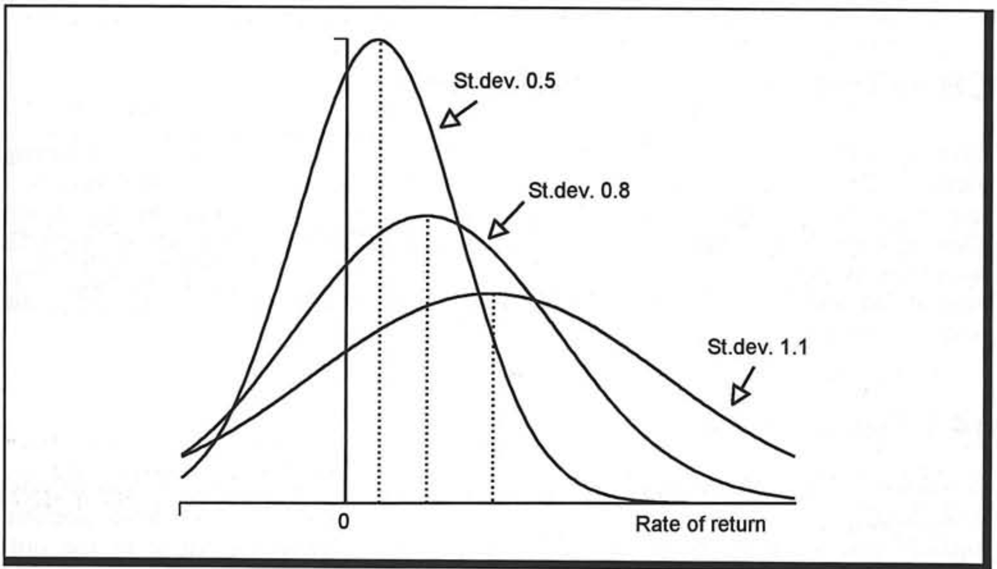

Figure 1: Examples of three investments with a different risk profile

14.3 Attitudes towards risk

In mathematical terms, attitudes towards risk can best be formulated using utility functions. Assume that an investor has a utility function which can be described simply as:

$$U(X)$$

where:
- U = A measurement of utility level;
- X = The expected return on a specific project.

Normally one would assume that the utility of an investor increase with the rate of return received. That implies that:

$$U'(X) > 0$$

where:
' = Indicates the derivative of U with respect to X..

If an investor is neutral towards risk, then his utility is only affected by the expected rate of return. In that case $U''(X) = 0$. Normally, however, most people will have an aversion against risk. If given the choice of receiving US$ 10,000 with certainty against the alternative of getting either US$ 8,000 or US$ 12,000, each with 50% probability, most people would choose the first alternative. In the case of risk avert investors, $U''(X) < 0$. It is of course possible that some investors love to take risk so much that they are willing to take on more risk without any compensation in terms of higher expected outcomes. Risk lovers have a utility characterised by $U''(X) > 0$.

Risk aversion is the normal assumption in investment theory, and then it follows that if one offers more risky projects, compensation must be made in terms of higher expected returns.

Risk, in terms of uncertainty related to future outcomes, is a phenomenon we all live with every day, and to accept risk in exchange for a compensation in terms of higher profit is one of the most fundamental principles in a capitalistic society.

14.4 Types of risk

The unanticipated part of the return of an investment, that portion resulting from surprises, is the true risk of any investment. If all outcomes are known and we always receive what we expect, no risk exists. The risk of owning an asset comes, therefore, from surprises, from unanticipated events.

Some surprises, like OPEC affecting the world oil price, a war in the Middle East or a change of economic policy in a country affecting inflation rates and interest rates, are all surprises that affect almost everyone within an economy. This kind of risk is normally called *systematic risk*. A systematic risk is one that influences a large number of assets, and because such risks have market-wide effects, they are sometimes called *market risk*.

Other surprises can affect a single asset, or a narrow group of assets. If it is known that the managing director of a shipping company must step down because of allegations of fraud, this event may affect the company value, but will hardly have a market-wide effect. If there is a strike in a dry bulk port, this will most likely affect the dry bulk market, but will have little effect on the container market or even the tanker market. This kind of risk is normally called *unsystematic risk*. As it only affects one, or a few assets, it is also called *unique risk* or *asset-specific risk*.

Sometimes it is difficult to make a clear distinction between these two main types of risk as most economic activities are interrelated one way or the other. It is still an important distinction, which is used in portfolio management.

14.5 Risk reduction and portfolio theory

So far only individual investments have been considered. For shipping companies it is more relevant to consider the sum of all investments - or the portfolio of investments (or economic activities) that the company is engaged in. Portfolio theory builds upon the fundamental observation that if investment alternatives are not perfectly positively correlated, the risk of the portfolio can be reduced by a special combination of those assets.

The line of reasoning is like this: If only one asset existed, then the portfolio would fluctuate mainly because of asset-specific events. In a larger portfolio of assets, some assets will go up and some go down in value because of asset-specific events, but these variations will tend to cancel each other out as the number of assets grows. This way variability of individual assets can be largely eliminated. This is the same as saying that unsystematic risk can be eliminated by diversification. This is why unsystematic risk sometimes is also called *diversifiable risk*.

To see the principle of risk reduction in portfolios, a simple example may be instructive. Assume two shipping companies, VL Ltd. and SP Ltd. with a totally different profile as regarding expected profit. Assume that through scenario analysis four different states of the world have been identified and for each the expected return for the two companies is as given in **Table I**.

State	Return % - RVL	Return % - RSP
1	-20	5
2	10	20
3	30	-12
4	50	9

Table I: Expected returns for two companies

From these numbers it is possible to calculate the expected return for each company and the variances of their returns. As variance is measured as the squared deviation from the mean, one needs to calculate the deviations for each of the 4 states.

The expected return is simply the average:

$$EVRL = \frac{-20+10+30+50}{4} = 17.5\%$$

$$ERSP = \frac{5+20-12+9}{4} = 5.5\%$$

Table II summarises the intermediate calculations needed for the variances:

The variance (var) is defined as the average square deviation from the mean, so:

$$var(RVL) = \frac{0.2675}{4} = 0.066875$$

State	Deviation from ERVL	Deviation from ERSP	Squared deviation VL	Squared deviation SP
	(RVL-ERVL)	(RSP-ERSP)	$(RVL\text{-}ERVL)^2$	$(RSP\text{-}ERSP)^2$
1	-0.375	-0.005	0.140625	0.000025
2	-0.075	0.145	0.005625	0.021025
3	0.125	-0.175	0.015625	0.030625
4	0.325	0.035	0.105625	0.001225
Total			**0.267500**	**0.052900**

Table II: Intermediate calculations needed for the variance

$$var(RSP) = \frac{0.0529}{4} = 0.013225$$

The standard deviation (sd) is simply the square root of the variance, so:

$$sd(RVL) = 0.066875^{0.5} = 0.1485 \ (or\ 25.86\%)$$

$$sd(RSP) = 0.013225^{0.5} = 0.1150 \ (or\ 11.5\%)$$

This shows that the company with the highest expected return also is the most risky company.

Portfolio management is, however, primarily concerned with how the return on one asset correlates with the return on another asset. For this purpose one needs the covariance and the correlation for the assets. The covariance is calculated by multiplying the deviation from the mean for one company with that of the other company for each state of the world and find the average. The product of the deviations is found by multiplying the numbers in column 2 with the numbers in column 3 (**Table II**) and finding the average. The figures are given in **Table III**.

State	Product of deviations	Result
1	0.375*0.005	0.001875
2	0.075*0.145	-0.010875
3	0.125*-0.175	-0.021875
4	0.325*0.035	0.011375
Total		**-0.0195**

Table III: Intermediate calculations to obtain covariances

The covariance is then the average:

$$cov(RVL, RSP) = \frac{-0.0195}{4} = -0.004875$$

The correlation coefficient is defined as the covariance divided by the product of the standard deviations:

$$corr(RVL, RSP) = \frac{cov(RVL, RSP)}{sd(RVL) * sd(RSP)}$$

$$corr(RVL, RSP) = \frac{-0.004875}{0.2586 * 0.1150} = 0.1639$$

If the returns for both companies were closely correlated, then the deviation from the mean would have the same sign. Every time one company had negative profit, so would the other, so the product of deviation would be positive. When one is negative and the other is positive, the covariance tends to be negative, which also always gives a negative correlation coefficient. The correlation coefficient will be between -1 and +1 and if negative, we talk about negatively correlated assets, if positive we talk about positively correlated assets and if zero uncorrelated assets.

Looking at the risk and return for a portfolio, we need to define the expected return and the variance of the portfolio. The expected return for the portfolio (ERP) is simply the weighted average of the individual returns, where the weights are the proportions of the total investment for each asset. In this example, if 60% was invested in VL and 40% in SP, the expected return for the portfolio would be

$$ERP = 0.6 * 0.175 + 0.4 * 0.055 = 0.127 \ (or\ 12.7\%)$$

Let now WVL be the proportion of the portfolio invested in VL and WSP be the proportion invested in SP (WVL+WSP=1). The variance of the portfolio, var (P), can be written as

$$var(P) = WVL^2 * var(RVL) + WSP^2 * var(RSP) + 2 * WVL * WSP * cov(RVL, RSP)$$

The variance of the portfolio is not just the sum of the variances weighed by the square of the proportions of each asset, but also the covariances matter. Since

$$cov(RVL, RSP) = cov(RSP, RVL)$$

it does not matter how the variables are numerated.

In our example, still assuming a 60% share of VL and 40% of SP, the variance of the portfolio becomes:

$$var(P) = 0.6^2 * 0.66875 + 0.4^2 * 0.013225 + 2 * 0.6 * 0.4 * (-0.004875) = 0.023851$$

The standard deviation for the portfolio sd(P) is simply the square root of the variance:

$$sd(P) = 0.023851^{0.5} = 0.1544 \ (or\ 15.44\%)$$

This can be interpreted as for individual assets. The portfolio expected return is 12.7% and the standard deviation is 15.44%, so if we assume that the return is normally distributed, it follows that in 68% of all cases the return on the portfolio will be between -2.74% (12.7-15.44) and 28.14% (12.7-15.44).
We can see from the formula for the variance of the portfolio that it is the third element in the formula that matters for diversification. If two assets are negatively correlated, the third element (the covariance) will be negative and this leads to a *reduction* in the portfolio variance.

So far only one combination of the assets has been investigated. In principle an unlimited number of combinations exists. **Figure 2** shows the possibilities. The figure shows the expected returns and the standard deviations of several combinations. Investing in SP alone gives a low expected return, but also low risk. Investing in VL alone gives both higher risk and expected returns. If VL and SP were perfectly correlated (correlation coefficient = 1), any combination of the two assets would lie on the straight line drawn between SP and VL. In this example the correlation coefficient is -0.16, so risk reducing possibilities exist. Four specific portfolios are indicated in **Figure 2**, and the curve combining the points shows all possible combinations. The portfolio that minimises the variance of the returns is also indicated. That would have been a portfolio with 81.4% of SP and 18.6% of VL.

To consider what is the *optimum* portfolio, one needs to know if a risk-free alternative exists and if borrowing can take place at this risk-free rate. Secondly one needs to know the risk preferences of the portfolio holder. **Figure 3** illustrates the problem. Assume that it is possible to borrow at a risk free interest rate of 4%. The shaded area in **Figure 3** indicates all feasible portfolios and the curved line from MV to VL indicates all efficient portfolios (i.e. all points on this line are better than any other point below the line) and this is called the efficient set. If a risk free alternative exists, a new portfolio could be constructed, consisting of some risk free investment and some risky investment. The straight line from point rf which is a tangent to the efficient set, is the best set of such combinations. This is referred to as the capital market line. Any combination between rf and A will consist of some risk-free and some risky investment. Points beyond A are also feasible, since it is assumed possible to borrow money to expand beyond the point achievable without borrowing.

One cannot say which point is the optimum point without knowing the risk preferences. One can conclude, however, that point A will always be the optimum construction of the risky part of the total portfolio. This is known as the separation principle. The point A can be found without knowledge of risk preferences. The final optimum portfolio cannot.

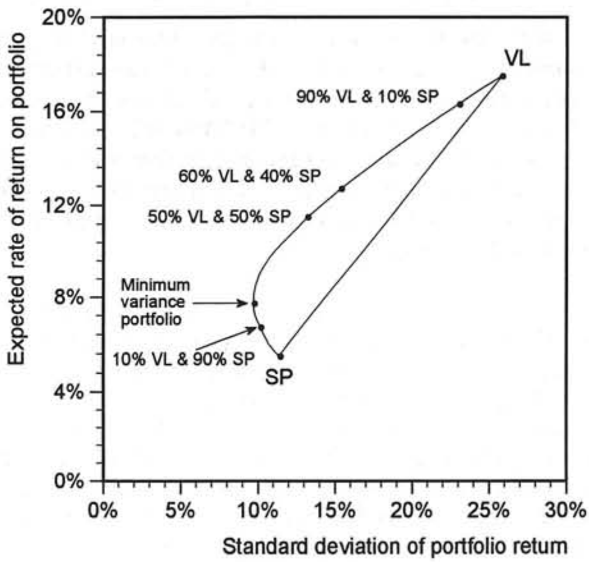

Figure 2: Possible portfolios from the assets SP and VL

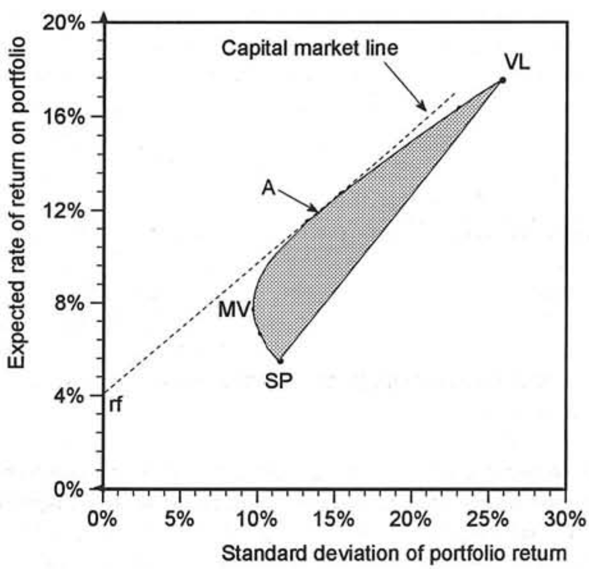

Figure 3: Optimal portfolio solutions

If assets are perfectly correlated, all risk can be eliminated. This is shown in **Figure 4**. When the correlation is 1, a straight line between A and B indicates all possible portfolios combining the two assets and no diversification is possible. As correlation goes towards -1, the efficient set curves become more and more curved, until all risk is eliminated at point C, where the correlation coefficient is -1. This is more of theoretical, than practical interest, however, since one hardly will ever be able to find two assets that are perfectly correlated. A main point in portfolio theory is, however, that the correlation needs not be even negative for some diversification gains to exist. As long as the correlation is not exactly 1, some diversification possibilities exist.

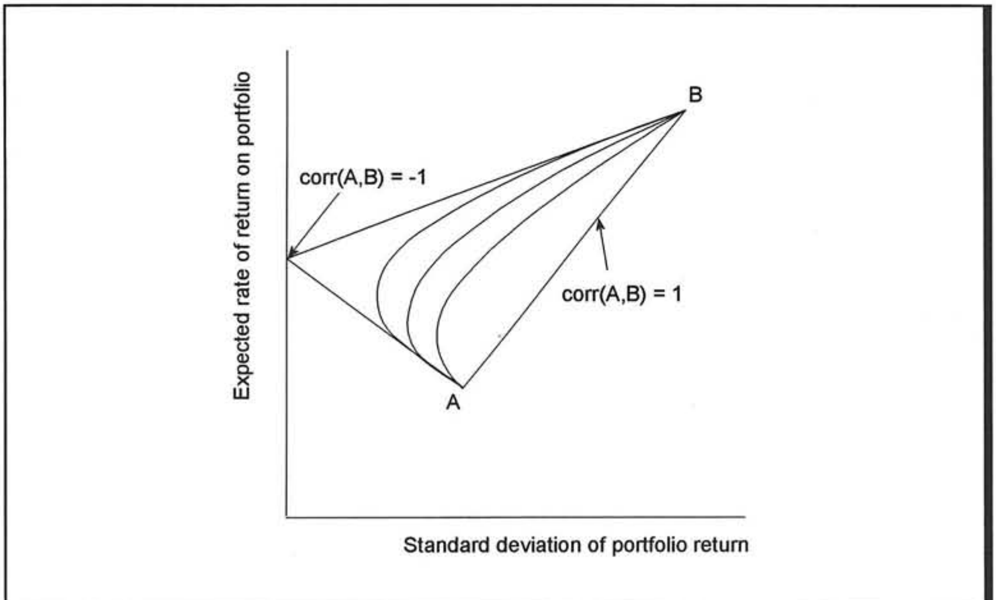

Figure 4: Correlation and risk reduction

14.6 Diversification possibilities in shipping

The simple example could easily be generalised to the case of many assets or activities. Software programmes are available for the calculation of more complex portfolios. Some considerations must be made, however, before using portfolio-theory to diversify a company.

The main question that must be asked is: Is it the company which should diversify or should not simply the owners themselves do the diversification by financial investments? If capital markets work well, they can by placing their money in different companies obtain the desired portfolio. For investors it may be an advantage that shipping companies specialise completely, then they are more easy to analyse and monitor over time.

If the company's owners prefer to have a well diversified company, the company can also obtain diversification by investing in stocks rather than to actually buy ships and try to operate these in many different segments. It is not easy for one company to maintain the core competence needed to be successful in many segments.

It is easy to underestimate the transaction costs of constantly adjusting a portfolio of investments if this consists of many assets.

With these considerations in mind, one can ask how large the diversification potential really is in shipping. In **Table IV** some freight rates for various ships have been correlated to examine whether different ships are highly positively correlated.

	T30	T130	T250	B55	B120	G19	G34	EFE	NAW
T130	0.75	1							
T250	0.69	0.94	1						
B55	0.53	0.76	0.64	1					
B120	0.29	0.54	0.68	0.31	1				
G19	0.66	0.75	0.60	0.92	0.25	1			
G34	0.65	0.67	0.52	0.92	0.13	0.98	1		
EFE	0.36	0.14	0.06	0.39	0.08	0.55	0.52	1	
NAW	-0.59	-0.70	-0.51	-0.79	-0.24	-0.80	-0.76	-0.45	1
EA	0.28	0.74	0.79	0.60	0.59	0.49	0.39	0.17	-0.44

Data source: Lloyd's Shipping Economists, yearly data 1979-1995

T = tankers of sizes 30,000 - 130,000 and 250,000 dwt
B = bulk carriers of size 55.000 and 120,000 dwt
G = general cargo ships of size groups 12,000-19,999 and 20,000-34,999 dwt
EFE = container unit rates for Europe - Far East
NAW = container unit rates for North Atlantic Westbound
EA = container unit rates for Europe - Australia

Table IV: Correlation coefficients of freight rates for various ship types 1979-95

Some correlation coefficients are close to 1. The Million Barrel Tanker is closely correlated with the VLCC, the Panamax bulk carrier is closely correlated with both size groups of general cargo ships which are also closely correlated with each other. Another striking result is the fairly strong negative correlation between the Westbound container traffic in the North Atlantic and all other activities. In general, however, the partial correlations show a positive correlation between 0.4

and 0.7, which indicate some diversification potential, but not a very large potential.

These correlations are simple indications, as no attempt has been made to convert the freight rates into comparable earnings per day, which would be an appropriate measure. From an older, and partly confidential study this was done, however. Detailed statistics of quarterly earnings where every effort was made to make the figures comparable, gave partial correlation coefficients for 6 different shipping activities as indicated in **Table V**.

	Line 1	Line 2	Line3	Tankers	Dry Bulk
Line 2	-0.14	1			
Line3	0.00	0.30	1		
Tankers	-0.30	0.30	0.40	1	
Dry bulk	0.76	-0.25	-0.35	-0.55	1
Oil rigs	0.28	-0.30	-0.35	-0.70	0.60

Source: Per Axel Koch. 1987 (in Norwegian only)

Table V: Partial correlations for main shipping activities 1974-86

Again some interesting negative correlations are found, but the further analysis indicated that the potential for risk reduction was limited because the main activities of the company was very exposed to one, single common factor - the oil price. This systematic risk dominated the potential gains of reducing the unsystematic risk. This should be kept in mind before employing portfolio theory as a main tool of risk reduction - there may be underlying variables that in a systematic way may influence all assets in the portfolio.

14.7 Forward and futures markets

A forward contract is a contract between two parties specifying a future delivery of a commodity (or service) at an agreed price. The underlying commodity or service is called the deliverable instrument. This is a tailor made contract, where all relevant aspects about the future is agreed upon today, i.e. the quantity, the date and place of delivery as well as the price is agreed to in advance.

Forward contracts are well known in shipping, as all time-charter contracts are forward contracts and most contracts of affreightments are forward contracts. The main characteristic of a forward contract is that the seller is obliged to deliver and the buyer is obliged to accept the deliverable instrument. This is also the main problem with a forward contract. If, for example, an oil company signs a three year time-charter contract for a semi-submersible rig at very high rates per day and then shortly after the oil price drops, then the oil company has strong incentives to default on the contract. This actually happened in the mid 1980s, but there are other famous forward contracts where one of the parties has defaulted. Perhaps the most famous one was Coca Cola which in the early part of this century made a forward agreement with their bottlers to supply them with cola syrup at a fixed price forever! As they could not live with this contract, Coca Cola defaulted on the forward contract, but managed through a lot of legal dispute to substitute it with a contract with an inflation-escalator clause.

A futures contract is similar to the forward contract, but with important modifications. Transactions for futures contracts take place on financial exchanges. As with a forward contract a futures contract will be tied to an underlying instrument. The main differences between the forward and the futures contracts are:

- With a futures contract, the seller can choose to deliver any day of the delivery month;
- With a futures contract, both the seller and the buyer can nett out their positions by a purchase or a sale, in which case no actual delivery needs to take place;
- The prices of a futures contract are *marked to the market* on a daily basis. This means that the margins from day to day are settled on a daily basis;
- The futures contract is standardised.

The Wall Street Journal lists every day a long series of futures contracts:

- About 25 contracts for grain, oilseeds, livestock, food, fibre and wood;
- About 10 contracts for metals and petroleum;
- About 20 contracts for various financial instruments (currencies, bonds, etc.);
- About 5 contracts for financial indexes like the S&P 500 Index or the NYSE Composite.

Chicago is a main city for futures contracts (Chicago Board of Trade - CBT, Chicago Mercantile Exchange - CME , International Money Market in Chicago - IMM) and so are New York (New York Cotton Exchange - CTN, Financial Instrument Exchange in New York - FINEX, New York Mercantile Exchange - NYME, New York Futures Exchange - NYFE) and London (London International Financial Futures Exchange - LIFFE).

Futures contracts are handled on exchanges. The contracts are standardised with detailed specifications of

- The deliverable instrument - the underlying asset;
- Contract size;
- Delivery arrangements;
- Delivery months;
- Price quotes;
- Daily price movement limits;
- Position limits.

Price movement limits are specified by the exchange. Oil futures typically have a limit of 1 US$. If the price moves up or down to this limit, the contract is said to be limit up or limit down and trading ceases for the day. This has been made to prevent large price movements due to speculative excesses. The position limit has the same motive - to prevent speculators to hold too many contracts.

The main characteristic of a futures market is the marking to market mechanism. An example can illustrate this. **Table VI** could have been a quote from the Wall Street Journal on September 12, 1996.

FUTURES PRICES

WHEAT (CBT) 5,000 bu.; cents per bu.

						Lifetime		Open interest
	Open	High	Low	Settle	Change	High	Low	
Sept	411	4161/4	407	407	-61/4	421	272	423
Dec	427	4321/4	422	4231/4	-51/2	4321/4	289	47,454
Mar x7	4301/2	436	4261/2	427	-41/4	436	323	42,823
May	409	4431/2	404	405	-51/2	420	330	3,422
July	375	3761/2	369	3703/4	-63/4	395	327	4,805

Table VI

This wheat contract is traded at the Chicago Board of Trade with a contract size of 5,000 bushels (a dry measure of 8 gallons, or 35.24 litres (US)), the prices being in cents per bushel and the trading months are September, December, March, May and June. The line for the September contract says that the first trade of the day started at US$ 4.11, reached a high level of US$ 4.1625 and a low level of US$ 4.07 where the contract closed, or settled that day. This was US$ 0.0625 down from yesterday, where the closing price must have been US$ 4.1325. Since this is in August, the contract has been trading for less than a year and the overall high has been US$ 4.21 and the low US$ 2.72. Finally we learn that the number of contracts outstanding (open interest) is only 423 (compared to more than 40,000 for the December and March contracts).

Suppose we buy 20 contracts at the price US$ 4.07 on this Thursday, 12 September. We are now in a position to ask for delivery of 100 bushels of wheat on any remaining day of September. Assume we do this on Monday 16 September after the price has developed as follows:

- Friday US$ 4.05
- Monday US$ 4.12

When we buy the contract, an account must be opened with a broker, who is commissioned by the Clearinghouse of the exchange to handle margin settlements. He demands an initial margin. This could be 5-10% of the total contract amount. Our purchase has a value of US$ 407,000 (4.07*5,000*20), so assume we deposit US$ 20,350 as an initial margin. On Friday the price goes down and we will have to pay 2 cents per bushel to our margin account within one business day, i.e. US$ 2,000. On Monday the price has gone up to US$ 4.12, and the broker will make sure that money is transferred from the Clearinghouse to our margin account. Since the price is up 7 cents per bushel, US$ 7,000 is credited our margin account. Assume that we decide to take delivery of the wheat on this day. We then have to pay US$ 4.12, or a total of US$ 412,000 to get the 100,000 bushels of grain. Since we are on the buying side of the contract, a seller must provide the wheat. On exchanges with high volumes, buyers and sellers are chosen at random by the Clearinghouse to either take delivery or provide the underlying commodity.

This is already paid US$ 20,350 in initial margin, we actually pay US$ 391,650 for the wheat on Monday (412,000-20,350). The total price for the wheat is thus (we have assumed no commission to the broker and disregarded interest on the margin account):

$$407{,}000 = 20{,}350 + 2{,}000 + 391{,}650 - 7{,}000$$

or exactly US$ 4.07 per bushel as the price was on Thursday 12. The system of marking to market through the daily settlements has the important function of reducing the risk that one of the parties will default on the contract, since there is no accumulation of loss.

The futures markets play an important role for speculators, and can serve as a price forecasting instrument, but the primary function is as an instrument to secure prices.

14.8 BIFFEX

The most important futures market in shipping is traded at BIFFEX - The Baltic International Freight Futures Exchange - in London, which since 1991 has been merged with London FOX (London Futures and Options Exchange). Unlike the commodity futures, the Freight Future on BIFFEX does not have a deliverable instrument. Instead, what is traded is a contract based on the Baltic Freight Index (BFI), which was briefly explained in section 7.1. The value of the index is published every day on the basis of freight rate estimates submitted by a panel of shipbrokers to the BIFFEX-committee.

The index is assigned a money value and this is what is delivered. There are no actual deliveries of freight services taking place, only the money equivalent of the freight market level.

The contract is defined in terms of 'lots' of US$ 10 per point of the BFI. If the BFI stands at 1050, then one lot is worth US$ 10,500.

The times of delivery at BIFFEX are defined as January, April, July and October up to two years forward. In addition trading can take place spot (current month) or prompt (next month). Last trading day is the last working day in the month of delivery, settlements take place on the first work day after the last trading day, and the settlement price is based on an average of the 5 last days of trading.

Since no physical delivery of transport services takes place, the usefulness of trading on BIFFEX will depend on how closely the real world transport problem is correlated with the BFI. Although the BFI has been constructed (and revised several times) to be a good overall index, it is slightly biased towards grain, Panamax size of vessels and Atlantic basin. Each trader on BIFFEX must in principle calculate the correlation between the BFI and the actual trade that is under consideration.

Hedging a spot contract on the BIFFEX

Hedging simply means to actively try to reduce the risk exposure. The opposite is speculation, where risk normally is enhanced.

The buyer of a futures contract is said to take a long position, or a long hedge, while the seller of a futures contract takes a short position, or short hedge. A couple of examples of how to use the BIFFEX might be instructive.

A shipowner has fixed a ship and the ship will be redelivered at the end of January. The freight market is presently good, but the general sentiment is that the market will go down. Charterers, therefore, hesitate to fix for January now, they rather wait and see the freight rates go down. Besides, the shipowner is not sure about the exact date at which the ship will be open. The shipowner wishes to cover the risk of a future decline of the freight market by means of a hedge via BIFFEX. This means he will have to go short and sell futures contracts.

The ship is a 60,000 dwt Panamax bulk carrier, fixed on the route US Gulf to ARA range (Antwerp-Rotterdam-Amsterdam) at US$ 9,225 per tonne. The BFI today stands at 1067.5, while the price of the January future is 1210.

The relation between the real spot freight rate and the BIFFEX freight rate, called implied freight rate, is calculated as follows:

- Implied freight rate is: (1210/1067.5) * US$ 9,225 = US$ 10.46 per tonne
- The freight risk of the shipowner is: 60,000 tonne * US$ 10.46 = US$ 627,000
- The number of future contracts the shipowner has to sell is:
  US$ 627,000 / (1210 * US$ 10) = 51.9 or 52 contracts.

Suppose that the market deteriorates, indeed towards January, and the shipowner fixes his ship at the end of January for US$ 8 per tonne, while the BFI stands at 1070. The selling of the futures at 1210 gives a profit per contract of (1210-1070)*US$ 10 = US$ 1,400, but the shipowner must also pay some commission to the broker (this can vary from US$ 20-US$ 40 per contract). Assuming a commission of US$ 25 per contract, the nett account for the shipowner will be:

- The shipowner loses in the physical market (relative to the lock-in price of US$ 9,225): 60,000 * (US$ 8 - US$ 9,225) = - US$ 73,500
- He makes a profit on his futures of: 52 * (1210 - 1070) * US$ 10 = US$ 72,800
- Commission cost of the BIFFEX contracts: 52 * US$ 25 = - US$ 1,300

The total loss is US$ 2,000 (-73,500 + 72,800 - 1,300), while without the hedge this would have been US$ 73,500.

More often it is the income per day that shipowners wish to secure. In the beginning of the 1990s when the BFI fluctuated around 1600 and the bunker costs accounted for about 20% of the total costs, a rule of thumb was developed that the BFI minus 300 points multiplied by US$ 10 would give the TC-equivalent of the index. This could be used to check the hedge level of the BIFFEX. An example may be instructive.

A shipowner has in March a Panamax bulk carrier of 64,000 dwt which will be open for another 4-month contract in July. Assume that the current BFI is 1500, then this corresponds to a TC-equivalent of US$ 12,000 per day (1500-300)*US$ 10. Assume further that the July BFI stands at 1650. This corresponds to a TC-rate of US$ 13,500, which the owner finds attractive. He wishes to 'lock in' this rate for a period of 120 days, as he fears the market will actually go down.

The difference between the current market and the implicit TC-rate for July is US$ 1,500 (13,500-12,000). For a 4-month period this corresponds to an income differential of US$ 180,000 (120*1,500). As the difference between the current BFI and the July level is 150, each contract has a differential value of US$ 1,500. The owner must, therefore, sell 120 contracts to lock in this US$ 180,000.

If the market in July has gone down to a level of US$ 11,000 per day and the BFI is 1400, the shipowner will stand to loose US$ 1,000 per day compared to the current market level of US$ 12,000 per day, so for another four months contract he 'loses' US$ 120,000. On the other hand he can sell his July contract for a BFI level of 1650, while the actual market is 1400, so the differential is 250, or US$ 2,500 per contract. As he can sell 120 such contracts, a profit of US$ 300,000 is made on the futures contracts, so the total gain is US$ 180,000 (minus commission). If the market goes up instead, he will loose on the futures, but get a higher than expected contract in the market, which just about offsets each other. In this case he would have been better off not selling the futures, but the point is that it is price security you get in the futures market, and this he has achieved.

14.9 Bunker hedging

The oil majors offer the shipowner the instrument of the *fixed price swap*, in combination with a *price protection option* in order to lock in the bunker costs to a fixed oil price over a fixed period of time for a fixed volume. Through the payment of a price protection premium to the oil company, the shipowner will not pay more for his fuel oil even if the price of oil increases steeply within the agreed period. An example will illustrate the hedging instrument.

A shipowner pays the price protection premium to the oil company in return for protection at a ceiling price; e.g. US$ 80 per metric tonne for a quantity of 20,000 tonne per month during the year 1990. The premium is US$ 6 per month or US$ 6 * 12 months * 20,000 tonne = US$ 1,440,000 in total for the year, to be paid on January 5th of 1990.

Figure 5 shows a graph with the price development of HSFO NWE Cargoes CIF from Platts. The shipowner who hedged his bunker needs for a fixed price of US$ 80 per month, 'lost' the premium during the months May/July, but this was compensated by lower prices, while he saved a phenomenal amount of money during the months August/December in the order of magnitude of US$ 40 per month, 5 months * 20,000 tonne * US$ 40 = US$ 4,000,000. These savings are much more important than the costs of the premium. Note that the price protection option works well with a volatile oil market.

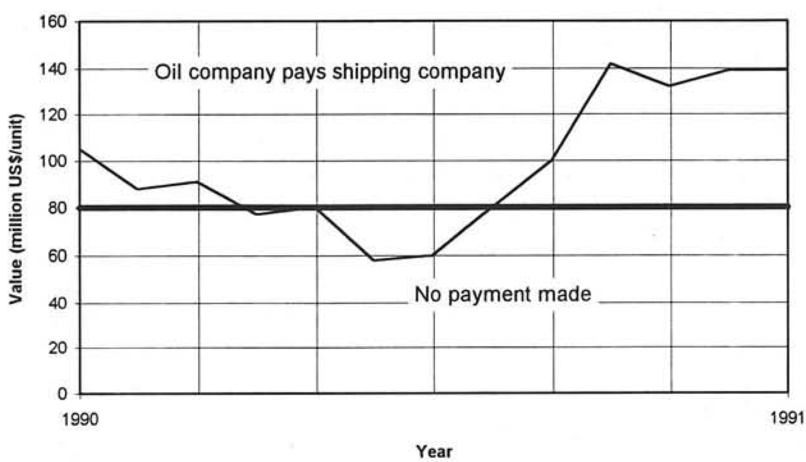

Figure 5: Price development of HSFO NWE Cargoes CIF from plats

14.10 Options

An option is a right, but not an obligation, to buy or sell an asset at a fixed price on or before a given date. The holder of an option will use his option only if it is smart to do so, otherwise the option can simply be thrown away. This is a very important feature compared to forward and futures, where delivery is expected to take place irrespective of whether one of the parties are losing.

There is a special vocabulary associated with options. Some important terms are:

- *Exercising the option* - the act of buying or selling the underlying asset via the option contract;
- *Striking (or exercise) Price* - the fixed price in the option contract at which the holder can buy or sell the asset
- *Expiration date* - the maturity date of the option. After this date, the option is dead;
- *American vs. European option - A*n American option can be exercised anytime up to expiration date, while a European option can only be exercised on the expiration date;
- *Call option* - the right to *buy* an asset at a fixed price at a specified time;
- *Put option* - the right to *sell* an asset at a fixed price at a specified time.

14.10.1 Traded options

The most common option is the option on a common stock. A buyer of a European call option for a particular share at an exercise price of, say US$ 100 will at expiration day exercise his option only if the share at that time is worth more than US$ 100, otherwise he will not use the option. **Figure 6** shows the value of the options at expiration dates for both buyers (long position) of puts and calls and sellers (short position) of puts and calls.

If these option positions are combined with a position in the actual asset, a multitude of different payoff profiles can be created. Some of the more popular trading strategies are just briefly mentioned below. It is way beyond the scope of this chapter to go into details about option trading, which is a highly specialised business.

- *Bull spread* - the combination of a short and long call, where the short call has a higher strike price, used when prices are expected to increase;
- *Bear spread* - the opposite of bull, used when prices are expected to fall, and is a combination of a short and long call, where the long call has a higher strike price;
- *Butterfly spread* - involves three options with different strike prices: a long call with low strike price and long call with high strike price, then to short calls with a strike price halfway between the two others;
- *Straddle* - a combination strategy of going long in both a call and a put in the same stock with the same exercise price;

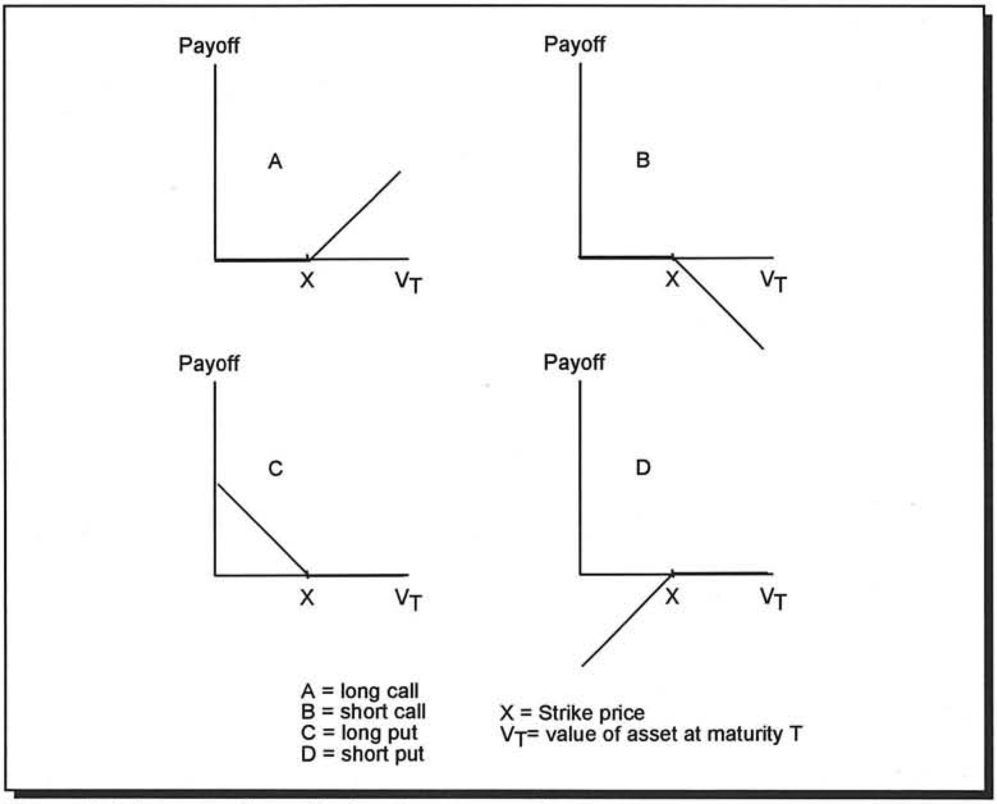

Figure 6: The pay-off profile for European options

- *Strip* - a combination of long call and two long puts;
- *Strap* - a combination of two long calls and one long put;
- *Strangles* - a combination of long call and long put, but with different strike prices.

Some possible guidelines for when the various strategies should be used are illustrated in **Figure 7**, where the highly specialised terminology is obvious.

14.10.2 Real options in shipping

Options are not only those traded at stock exchanges. In shipping options are quite common:

- Consecutive voyages for spot contracts;
- Time charter options;
- Time charters with purchase option for the vessel;
- Newbuilding options;

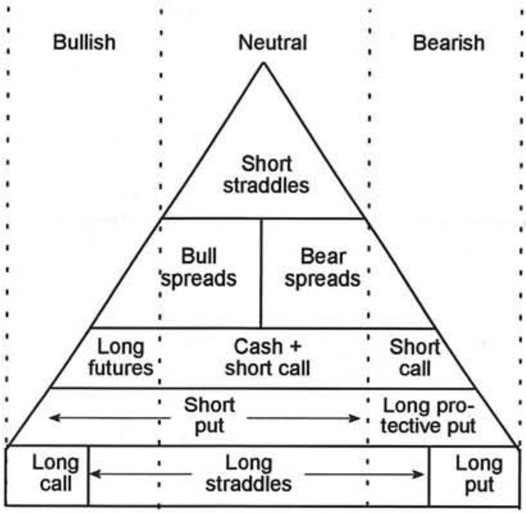

Figure 7: Trading strategies for options

Such options are normally called real options as opposed to traded options.

Furthermore, strategies for lay-up, the prolongation of the vessel's life or even scrapping can usefully be studied by thinking in terms of options. New theories for the so-called contingent claims analysis has a great potential in these areas.

14.10.3 Option on future freight rate

To see some of the principles involved, a simple example could be instructive.

Assume that we have a shipowner and a charterer with a spot contract for one period, where the TC-equivalent of the spot rate is US$ 14,000.

Assume for simplicity that we set the risk-free interest rate to 0, and that we only consider two periods.

The current TC-rate for the two periods is US$ 13,600, but the spot rate for period 2 is unknown. For simplicity, assume that the spot rate in period 2 will be either US$ 16,000 or US$ 12,000 with equal probability.

Suppose the owner and the charterer are considering the following option contract:

The contract gives the charterer a right, but no obligation, to have the ship at his disposal in the second period for a rate of US$ 14,000. The option must be declared by the end of the first period.

Using the terminology from the option theory, this deal is a long, European call on the future freight rate with maturity one period and a strike price of US$ 14,000.

The problem is: How much is such a contract worth for the charterer, or put differently: How much more (option premium) can be paid over and above the spot rate in the first period for this option contract?

To answer this, a careful look at the potential cash flows is necessary. If the option is exercised, the charterer could relet the ship in the spot market to the higher rate and cash in the difference between the strike price and the market price. If the spot rate is lower than the strike price, the option will not be exercised.

A decision tree as in **Figure 8** illustrates the problem.

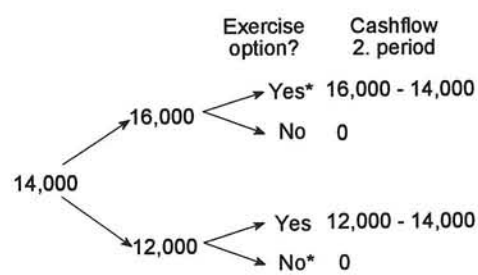

Figure 8: Decision tree for the option problem

It is clear that the charterer will only exercise the option if the freight rate increases, and then the cash flow in the second period is US$ 2,000.

To calculate the price the charterer should be willing to pay today (before knowing the spot rate in the second period) the principle is that equal cash flows should be equally priced in a well functioning market.

There are two ways one could calculate this. One approach would be to make a 'homemade' option strategy, using available instruments to create an identical stochastic future cash flow. The cost of this strategy would give the price of the option. The other method would be to calculate the cash equivalent by adjusted probabilities.

A possible homemade option that will duplicate the cash flow, is:

- Hire half a vessel on TC for two periods;
- Relet half a vessel spot in each period;
- Combine this with one-periodic, risk-free money transfer to get the duplication.

In our case this will look like **Table VII**.

	First period	Second period	
Strategy element		Rate up	Rate down
Hire in 1/2 ship TC	-6,800	-6,800	-6,800
Relet 1/2 ship spot	+7,000	+8,000	+6,000
Lend risk free	-800	+800	+800
Portfolio	-600	+2000	0

Table VII: The result of a duplicating strategy

This strategy might look strange, but has been constructed so that the cash flow is identical to the option. To get this cash flow in the second period, the cost in period one is US$ 600. This must then be the highest price that the charterer would be willing to pay for the option.

An alternative method is to use risk adjusted probabilities. This can be fairly complicated, but is easily applied to this example. Consider now an alternative strategy:

- Hire one vessel on TC for two periods;
- Operate the vessel spot in both periods;
- Make risk-free money transfers so that cash flow in the first period is 0.

The resulting strategy is shown in **Table VIII**.

	First period	Second period	
Strategy element		Rate up	Rate down
Hire in 1 ship TC	-13,600	-13,600	-13,600
Relet 1 ship spot	+14,000	+16,000	+12,000
Lend risk free	-400	+400	+400
Portfolio	0	+2,800	-1,200
Probability		P	(1-p)

Table VIII: The result of a strategy with cash flow = 0 in the first period

To get comparable cash flows, the security equivalent of the cash flow in the second period must be equal to the first period, where it is 0. The risk adjusted cash flow in the second period will thus be:

$$2{,}000 * p + (-1{,}200) * (1 - p) = 0$$

$$p * (2{,}800 + 1{,}200) = 1{,}200, \text{ so}$$

$$p = 0.3$$

This risk adjusted probability for rate increase can now be used to calculate the option value:

$$+2{,}000 * p + 0 * (1 - p) = 600$$

just as expected.

Contingent claims analysis is also applicable to much more complex situations. The critical set of assumptions for the analysis to have practical value, is the assumption regarding freight rate processes. In the example above only two alternatives are given. In practise more complex processes are often used.

14.10.4 Evaluation of options

The most famous formula for evaluation of options is the so-called Black-Scholes formula for the prices of European calls and puts. This looks fairly complicated, but is of great practical value. The formula for a European call is:

$$C = S * N(d_1) - X^{e^{-rT}} * N(d_2), \text{ where}$$

$$d1 = \frac{\ln \frac{S}{X} + (r + \frac{s^2}{2}) * T}{(s * T^{0.5})}, \text{ and}$$

$$d2 = d1 - s * T^{0.5}$$

Where:

S = The stock price
X = The exercise price
r = The risk-free interest rate
T = The time to expiration
s = The standard deviation (volatility) of the stock price and N(z) is the cumulative probability function for a standardised normal variable.

Essentially, the Black-Scholes formula is based on the assumption that the stock value follows a log-normal diffusion process (Geometric Brownian motion). Several studies have indicated that this is not a good representation of the freight rate processes. Freight rates are highly volatile, and freight rate levels move in cycles. That means that when freight rates are very high, the probability of a lower rate in the next period is higher than the probability of getting a higher rate. Shipping is therefore, more characterised by a price development where freight rates are drawn towards a long run equilibrium situation (break even rates for newbuildings). Such rate processes are normally called mean reverting processes.

Let dz(t) be the increment of a standard Brownian motion. A rate process R(t) will in the case of a log-normal distribution be

$$dR(t) = u\,dt + s\,dz(t)$$

where:

u = The expected drift term
s = The volatility

A mean reverting process, like the so-called Ornstein-Uhlenbeck process would be

$$dR(t) = k(a - R(t))\,dt + s\,dz(t)$$

where k > 0 is the factor pulling the rate back towards the equilibrium level a, and s is the volatility.

Unfortunately, this particular formulation of the rate process, although it performs better that the simple Brownian motion, does not perform too well in empirical studies of shipping freight rates. This is an area of research still in its infancy, but there is no doubt that in the future contingent claims analysis and options will play an important role in giving the shipping industry better tools for the handling of risk. The chapter notes give some hints for further readings.

CHAPTER 15: INVESTMENTS, FINANCE AND STRATEGIES IN SHIPPING

Shipping is a highly volatile business. To have success in shipping, timing is everything. A ship purchased at the right time has laid the foundation for fortunes, ships purchased at the wrong have been the end of many companies. **Table I** indicates the problem. It shows the nett discounted value of tankers delivered in the years 1970-74. The calculation is based on the assumption that the vessels were traded in the spot market for 20 years after delivery at current rates. For comparison, the third column contains the ship prices two years earlier, assuming a delivery time of 2 years. The table speaks for itself, timing is indeed essential.

Delivered	NPV US$/dwt	Price US$/dwt	Ordered
1970	154	63	1968
1971	97	71	1969
1972	74	100	1970
1973	71	129	1971
1974	-5	129	1972

Table I: The essence of timing - tanker deliveries

Shipping is also a highly cash flow oriented business where cash is the king. An important element in any cash flow is the financing of the ship. A high mortgage on a ship places heavy burdens on the cash flow. The history of shipping is very much the history of mismanaged cash flows and banks losing money. A very brief look at the history of ship finance might be instructive.

15.1 Ship finance in the past

The history of ship finance in the postwar period can crudely be divided into some sub-periods:

1950-67 Banks are getting interested in shipping;
1967-73 A ship lending boom;
1973-77 Problem loans are troubling the market;
1977-87 A decade of careful bankers;
1987-91 A wave of creative financing.

1950-67 Banks are getting interested in shipping

Particularly after the Korean War, when many shipowners earned a lot of money, banks started to become very interested in shipping, to the extent that some banks developed shipping finance as one speciality. Banks like First National City Bank (now Citibank), Chemical Bank, Chase Manhattan Bank and Hambros Bank were specialist banks for shipping at that time. They were all basically conservative asset financiers, so the main structure of financing was 50% of the value of a ship against a first mortgage, as long as the ship was not older than five years. Leading banks dealt mostly with customers they knew well.

In the mid 1950s, the Stirling Pound started to loose credibility and the Suez crisis dealt the major blow to the confidence in Stirling. Hambros started to build up a dollar deposit to be able to continue ship finance, and this was important in the development of the Eurodollar market.

In the early 1960s capital requirements started to become a problem although shipyards could offer credit. As this was not backed by governments as later became the model, a new market developed where the commercial banks provided newbuilding finance on behalf of the shipyards. From 1964 onwards, the world shipbuilding industry expanded at a rate the world had never seen and eventually ended 10 years later with a capacity much too large for the needs of the shipping industry.

In the slump of 1966-67, many banks learned a lesson on the volatility of the shipping industry, but this was soon forgotten when Israel and Egypt started war and the Suez Canal was bombed.

1967-73 A ship lending boom

The incredible rate increases in the aftermath of the Middle East war and the very high demand growth rates of the late 1960s made almost every bank wanting a piece of the shipping cake. The majority of the new banks entering the scene were without any prior background in shipping, so the quality of much of the ship lending was really poor as the banks lacked the necessary competence to evaluate the assets.

A lot of lending was based on 'names' - any leading shipowner could acquire large funds simply because of reputation. All of this eventually created an atmosphere of overconfidence. In the Norwegian market newbuildings were the big thing and vast amounts were committed to newbuilding projects. Hilmar Reksten was one of the leading persons ordering large tankers.

In Greece the investments were concentrated on secondhand vessels, where a number of young would-be shipowners tried to buy ships cheaply and fixing them for periods long enough to satisfy the banks. This so-called cash flow financing became a speciality of First National City Bank, which set up an office in Piraeus.

As long as the bank felt safe that repayment was secure, the bank was flexible in their lending, even to one-ship companies.

In Japan the so-called 'Shikumi-Sen' deals contributed greatly to the shipbuilding programme of Japanese yards. The deals were set up to avoid the problem of costly Japanese crews and involved three parties: The Japanese Trading houses, Hong-Kong shipowners and Japanese shipyards. By offering long term charters, often 15-20 years, ships were built in Japan and operated by Hong-Kong owners. The vast fortunes of Yue-Kong Pao were built on 'Shikumi-Sen' deals.

1973-77 Problem loans are troubling the market

After the oil price shock, the walls came tumbling down and it took only a very short period before many companies were in deep trouble. The first to fall was Hilmar Reksten - the most expansive of the Norwegian owners, but also Havtor, Fearnley & Eger and other companies saw their equity gone in a short period of time.

Norwegian owners were hit hard, as they had mostly been engaged in newbuildings. The problems spread all over the industry, however, and companies like Court Line, Maritime Fruit Carriers and the Greek owner Colocotronis caused many banks to bleed.

1977-87 A decade of careful bankers

In 1976-77 a number of banks left the industry completely and the whole industry changed character. So many left ship finance in the years immediately after the crisis in 1974 that in 1982 very few persons fully, employed in ship finance, had an experience of more than 10 years.

The 1979-80 period saw some high rates and some firmly believed that the problem years in shipping were just about over. Again some banks began competing on cutthroat terms, and one US bank, Colonial Bank, lost a lot of money in 1982 when the small boom quickly disappeared.

The period is mainly one of more caution and generally planning for recovery, however.

1987-91 A wave of creative financing

Following the sharp increases in shipbuilding prices (as discussed in chapter 4), the secondhand prices rose sharply and steadily from 1987 and gave rise to a series of investments, mainly concentrated on the Norwegian market. More than 50% of the sales and purchases in this period, had Norwegian participants. This was due to a combination of several factors. An important factor was increasing secondhand values, combined with a most favourable Norwegian tax system, in particular for the so-called K/S (kommanditt-selskap). The K/S is a type of limited partnership where the partners only need to put up a small amount of the total project costs up front, but can enjoy tax benefits from the total cost of the project. If the project goes according to plan, no more capital will be called in, so with little equity, large projects can be financed and the tax benefits are great. At this time the Norwegian government launched the Norwegian International Ship register (NIS), which also contributed to the general optimism in the market. The expansion period lasted until 1990-91, where the K/S system more or less collapsed. In addition to the traditional shipping investor, a number of corporate investors and private persons without shipping experience, joined the race and a number of intermediaries started project finance on a large scale. Many projects should never have been undertaken, and when problems started, the K/S-participants found out that their liability was still for the total project cost and capital had to called in on a large scale for many projects. Eventually the Norwegian government introduced a new tax system in 1991 which made the K/S much less attractive and the K/S market collapsed. Still, one believes that the K/S system managed to raise some US$ 3 billion in the period 1986-89.

15.2 Ship finance today - the options

Without going into detail about all possible sources of finance, the list below indicates the possibilities.

- Bank loans;
- Non-bank lending;
- Subsidies and shipyard credit;
- Subordinated debt (ranks after major debt, but before equity);
- Corporate finance (as opposed to project finance);
- Securitisation of debt (the conversion of asset-backed income into packages of securities, which are offered to investors);
- Leasing;
- Equity finance.

There is more focus in recent years on how shipping can broaden the financial base, and particularly how shipping can be made more attractive in relation to equity finance. Going public is more often considered by privately owned companies, often in combination with a merger to consolidate a shipping segment.

Leasing is also becoming more interesting. A finance lease is comparable to a bareboat charter. The lender, or the lessor (often a leasing specialist or a big bank) purchases the title to the vessel in question and sells this right to the borrower (the lessee) in exchange for a regular and equal payment. Sometimes leasing arrangements function as an off-balance-sheet finance, whereby the borrower can raise more money on a given equity base.

Financial creativity, which often is the same as combining various financial instruments with charter contracts, is going to play a more important role in shipping finance in the future.

Often it is argued that ship finance will be a major restriction for shipping, in later years this has been a standard discussion on seminars focussing on the renewal of the tanker fleet. History indicates that ship finance will not be a problem if the prospects for the industry are good enough. More often than not, good projects are the main limitation for shipping, not lack of finance.

Example of a sale and charterback deal

The following is an example of how one can combine a finance scheme with a charter scheme. It involves the sale and charterback of nine refrigerated cargo vessels to be chartered by PPI Del Monte Fresh Produce B.V., March 1990

The summary of principal terms of the sale and charterback transaction are shown

Charterer

PPI Del Monte Fresh Produce BV ('PPI Del Monte'), a Netherlands corporation, or one more wholly owned subsidiaries of PPI Del Monte. PPI Del Monte is a wholly owned subsidiary of Polly Peck International, PLC ('PPI').

Shipowner

A special purpose corporation or ownership trust to be created solely for the purpose of this transaction and to be owned beneficially by the Participants. The Shipowner will be organised or created under the laws of a jurisdiction selected by the Participants and acceptable to PPI Del Monte.

Participants

One or more financial institutions to be selected by PPI Del Monte with the assistance of the First Boston Corporation and Merrill Lynch Capital Markets, acting as financial advisors to PPI Del Monte.

Other parties

Other parties, such as residual value insurers, may be included in the transaction depending upon transactional structures proposed by prospective Participants.

Vessels

Nine new refrigerated cargo vessels (the 'Vessels') designed to carry palletised and containerised cargo and presently under construction, or recently delivered, by Astilleros Espanoles S.A. (the 'Shipbuilder'), an experienced builder of refrigerated cargo vessels located in Seville, Spain.

Vessel class	No. of vessels	Capacity (Cubic feet)
Planter Class	4	374,000
Trader Class	2	571,000
Pride Class	3	571,000

Vessel cost

The cost of the Vessels will approximate the current appraised fair market value, which will be subject to verification by an appraisal prepared by an independent appraiser selected by PPI Del Monte and reasonably acceptable to the Participants. The approximate cost (plus or minus 10%) of the Vessels is as follows:

Vessel class	Cost per vessel (million US$)	No. of vessels	Approximate total cost (million US$)
Planter	21.0	4	84.0
Trader	28.0	2	56.0
Pride	29.0	3	87.0
			227.0

Vessel delivery dates and transaction closing dates

The delivery date of each of the nine Vessels and the anticipated closing date of the sale and charterback transaction with respect to each of the nine Vessels are as follows:

Hull no.	Vessel class	Date of delivery by Shipbuilder	Transaction closing date
270	Planter	09/20/89	06/12/90
271	Planter	10/18/89	06/12/90
272	Planter	01/25/90	06/12/90
273	Planter	02/28/90	06/12/90
50	Trader	02/28/90	06/12/90
51	Trader	03/31/90	06/12/90
278	Pride	09/30/90	09/30/90
279	Pride	11/30/90	11/30/90
280	Pride	01/31/91	01/31/91

On the closing date for each Vessel, the Shipowner will purchase the Vessel from PPI Del Monte and will charter the Vessel to PPI Del Monte under a bareboat charter.

Interim charter period

There will be an interim charter period, if necessary, commencing upon delivery and expiring on a date within six months of delivery designated by the Participants.

Base charter period

The charter will have a base charter period of at least 10 years and not more than 16 years, commencing on the closing date for the Vessel or, if applicable, on the expiration of the interim charter period.

Charter hire

PPI Del Monte will pay charter hire to the Shipowner semiannually during the base charter period.

Currency of payment

Charter hire and payments of, or determined by reference to, termination value or stipulated loss value will be payable in USdollars.

Interim charter hire

Charter hire will be payable for the interim charter period, if any, determined by using the daily equivalent of the charter hire for the base charter period.

Charter hire adjustments

Before the closing date for each Vessel, the charter hire, stipulated loss values and termination values for the Vessel may be adjusted to reflect changes in the following pricing assumptions for the bareboat charter of the Vessel: (i) the assumed closing date, (ii) the assumed Vessel cost, and (iii) the assumed transaction costs. If as a result of any such adjustments, the present value of the adjusted charter hire (discounted at 13% per annum) is more than 15 basis points higher than the present value of the charter hire as originally determined, PPI Del Monte may cancel the commitments of the Participants with respect to that Vessel, without any cost or further obligation of PPI Del Monte.

Charterer's mid-term termination option

On a specified date before the expiration of the base charter period, but no earlier that the eighth anniversary of the closing date for any Vessel, PPI Del Monte will have the right to terminate the bareboat charter of the Vessel and return the Vessel to the Shipowner. Concurrently with the return of the Vessel, PPI Del Monte will make payment of all regular hire accrued to the date of termination, and not theretofore paid, and any other guaranteed payments that are required by the Shipowner as a result of a shortfall, if any between the fair market sales value and the termination value of the Vessel. Upon payment of those amounts, PPI Del Monte will have no further obligation with respect to the Vessel.

In the event that PPI Del Monte exercises its option to terminate the bareboat charter of the Vessel and the fair market sales value exceeds the termination value of the Vessel, PPI Del Monte and the Shipowner will share, in accordance with a sharing arrangement to be negotiated, the excess residual proceeds.

Sale of Vessels at end of charter period

At the expiration of the base charter period for each Vessel, PPI Del Monte, as agent for the Shipowner, will sell the Vessel on behalf of the Shipowner and will be entitled to receive as a remarketing fee an amount equal to 99% of the amount, if any, by which the nett proceeds of sale of the Vessel exceed the termination value or any other guaranteed payments required by the Shipowner.

Redelivery

At the expiration or earlier termination of the base charter period with respect to each Vessel, PPI Del Monte will return the vessel to the Shipowner (or, if the Vessel has been sold, to the purchaser) at a port to be designated by PPI Del Monte and reasonably acceptable to the Shipowner (or the purchaser, as the case may be) in good working order and repair, ordinary wear excepted, and 'in class' without outstanding recommendations.

Option to extend base charter period

To be negotiated

Nett financing

Each bareboat charter will be a 'nett lease' under which PPI Del Monte will be responsible, on a hell-or-high-water basis (subject to customary exclusions and contest rights), for all the costs and expenses of operation, ownership and maintenance of the Vessels during the charter period, except for certain taxes, which are discussed below (see Indemnification).

Registration

The Vessels will be registered in the name of the Shipowner under the laws of Liberia or another jurisdiction selected by PPI Del Monte and reasonably to the Participants.

Use

PPI Del Monte will have the unrestricted right to use each Vessel in worldwide trading in any lawful manner and will have the right to subcharter each Vessel to any subcharterer PPI Del Monte may select, provided that PPI Del Monte will not be relieved of any of its obligations under the bareboat charter as a result of a subcharter. PPI Del Monte will maintain logs of the location of each Vessel in accordance with the same procedures PPI Del Monte uses for other vessels which it operates.

Maintenance and repair

PPI Del Monte will maintain each Vessel in good operating order, repair and condition, ordinary wear excepted, in accordance with the same standards as those PPI Del Monte uses in the maintenance and repair of similar vessels, which it owns or charters. PPI Del Monte will also keep each Vessel 'in class'.

Improvements

PPI Del Monte will have the right to make severable improvements or additions to the Vessels, provided that the improvements and additions are removable without causing material damage to the Vessels, and may remove any or all of those improvements or additions in the event of early termination or at the expiration of the charter period. PPI Del Monte also will have the right to make nonseverable improvements or additions to the Vessels and will have the right to finance any such nonseverable improvements or additions through the Shipowner or otherwise, as long as such nonseverable improvements do not diminish the value or utilisation of the Vessels.

Insurance

PPI Del Monte will maintain casualty insurance on each Vessel in an amount which PPI Del Monte, in its reasonable judgment, considers prudent and at least equal to the amount of coverage PPI Del Monte maintains for similar vessels which it owns, subject to standard industry deductibles. If such casualty insurance becomes unavailable or available only on terms which PPI Del Monte, in its reasonable judgment, considers uneconomic, PPI Del Monte will have the right to self-insure for casualty. PPI Del Monte also will maintain protection and indemnity insurance with respect to each Vessel, subject to deductibles that are consistent with the terms of insurance covering vessels owned by PPI Del Monte.

Event of loss

If a vessel suffers an actual or constructive total loss or if title to a Vessel is requisitioned by any governmental authority, PPI Del Monte will be required to pay the Shipowner a stipulated loss value payment in the amount necessary to return to the Participants their unrecovered investment and to preserve their expected economic return to the date of termination of the bareboat charter with respect to the Vessel suffering the event of loss.

Indemnification

PPI Del Monte will pay or reimburse the Shipowner and the Participants for all incremental liabilities, expenses, fees and taxes imposed by any governmental authority of any jurisdiction which would not have been imposed or asserted but for the Vessel financing transaction, subject to customary exclusions and contest rights. PPI Del Monte will not be required to pay or identify for any taxes or other governmental charges on, with respect to or measured by the net or gross income, capital, nett worth or gross receipts of the Shipowner or any participant, and will not be required to pay any other taxes or other governmental charges incurred by the Shipowner or any participant other than as a result of an act or omission of PPI Del Monte. PPI Del Monte generally will be responsible for filing any returns required with respect to indemnifiable taxes and will have the right to contest, or to require the Shipowner or the Participants to contest, any disputed liability to pay an indemnifiable tax.

Appraisal

Before the closing date for each Vessel, an appraiser selected by PPI Del Monte and reasonably acceptable to the Participants will prepare an appraisal in form and substance satisfactory to PPI Del Monte and the Participants with respect to the Vessel.

Events of default

The bareboat charter will contain certain limited events of default consisting of payment default after written notice and a five-business-day cure period, certain insurance and representation defaults after notice and reasonable grace periods and customary bankruptcy defaults. The bareboat charter will not contain any operating or financial convenants relating to PPI Del Monte, nor will the bareboat charter contain any events of default relating to defaults on or acceleration of any other indebtedness of PPI Del Monte.

Transaction costs

The following fees and expenses will be included in the total cost of the Vessels: Legal fees and expenses of all parties (other than PPI Del Monte), duplicating costs, appraisal fees, the fees and expenses of First Boston and Merrill Lynch and other incidental costs approved by PPI Del Monte.

Governing law

To be determined.

15.3 The investment options

By the end of the day, it are the strategies of the shipping companies and their choice of investments that will determine the success or failure for international shipping. As discussed in chapter 8, shipping can broadly be divided into four main categories:

- Commodity shipping (mostly tankers and dry bulk);
- Specialty shipping (heavy lift, diving vessels, FPVs, etc.);
- Contract shipping (chemicals, bulk pools, etc.);
- Industry shipping (LPG, LNG, car carriers, cruise, etc.).

Given the historical volatility of shipping, many of the larger shipping companies are today looking towards more industry shipping activities in order to reduce the variablity of income. This is not necessarily an easy task. To prevent competition and to be successful in segments where economies of scale are present, require that the barriers to entry are sufficiently high.

Some main sources of barriers to entry can be:

- Technology - through innovations. Generally, shipping is characterised by a very fast technology diffusion process, i.e. shipowners only have a very limited time window in which to harvest, before an innovation is successfully copied. Shipping is not a sector where a strategy of technological leadership will pay off.

- Creating customer loyalty - i.e. developing a service with so much value added for the customer that he does not easily switch to a competitor. This is an area where a lot more could be done.

- Rules and regulations - could be important barriers to entry if regulations specify higher standards, which are costly to meet. This is slowly materialising also in the bulk sector and has already had a great impact in the ferry business as, in that sector the cost of safety is increasing fast.

- High exit barriers - this is actually an important entry barrier. If it is difficult to sell vessels in a very specialised segment, this reduces the flexibility of the investor and may prevent him from trying to go in.

If everyone is attempting going industrial, the outcome is certain: The majority will fail, simply because an industry shipping segment is characterised by very few operators. What typically has happened in cruise, chemicals and gas is that the number of main operators today are quite limited and many companies have either merged, been purchased, restructured or have left the business altogether, because a consolidation is necessary if a minimum of profitability shall be obtained. It is, therefore, not necessarily the only right thing to try to be more industrialised.

For companies with their main business still in bulk, successful timing of investment decisions is the main source for profit. As the world becomes more and more complicated, the winners will most likely be those companies which put the right emphasis on market analysis and a fundamental understanding of the world economy.

15.4 Structural problems in the tanker sector

The tanker industry has been in a crisis for more than 20 years. An important structural shift took place in the industry about 25 years ago. In the whole history of the tanker industry from the first tanker Gluckauf was launched in 1886 and until the beginning of the 1970s, the major oil companies have dominated the tanker shipping industry. With large own fleets and large fleets on long time charters with independent shipowners, the oil companies controlled the tanker shipping industry. In 1971 the oil companies owned 26% of the tanker fleet and had an additional 45% on time charter. The technological development was dramatic with the larger ship sizes increasing from 3,000-4,000 dwt around 1900 to 16,000-17,000 in 1945 to 200,000 in 1966 and 560,000 by 1975. The advantages of economies of scale and increased efficiency have reduced the transportation cost element from about 50%[1] in 1950 to some 2-8% in the beginning of the 1990s. A VLCC could in 1969 carry oil from Kuwait to Rotterdam at a unit cost 33% lower than an Aframax on the same route (Stopford, 1996). The relationship between oil companies and independent shipowners was based on this development - by constantly offering cheaper transportation solutions it was easy to agree on long term contracts to the benefit of both parties.

Since 1973 the technological development of tankers has stopped. With the double-hull requirements one could argue that there has been negative technological development. The current newbuildings have lower carrying capacity per dwt, are generally smaller than the largest existing ships and are generally more expensive to maintain and they cost 15-20% more to build than single-hull vessels. In addition, the enormous overcapacity that was built up in the mid 1970s has depressed spot rates to a level 25-30% of the break-even rates for newbuildings. This implies that the independent shipowners do not have anything to offer in long term contract negotiations. The oil companies can in this situation completely control the development and only when they see a potential danger of running short of tonnage, will there be room for long term contracts again.

The role of the independent shipowner has therefore changed. Under such circumstances it is difficult to see the motives of those shipowners actually ordering large tankers. Clarkson research presented in 1993 a study on investment opportunities in large tankers and from the study one could piece together the scenarios on freight rates for the next ten years and the costs of operation various qualities of tankers. The result is given in **Figure 1**.

[1] Freight as per cent of total CIF value.

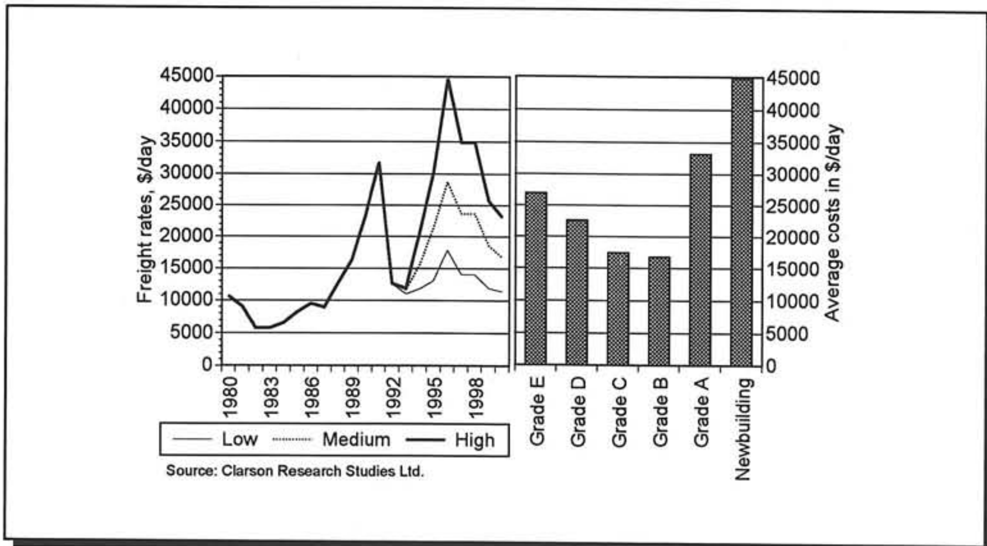

Figure 1: VLCCs operating costs and income potential as seen 1993

Only in once every ten years does the most optimistic scenario indicate a freight rate level high enough to match the cost of newbuilding. That cost assumes that the cost will occur every single day for those 10 years. Still investors are ordering new ships. The age profile for tankers as of March 1996 is given in **Figure 2**.

As can be seen from this figure, quite a lot of investments have taken place in the 1990s. In fact, the renewal of the tanker fleet has taken place in a period where freight rates do not support newbuildings at all. This is partly due to the fact that the cargo owners are investing, but also some independent shipowners have invested.

It is not easy to forecast, and **Figure 3** indicates that even the best oil market specialists have had problems in the past.

One should hope that future investment decisions in shipping, whether in tankers or more specialised ships, are based on better analyses than many of those seen in the past. Particularly one should hope that new orders are not only placed because the spot market is going up. This has indeed been the tendency in the past, as seen in **Figure 4**. More emphasis should be on market analysis and a better understanding of the market might improve this in the future.

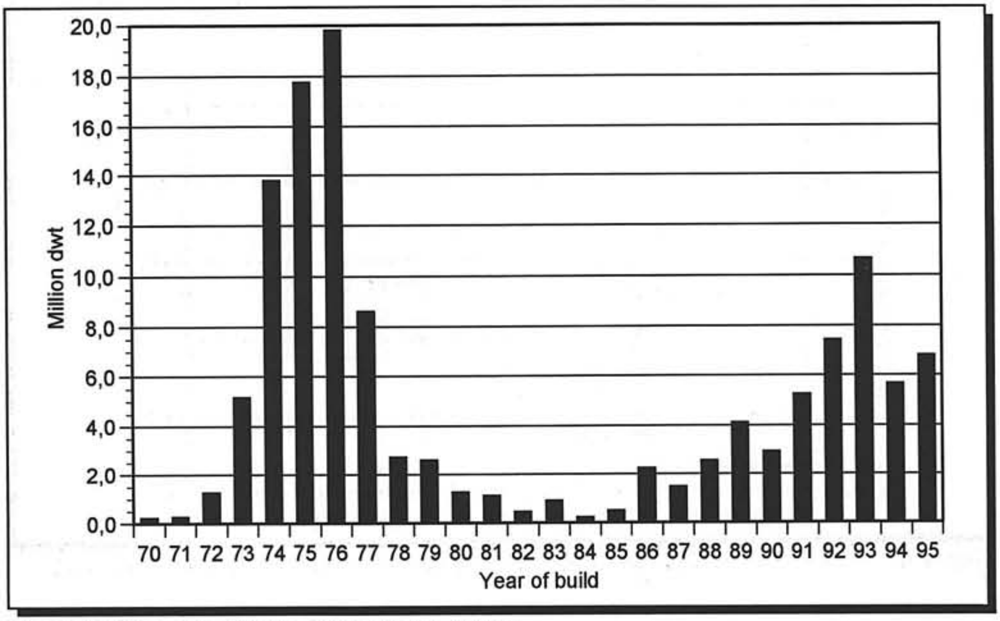

Figure 2: The age profile for tankers, 1996

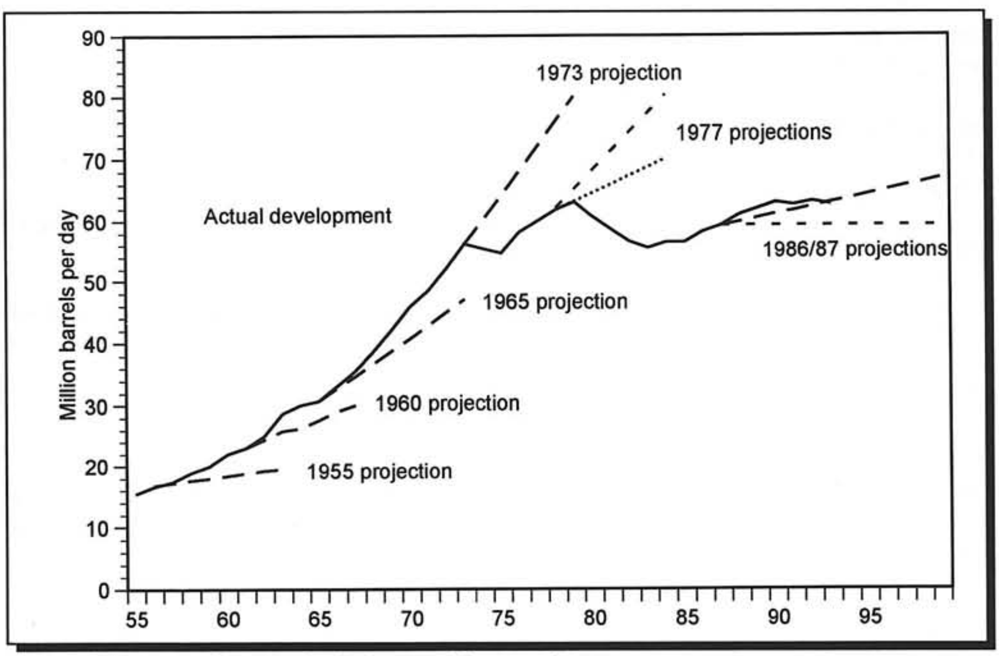

Figure 3: The problems of oil demand forecasting

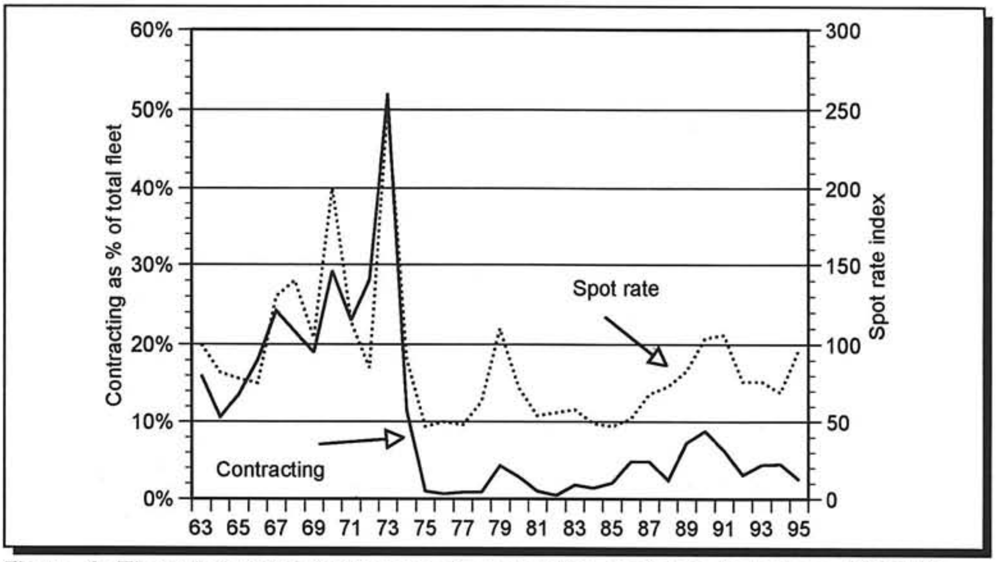

Figure 4: The relationship between orders and the spot rate in tankers 1963-95

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SHIPPING

Shipping is a multifaceted industry which is rather complex to define from an academic point of view. This book attempts to grasp these complexities and provide the reader with an overview of the main topics and terminology in shipping. It is based on material from our introductory courses at the universities in Delft and Bergen, and some sections contain material at an MBA level. It is meant primarily for students in engineering, economics, logistics and the like, but also professionals in the maritime industry may find new perspectives in the book.
The engineering/operations/logistics topics have been written by Niko Wijnolst, while Tor Wergeland wrote the chapters on economics and finance. The combination of the two disciplines does not yet exist in maritime textbooks and therefore we are convinced that we have achieved our objective of drawing a holistic view of the maritime world in which we have spent a large part of our lives.

prof. dr. ir. Niko Wijnolst
Delft University of Technology
Faculty of Mechanical Engineering
and Marine Technology

ass. prof. Tor Wergeland
Norwegian School of Economics
and Business Administration
Centre for International Economics
and Shipping

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