THE SECOND-HAND MARKET FOR BULK CARRIERS

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(ABSTRACT)

The thesis attempts to explain the resale prices of bulk carriers. The effects of the physical characteristics of ships on second-hand values, along with those of the prevailing freight rates in the market, and those of ship operating costs are theoretically discussed. The results of previous studies on the subject are presented.

The main hypothesis tested in the study is that a ship's resale price is the present value of the expected future cashflow generated by its operation. The expected future freight rates required for the analysis are obtained by assuming adaptive and rational expectations among others. Market expectations on freight rates, as measured by the price of freight futures contracts exchanged in BIFFEX, are also tested. The developed model is applied on recent ship sales with very encouraging results.

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The achievements of thought, including those of scientific thought, are important. The efforts put on those accomplishments though are wasted, when there are still people on the earth who do not enjoy the right of freedom.

I feel obliged to dedicate this work to the struggle of black South-Africans.

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CHAPTER 1

INTRODUCTION

This introductory chapter begins with a general section on shipping, in order to familiarize the reader with the workings of this industry. In recognition of the fact that any description of an entire industry, contained in a few pages, is by nature incomplete - especially when this industry happens to be the largest internationally traded service - it was decided to place emphasis only on the basic institutional aspects of shipping, and to introduce the terms that will be used later in the study.

The objectives of the thesis, and its outlay, are presented in the remaining two sections of the chapter.

1.1 Overview of the Shipping Industry

1.1.1 Shipping in the context of international trade in services

In economic terms, transportation of goods is an input in the process of manufacturing and distribution, since it adds spatial utility to raw and finished products. Passenger transportation is either an input service in the case of people moving from their residences to their working areas, or a final output in the case of touristic travelling.

Analysis of the IMF Balance of Payments statistics revealed that transportation is the largest single item in internationally traded services [31]. It was estimated that the overall trade in services in 1985 amounted to some SDR 760 billion, of which SDR 232 billion or 30% was contributed by international transportation services. Freight shipment services by all modes (water, land, air) amounted to SDR 95 billion or almost 41% of the total transportation bill, the remaining being contributed by international travel and tourism, passenger fares, expenditures by carriers at foreign ports, and some other expenditures of minor importance.

Although the distribution of the world's freight shipment expenditures by mode of transport is not available in value terms, waterborne freight shipment (hereafter simply "shipping") is by far the most important mode of goods' transport. It has been estimated that, in terms of weight, some 90% of all international trade moves by sea, and especially in long-distance trade, virtually all is seaborne [30]. In terms of ton-miles, the total ton-miles by sea are more than twice the total ton-miles by road, railway, and air, put together.

1.1.2 Types of shipping services

The demand for shipping services is derived from the demand for goods. Throughout the long history of shipping, types of services have been evolved in a way that fits best the particular characteristics of the trades served and cargoes moved. Therefore in disaggregating the shipping industry, one should look at:

(a) physical form of cargo (dry or liquid);
(b) method of packaging (loose, palletized, containerized, in bulk);
(c) unit value of cargo;
(d) preferred size of shipment (or consignment); and
(e) degree of concentration in the production/trading of a particular commodity.[1]

There are three types of shipping services in use today; liner shipping, tramp shipping, and own shipping. Their main idiosyncracies are discussed briefly in the following three subsections.

1.1.2.1 Liner shipping

Shippers of small consignments (less-than-full shiploads) of individually packaged or containerized goods are served by liner shipping. Liners follow relatively fixed routes and schedules, published and advertised well in advance. They call at several predetermined ports along their route, and require varied cargo-handling equipment to service the different types of cargo they may encounter.

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[1]Other trade characteristics such as the distance between origin and destination, and the available port facilities at both ends of the voyage have also an important role to play, but they affect mainly the selection of the size and design of the vessels to be employed, rather than the type of shipping services.

High-value processed goods and manufactures are almost exclusively moved on liners. Liner operators are usually large, diversified companies which, having to serve the needs of many regular and small shippers, usually maintain extensive marketing departments at their headquarters, and employ numerous agents around the world.

In order to suppress the competition from independent liner and tramp operators, liner companies serving the same route are usually organized in self-regulated cartels, known as "conferences". The great majority of the cargo carried by conference members have rates fixed collectively by the conference, and which are published in freight rate books, called "tariffs". Since a ship's carrying capacity can be either weight or volume constrained, liner tariffs are quoted on the basis of weight or volume, depending on the cargo's stowage factor.[2] Light or bulky cargoes are charged on a volume basis, while dense, heavy cargoes are charged on a weight basis.

In addition to setting tariffs, liner conferences set schedules for the defined routes over which they operate, and most importantly, they restrict entry. Conference membership imposes operational policies and obligations, and one admission requirement is the capacity and willingness to

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[2]Stowage factor relates volume to weight, and it is the reciprocal of density. It is usually measured in units of cubic feet per metric ton.

observe conference policies. These may include allocation of trade shares, restrictions on discounts and rebates, and pooling of earnings and sailings. The above refers to the "closed" conferences, where membership depends on the consent of existing operators only, and new entrants are not allowed. Closed conferences cover most trade routes of the world except the important U.S. trade. Restrictions on entry are not in accordance with the U.S. anti-trust legislation, and are not allowed in trades to and from the U.S. In these trades "open" conferences exist. Any shipping line can enter the applicable conference without the consent of existing members, provided only that the newcomer is prepared to obey all other conference rules.

There is a lot of debate on the usefulness and desirability of conferences, a system put in place more than a century ago.[3] Most scholars argue that conferences, taking advantage of their monopolistic or oligopolistic power, charge on a "what the market can bear" basis [5,10,48]. Ship operators estimate how much the shipper is prepared to pay and then fix a corresponding rate, as opposed to accepting a rate imposed by the interplay of market forces. On the other hand, advocates of the conference system argue that conferences represent institutional responses to the need for stable freight rates

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[3]The first conference was formed in 1875 in the UK-Calcutta trade.

and scheduled services, especially over thin routes - routes with small quantities of cargo [18]. In the absence of conferences, they argue, freight rates would frequently be bid below average and sometimes marginal cost, causing frequent bankruptcies of shipping companies which in turn, would mean that regular shipping services could not be maintained. The debate on liner conferences was fueled recently by the coming into force (in 1984, after almost a decade of heated discussions) of a piece of international legislation drafted by UNCTAD. UNCTAD in its efforts to enhance development of the developing countries' shipping industry, created the Liner Conference Code of Conduct, which requires among others, cargo sharing on a 40-40-20 basis (40 percent of the trade should be carried by the national lines of the origin country, 40 percent by the national lines of the destination country, and the remaining 20 percent by cross-traders). The complicated institutional issues of liner shipping will not be discussed any further here, since the implications of the conference system is a thesis topic on its own.

1.1.2.2 Tramp shipping

The tramp ship has been the only type of commercial vessel serving ocean trades for most of human history. The fundamental difference between liner and tramp shipping is that a tramp ship has no fixed itinerary, but instead, it picks up cargo where it is to be found and seeks new business for each voyage. This type of service is financially viable only for large consignments, and this is why most tramp ship voyages nowadays are made on behalf of a single shipper and carry a full or almost full load of a single commodity such as oil or coal. These economies of scale are graphically described by Frankel [18]:

> Just as it is less expensive for a church or social group to charter a bus for an outing rather than buy individual tickets, so too is it cheaper for a large shipper or importer of...[a commodity] to charter a full ship rather than a ship at conference tariff rates based on parcel lots.

Cargoes transported in large quantities are usually low-value agricultural and mineral products, in raw or semi-processed form, and they are almost exclusively moved in bulk. Tramp operators are usually small companies, whose marketing - or in the language of the maritime industry "chartering" - department can be a one- or two-man operation.

Unlike the liner vessel, which is operated under conference rules, the tramp ship is chartered in a competitive market. The shipper or charterer will generally place a request for a ship with an intermediary agent called "cargo broker", who will canvass the market for the lowest price of hire offered. Particularly in the case of government-owned cargoes, in most countries actual bids are requested and submitted.[4]

Tramp ships can be hired under the six types of charters discussed below:

(a) The simple voyage charter. Under a single voyage charter, a shipowner undertakes to transport a given quantity of cargo between specified loading and discharge ports. The charterparty document will also indicate, among other things, the vessel to be used, the lay days, the loading and discharge terms, and the freight rate. The lay days indicates the time period during which the ship must have arrived and be ready for loading operations. The allocation of cargo handling costs between the owner and the charterer will be expressed through terms such as: (i) FIO ("free in and out"), when the cost of loading and discharging are for the charterer's account (alternatives are FIOS ("and stowed"), FIOT ("and trimmed"), etc.; (ii) GL/FD ("gross load/free discharge"), when the owner is responsible for the cost of loading, and the charterer is responsible for the cost of discharging; and (iii) "Liner" or

[4]The competitive character of tramp shipping is discussed in more details in section 1.1.4.

"Gross" terms, when the cost of both loading and discharging operations are for the owner's account. In a single voyage charter, the freight rate is likely to be expressed either as a sum per cargo ton or as a lump sum.

(b) The consecutive voyage charter. The obvious difference between this charter type and the single voyage charter is that now the vessel involved is fixed to undertake several voyages which follow consecutively on each other. In other respects, the consecutive voyage charter is very similar to the single voyage charter. The freight rate is again likely to be a sum per cargo ton, however, it may contain clauses allowing the rate to vary with changes in bunker prices or currency fluctuations.

(c) The contract of affreightment (COA). Under a COA, the shipowner undertakes to transport a specified quantity of cargo over a specified time period between specified origins and destinations. No individual vessel is specified under a COA, which provides the owner with considerable flexibility in the operation. As with consecutive voyages, the freight rate per cargo ton is liable to be subject to escalation clauses.

(d) The timecharter. Under a timecharter, the shipowner puts his/her vessel and crew at the disposal of the charterer for a specified period of time. The charter document will indicate the vessel involved and a number of technical characteristics of the vessel, such as, its deadweight (DWT) tonnage[5], cubic capacity for cargo, its service speed and related fuel consumption. The charterparty document will also indicate the delivery/redelivery locations of the vessel, and the hire rate. The rate will be expressed either as a daily sum or as a sum per DWT per month. Charters covering long periods (longer than a year) are usually subject to an escalation clause designed to cover increases in operating costs.

(e) The tripcharter. The only difference between a tripcharter and a timecharter is that the charter period now is the time taken to complete one voyage. Rates are generally quoted on a daily basis.

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[5]The deadweight (DWT) capacity of a vessel is the total weight of cargo, bunkers, dunnage, provisions, water, stores, spareparts, and crew, expressed in metric tons, which a vessel can carry when fully loaded in salt water. It is the difference between the vessel's displacement and her lightweight (weight of steel structure). For more details refer to [4].

(f) The bareboat charter. Under the bareboat (or demise) charter, the charterer hires only the vessel itself. The charterer, therefore, takes on the additional responsibility (and cost) of crewing, provisioning, maintaining, insuring, and managing the ship. A bareboat charter may cover the anticipated working life of the vessel-making it in effect a form of leasing arrangement - or alternatively, if the charter covers a shorter period, the charterer may be given the option to buy the vessel.

The type of charter agreement concluded between an owner and a charterer will be determined principally by one or more of the following: (i) the number of cargoes to be lifted; (ii) the route, or routes to be followed; (iii) the time period required to move the cargo or cargoes; and (iv) the charterer's attitude towards the financial risks involved in controlling the shipping operation. Figure 1 illustrates the distribution of shipping costs between owners and charterers under various types of charters.

1.1.2.3 Own shipping

Own shipping is the third type of shipping services provided today. As the term suggests, own shipping is conducted by large producers, importers, and trading houses,

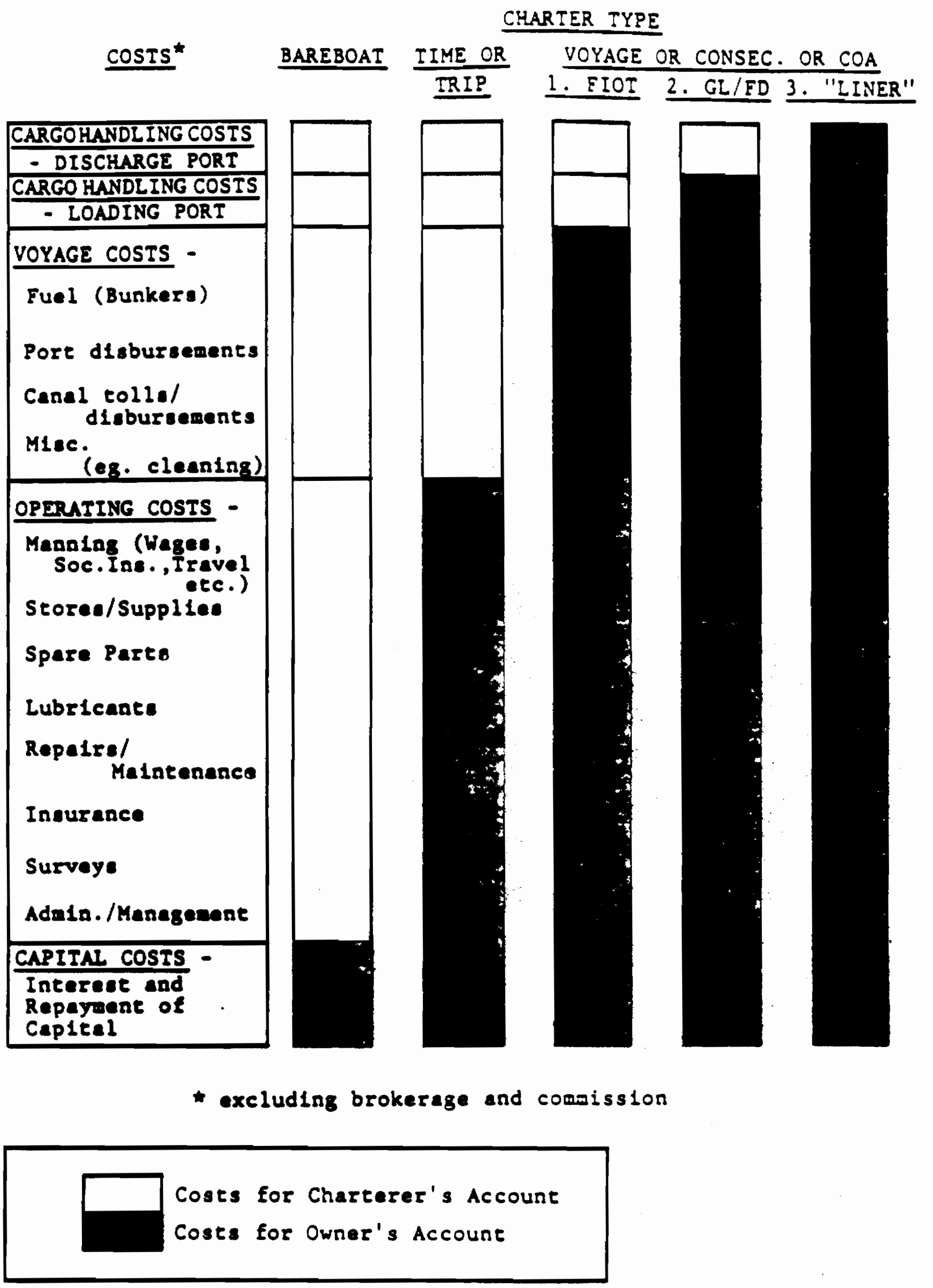

Figure 1. Owner/charterer cost distribution under different types of charter

Source: Drewry Shipping Consultants Ltd. [12] p. 16.

which carry their own goods on their own vessels. Normally, a shipping department within the company, or a shipping subsidiary of the parent firm is responsible for purchasing and operating the vessels employed in the company's own trade. Today's own shipping is confined to the carriage of a few commodities, which are exclusively low-value agricultural products and minerals, moved in bulk. In all respects, for large shippers, own shipping is an alternative to tramp shipping. Although the amount of cargo carried by this type of shipping is significant,[6] it will be shown in section 1.1.4 that own shipping does not oppress the competitive character of tramp shipping.

1.1.3 Ship types

In the past all three types of shipping services, discussed above, were served by ships of an "all-purpose" type - the "general cargo vessels". The idea behind such a ship was to maximize the chances of getting a cargo in any port of the world. General cargo vessels, designed to carry miscellaneous packaged cargoes, were equipped with two or more decks, and various types of cargo handling equipment (cranes, derricks, etc.). Loose or bulk cargo, or big lots of robust packaged cargo was stowed in the lower holds of a

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[6]Today about one-half of the world tanker fleet is owned or timechartered in long terms by the oil companies, while in the dry bulk market about 30% of the tonnage is owned by industrial companies [30].

typical "all purpose" vessel, while liquid cargo was carried in usually small-capacity tanks, built in the vessel.

Traditional "'tween-deckers" (general cargo ships with two decks) still carry part of liner trades, especially over the thinner routes, where the amount of available cargo is not sufficient to justify the large investments in ships and port facilities required by the employment of large modern liners, which on the other hand provide significant economies of scale. 'Tween-deckers are also used in tramp shipping to carry packaged cargo, but as the share of this type of cargo in the tramp trades constantly diminishes, so do the employment opportunities of general cargo vessels.

In the last 25 years, the potential savings from specialization and tailor-made ships, have embraced all types of shipping activities. In the liner trades, the disadvantages of handling heterogeneous articles have been mitigated by introducing standard "unit loads". Containers and "containerships" (single-deck vessels specializing in the carriage of containers) are the dominant and most well-known examples of this development. It is generally accepted that one containership can do the work of four to ten conventional general cargo vessels, depending on trade route and size [1]. In 1985, approximately 60% of the liner cargo was carried by containerships, and only 40% on-board general cargo ships. The containerization movement in the liner trades has had such pervasive implications reaching well beyond the shipping industry, that any attempt to discuss them here would be at the best poor.

As mentioned in section 1.1.2.2, cargoes moved by tramp shipping are mainly bulk commodities. Significant economies of scale in the movement of bulk cargoes can be achieved by increasing the size of consignments. In response to this fact, the tramp industry developed large specialized vessels; the so-called "tankers" and "dry bulk carriers" or simply "bulk carriers" fall into this category.

Tankers are large single-deck vessels, employed exclusively in the crude (dirty) oil trade, whose entire hull comprises of a series of tanks for the stowage of oil in bulk. They are usually equipped with powerful pumping equipment to speed up loading and discharging operations. Refined (clean) oil is only occasionally moved in tankers because of its corrosive properties; oil products and other liquid chemical substances are transported in specialized vessels called "product carriers" or "parcel tankers". In cases of severe shortages in the dry-bulk trades, some tankers may be found operating in the grain trade, but this happens very rarely, since they cannot compete effectively with the purposely built bulk carriers.

As the reader may suspect at this point, bulk carriers are single-deck vessels, of size similar to tankers, specializing in the carriage of dry bulk commodities. Dividers extending from one side of the ship to the other form a few large cargo areas called "holds". The deck above the holds have large openings (covered during sailing), called "hatches", to ease loading and unloading. Usually, the larger bulkers do not have any cargo handling equipment installed on-board, relying instead on shore-based, high-capacity, heavy-duty facilities. In most cases, this lack of handling equipment does not reduce employment flexibility, since these vessels almost always use port terminals specialized in handling bulk commodities.

The commodities transported by bulk carriers cover a wide range. Chief among them are the so-called five "major bulks" - iron ore, coal, grain, bauxite/alumina, and phosphate rock. Collectively, the major bulks account for around two-thirds of all dry bulk trade in tonnage terms [12]. Table 1 shows the composition of the major bulk trade in terms of tons and ton-miles. The share of the major bulks in the total international seaborne trade is shown in Table 2. Bulk carriers specializing in the iron ore trade have a strengthened structure, allowing for the carriage of heavy cargo, and are called "ore carriers". The major bulks together with crude oil account for the overwhelming majority of the commodities moved by own shipping, and therefore, tankers and bulk carriers are the types of vessels employed in this type of service.

In addition to the major bulks, a number of diverse commodities move in bulk, but in smaller quantities and over

Table 1. Development of world seaborne trade of major bulk commodities

YEAR	IRON ORE		GRAIN		COAL		BAUXITE AND ALUMINA		PHOSPHATE ROCK		TOTAL	
	MILLION METRIC TONS	'000 MILLION TONNE-MILES	MILLION METRIC TONS	'000 MILLION TONNE-MILES	MILLION METRIC TONS	'000 MILLION TONNE-MILES	MILLION METRIC TONS	'000 MILLION TONNE-MILES	MILLION METRIC TONS	'000 MILLION TONNE-MILES	MILLION METRIC TONS	'000 MILLION TONNE-MILES
	TOTAL SHIPMENTS											
1970	247	1 093	89	475	101	481	34	99	33	116	504	2 264
1971	250	1 185	91	487	94	434	35	108	35	121	505	2 335
1972	247	1 156	108	548	96	444	35	109	38	143	524	2 400
1973	298	1 398	139	760	104	467	38	133	43	159	622	2 917
1974	329	1 578	130	695	119	558	42	158	48	168	668	3 157
1975	292	1 471	137	734	127	621	41	168	38	127	635	3 121
1976	294	1 469	146	779	127	591	42	158	37	125	646	3 122
1977	276	1 386	147	801	132	643	46	167	44	160	645	3 157
1978	278	1 384	169	945	127	604	46	162	47	168	667	3 263
1979	327	1 599	182	1 026	159	786	46	169	48	177	762	3 757
1980	314	1 613	198	1 087	188	952	48	188	48	171	796	4 011
1981	303	1 508	206	1 131	210	1 120	45	172	42	139	806	4 070
1982	273	1 443	200	1 120	208	1 094	38	153	40	142	759	3 952
1983	257	1 320	199	1 135	197	1 057	36	145	43	159	732	3 816
1984	306	1 631	207	1 157	232	1 270	44	172	44	162	833	4 392
1985	321	1 675	181	1 004	272	1 479	40	166	43	156	857	4 480
	BULK CARRIER SHIPMENTS*											
1970	148	718	10	61	39	246	5	18	2	7	204	1 050
1971	160	827	12	75	38	223	5	20	2	12	217	1 157
1972	173	880	16	96	47	258	5	21	5	21	246	1 276
1973	217	1 084	18	112	55	300	6	25	5	21	301	1 542
1974	257	1 297	21	130	65	369	8	38	6	25	357	1 859
1975	233	1 220	43	260	75	436	10	55	4	16	365	1 987
1976	244	1 252	57	312	80	428	13	61	5	22	399	2 075
1977	235	1 206	60	337	88	449	16	65	8	34	407	2 091
1978	240	1 209	74	436	89	422	15	60	8	32	426	2 159
1979	294	1 475	81	486	105	565	17	72	8	35	505	2 633
1980	286	1 469	88	502	133	746	19	88	8	35	534	2 840
1981	281	1 448	103	604	143	817	18	80	7	30	552	2 979
1982	246	1 347	112	665	147	842	16	71	7	34	528	2 959
1983	235	1 205	115	698	144	860	18	80	9	52	491	2 895
1984	285	1 532	119	721	175	1 044	21	94	11	61	611	3 452
1985	295	1 551	117	690	210	1 238	21	90	11	58	654	3 627

*By ships of more than 40 000 dwt.

NOTE: Comparable figures for the period 1960-1970 are contained in Table III(a) of 'Maritime Transport, 1975'. A geographical analysis of bulk carrier movements for 1985 is contained in Table III(b).

Source: OECD [38] p. 172.

Table 2. Development of international seaborne trade
(Estimates of goods loaded)

Year	Tanker cargo		Dry cargo: Total		Dry cargo: Of which: main bulk commodities b/		Total (all goods)	
	Millions of tons	Percentage increase/ decrease over previous year	Millions of tons	Percentage increase/ decrease over previous year	Millions of tons	Percentage increase/ decrease over previous year	Millions of tons	Percentage increase/ decrease over previous year
1970	1 440	13.1	1 165	13.0	448	16.0	2 605	13.0
1980	1 871	-6.6	1 833	3.3	796	4.5	3 704	-2.0
1981	1 693	-9.5	1 866	1.8	806	1.3	3 559	-3.9
1982	1 480	-12.6	1 793	-3.9	759	-5.8	3 273	-8.0
1983	1 461	-1.4	1 770	-1.3	732	-3.7	3 231	-1.3
1984	1 478	1.2	1 886	6.5	833	13.8	3 364	4.1
1985	1 435	-2.9	1 895	0.5	857	2.9	3 330	-1.0
1986 c/	1 550	8.0	1 835	-3.2	810	-5.5	3 385	1.7

a/ Including international cargoes loaded at ports of the Great Lakes and St. Lawrence system for unloading at ports of the same system, but excluding such traffic in main bulk commodities.

b/ Iron ore, grain, coal, bauxite/alumina and phosphate.

c/ UNCTAD preliminary estimates.

Source: UNCTAD [44] p. 5.

shorter distances. Examples of what is considered to be the "minor bulks" are: agricultural products such as sugar, rice, oilseeds, and tampioca; forest products such as roundwood, sawnwood, woodchips, hardboard, pulp and paper; ores and minerals such as ores of chrome, nickel, zinc, copper, manganese, etc., sand, clay, industrial salt and gypsum; and manufactured products such as cement, fertilizers, iron/steel products, ferrons scrap and petroleum coke.

Besides the four main ship types mentioned so far - general cargo vessels, containerships, tankers, and bulk carriers - there are numerous other types of specialized vessels. Car carriers for small private cars, Ro-Ro (roll on - roll off) for trucks and chassis, train-car carriers, LASH (lighter aboard ship) and SEABEE (sea barge ship) for loaded lighters and barges, LNG carriers for liquified natural gas, LPG carriers for liquified petroleum gas, tugs, heavy-load and working vessels serving the needs of oil-rigs, all types of passenger ships, ferry-boats, and research ships is a far from comprehensive list. All these vessels, however, play a minor role in the international waterborne trade.

One type of ship which affects the bulk carrier market and is worth mentioning here is the so-called "combination carrier" or "combi" or OBO (for ore-bulk-oil). These are usually very large vessels, designed to operate in both the oil and dry bulk trades. The relative level of hire rates in those two markets usually determines whether "combis" seek employment in the oil or dry bulk trades. Table 3 shows the composition of the world fleet in terms of both GRT[7] and DWT.

1.1.4 Competition in the bulk trades

Klein et al. in [32] argue that the tanker, although specialized in crude oil transportation, does not represent asset-specific investment to any single producer or refiner (since it can be used equally well by other oil companies) and thus, its appropriable quasi rent is near zero. They go ahead and predict that "...tankers [should] not be extensively owned by...[oil companies]." Although the word "extensively" in the previous statement is very vague in quantitative terms, interviews of oil company executives conducted by Zannetos [47] result in the following:

> The oil companies claim that they attempt to supplement their ownership with vessels chartered on a long-term basis, to a total of 90% of their expected requirements. For the remaining 10%, they choose to depend on the spot market.

A less dramatic, but still considerable degree of own shipping is found in the dry bulk trades. The conclusions

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[7]GRT stands for "Gross Registered Tonnage", and is a measure of the covered and closed-in cargo-carrying spaces of a ship in volume terms. For more details refer to [4].

Table 3. Development of world fleet
(Ships of 100 GRT and over)

MID-YEAR	TOTAL GRT MILL.	TOTAL GRT % CHANGE IN YEAR	TOTAL DWT MILL.	TOTAL DWT % CHANGE IN YEAR	OIL TANKERS GRT MILL.	OIL TANKERS GRT % CHANGE IN YEAR	OIL TANKERS GRT % OF WORLD FLEET	OIL TANKERS DWT MILL.	OIL TANKERS DWT % CHANGE IN YEAR	ORE AND DRY BULK CARRIERS GRT MILL.	ORE AND DRY BULK CARRIERS GRT % CHANGE IN YEAR	ORE AND DRY BULK CARRIERS GRT % OF WORLD FLEET	ORE AND DRY BULK CARRIERS DWT MILL.	ORE AND DRY BULK CARRIERS DWT % CHANGE IN YEAR	OTHER VESSEL TYPES GRT MILL.	OTHER VESSEL TYPES GRT % CHANGE IN YEAR	OTHER VESSEL TYPES GRT % OF WORLD FLEET	OTHER VESSEL TYPES DWT MILL.	OTHER VESSEL TYPES DWT % CHANGE IN YEAR
1960	129.8	3.9	..	..	41.5	9.4	32	..	..	..	..	..	..	..	88.3	1.4	68	..	..
1961	135.9	4.7	..	..	43.8	5.7	32	..	..	..	..	..	..	..	92.1	4.2	68	..	..
1962	140.0	3.0	..	..	45.3	3.3	32	..	..	..	..	..	..	..	94.7	2.8	68	..	..
1963	145.9	4.2	..	..	47.1	4.1	32	..	..	..	..	..	..	..	98.8	4.3	68	..	..
1964	153.0	4.2	..	..	50.6	7.3	33	..	..	16.7	..	11	..	..	85.8	..	56	..	..
1965	160.4	4.8	..	..	55.0	8.9	34	..	..	18.8	12.6	12	..	..	86.6	1.0	54	..	..
1966	171.1	6.7	..	..	60.2	9.4	35	..	..	23.3	24.1	14	..	..	87.6	1.2	51	..	..
1967	182.1	6.4	..	..	64.2	6.6	35	..	..	29.1	24.8	16	..	..	88.8	1.4	49	..	..
1968	194.2	6.6	..	..	69.2	7.8	36	..	..	34.9	20.0	18	..	..	90.1	1.4	46	..	..
1969	211.7	9.0	..	..	77.4	11.8	37	..	..	41.8	19.8	20	..	..	92.5	2.7	43	..	..
1970	227.5	7.5	338.8	..	86.1	11.3	38	148.5	..	46.7	11.6	20	76.3	..	94.7	2.4	42	114.0	..
1971	247.2	8.7	376.2	11.0	96.1	11.6	39	169.4	14.0	53.8	15.3	22	89.0	16.6	97.3	2.7	39	117.9	3.4
1972	268.3	8.6	414.1	10.1	105.1	9.3	39	188.4	11.3	63.5	18.0	24	106.9	20.2	99.7	2.5	37	118.7	0.7
1973	289.9	8.0	452.5	9.3	115.4	9.7	40	209.7	11.3	72.6	14.4	25	123.3	15.3	101.9	2.2	35	119.5	0.6
1974	311.3	7.4	494.0	9.2	129.5	12.2	42	238.4	13.7	79.4	9.3	25	135.6	10.0	102.4	0.5	33	120.0	0.4
1975	342.2	9.9	553.4	12.0	150.1	15.9	44	281.6	18.1	85.5	7.7	25	146.8	8.2	106.6	4.1	31	125.0	4.2
1976	372.0	8.7	608.3	9.9	168.2	12.1	45	320.0	13.6	91.7	7.2	25	158.1	7.7	112.1	5.2	30	130.3	4.2
1977	393.7	5.8	648.8	6.7	174.1	3.5	44	335.3	4.8	100.9	10.0	26	174.4	10.3	118.6	5.8	30	139.1	6.8
1978	406.0	3.1	670.4	3.3	175.0	0.5	43	339.1	1.1	106.5	5.6	26	184.5	5.8	124.4	4.9	31	146.8	5.5
1979	413.0	1.7	681.5	1.7	174.2	-0.5	42	338.3	-0.2	108.3	1.7	26	188.5	2.2	130.5	4.9	32	154.7	5.4
1980	419.9	1.7	690.9	1.4	175.0	0.5	42	339.8	0.4	109.6	1.2	26	191.0	1.3	135.3	3.7	32	160.1	3.5
1981	420.8	0.2	697.2	0.9	171.7	-1.9	41	335.5	-1.3	113.1	3.2	27	199.5	4.5	136.0	0.5	32	162.2	1.3
1982	424.7	0.9	702.0	0.7	166.8	-2.8	39	325.2	-3.1	119.3	5.5	28	211.2	5.9	138.6	1.9	33	165.6	2.1
1983	422.6	-0.5	694.5	-1.1	157.3	-5.7	37	306.1	-5.9	124.4	4.3	30	220.6	4.5	140.9	1.7	33	167.8	1.3
1984	418.7	-0.9	683.3	-1.6	147.5	-6.2	35	286.8	-6.3	128.3	3.2	31	228.4	3.5	142.9	1.4	34	168.1	0.2
1985	416.3	-0.6	673.7	-1.4	138.4	-6.1	33	268.4	-6.4	134.0	4.4	32	237.3	3.9	143.9	0.7	35	168.0	-0.1
1986	404.9	-2.7	647.6	-4.0	128.4	-7.2	32	247.5	-7.8	132.9	-0.8	33	235.2	-0.9	143.6	-0.2	35	164.9	-1.8

NOTE: Ore and dry bulk carriers (which include combination carriers) are included with 'Other vessel types' for the period prior to 1963.
.. signifies data not published in Lloyd's Register of Shipping Statistical Tables or calculated therefrom.
The Great Lakes fleets of Canada and the United States, and the United States reserve fleet are included.

Source: OECD [38] p. 195.

of an UNCTAD study [43], devoted to this subject, are presented below:

- "International seaborne movements of iron ore and bauxite/alumina are controlled to a high degree by transnational corporations based in developed market-economy countries, which are engaged in vertically integrated activities extending from mining to the production of steel and alumina/aluminum...It is estimated that two-thirds of world movements of iron ore, and probably an even higher proportion of bauxite/alumina, are tied to the transnational companies in this manner, and may be considered captive cargo."

- Similar considerations appear to apply to a lesser extent in the case of international seaborne movements of coal and phosphates.

- "The world-wide trade in grain is almost completely dominated by five privately owned and operated transnational concerns which control transport by virtue of the controls they exercise at both ends of the trade."

The extensive own shipping in both liquid and dry bulk trades documented in the preceding paragraphs, has been considered by some as a factor limiting competition in the corresponding markets for shipping services. The same UNCTAD publication cited above concludes:

> "Although some transnational corporations possess their own fleets (particularly those engaged in iron ore/steel operations), for the most part they use long-term charters and contracts of affreightment. The majority of such arrangements are either concluded with "closely related parties" or negotiated privately with shipowners with whom the transnational corporations have had long-standing business relationships...These interrelationships present a formidable barrier to any new shipowner, especially one from a developing country trying to break into sea transport operations, and in fact

very few such shipowners appear to have succeeded in doing so."

Furthermore, in view of this "problem", some have gone as far, as to propose international regulation of bulk shipping similar in form to the cargo reservation scheme of the UNCTAD's 40-40-20 formula applicable to liner trades. In the remainder of the section, it will be shown that: (i) own shipping not only does not create a problem seen as such in the UNCTAD's report, but if it does, it is in a direction opposite to the one implied by UNCTAD; and (ii) protectionistic measures, if applied in bulk trades, can only hurt international economy, including that of the developing nations, for the benefit of which the measures are considered in the first place. Three different approaches will be used in proving the former.

Firstly, the transnational corporations have to choose between two alternatives. They can either (i) sell on an fob basis, in which case the buyers will provide the means of transportation on their own expense; or (ii) sell on a cif (or delivered) basis, in which case transportation is provided by the sellers, since transport cost is included in the price.

Under the fob alternative, the buyer will transport the goods on either a chartered or an owned vessel. If it is a chartered vessel, the rate will be determined in the open market under perfect competition. If it is an owned vessel, the transport cost can never be above the market rate because otherwise the buyers will prefer to use a chartered vessel instead. The equivalent rate in an owned vessel operation should also exceed the long-run cost of maintaining and running the ship by the minimum return that is necessary to keep the required investment in the industry. In either case therefore, under the fob alternative, the transport cost will approach the competitive rate.

Although the fob option is satisfactory to the buyers, it creates practical problems to the sellers. The markets of primary commodities of more or less standardized quality, like those of crude oil and major bulks, are buyers' markets, in the sense that buyers can easily switch suppliers if there are differences in delivered prices. Therefore, for given fob prices, fluctuations in transportation cost will be reflected in the cost to the buyers, and this in turn, will affect the volume of sales. Whenever rates are low, the goods which travel the longest will be relatively favored, and when rates are high the closest to the buyers will be in the most advantageous position. Such possible changes in sources of supply will introduce a lot of uncertainty in the sales revenues and production planning of the transnational corporations, and also leave those companies to the mercy of those who happen to control transportation. So an fob price is not practical for the transnational concerns, and they prefer to sell on a cif basis.

Under the cif option, the transportation cost that sellers include in the delivered price must again be based on the long-run costs of ship operation and must include the minimum return that is necessary to keep the required investment in the industry. It cannot be higher than long-run cost because otherwise the buyers will prefer to buy on an fob basis (from this or another supplier) and own their own vessels (or charter from independents). Once such a long-run cost is established and included in delivered prices, the owners of vessels operating in the market (either the transnational corporations themselves or independents) cannot price their services on a different basis. In fact, in order to eliminate some instability from their sales and investment plans, the producers may offer to the buyers an incentive in terms of lower transportation costs included in the cif price, and so encourage the buyers to choose a delivered price. Thus, under either alternative (fob or cif) the markets will operate in a manner approaching perfect competition.

The second way to reach the same conclusion draws on the concept of contestable markets, introduced by Baumol in 1982. Davies in a 1986 article [9] shows that the international liner shipping industry satisfies all the necessary conditions for a contestable market, and thus, it may be judged as such. In fact, the contestability theory explains the frequent bankruptcies in the industry, and the observed rates of return on capital which are often below normal commercial standards (both these facts sound paradoxical for a cartelized industry). His main arguments are summarized below:

(a) Symmetrical market position of incumbents and entrants. "Both entrant and incumbent have access to identical technology: the market for new or used vessels and equipment is a world market in which all firms can equally make purchases. Under carriage of goods laws all firms too are equally placed..."

(b) Absence of sunk costs. "Capital requirements are often high and a relatively large proportion of total costs consequently fixed; yet it is evident that this does not give rise to significant sunk costs. The inherent mobility of ships...allows them to be moved from trade to trade, and the existence of an active second-hand market means they can also be disposed of relatively easily...The ease of exit...becomes still greater when one considers...[that] vessels, containers and other equipment may be chartered or leased, and indeed some major companies acquire almost all of their assets through the rental market."

(c) Possibility of contracts for entrants. "The negotiation of contracts by new lines is normal practice to the extent that departures therefrom are virtually unheard of." In addition, "any change in the prices of conference cartels normally requires consensus among member lines,...[which results in the]...inability to take a rapid and unified rate stance to match outsiders."

The arguments under (a) and (b) above apply directly to the bulk shipping markets as well. Regarding the possibility of contracts for entrants, the practice of the "run and hit" principle not only is easily observable in tramp shipping, but in fact, it is the way of conducting business (the reader may want to review the definition of tramp shipping in section 1.1.2.2). In addition, there is no apparent reason to believe that even the powerful transnational interests in the oil and bulk trades will not be happy to award a contract to an entrant who undercuts the prevailing rates in the market. The bulk shipping markets hence, satisfying all the necessary conditions, can be characterized as contestable markets, which means in turn, that they will operate in a manner approaching perfect competition.

The third approach which will be employed here, is stronger than the other two discussed so far, in the sense that it goes beyond perfect competition. The fact that transnational corporations have significant control over the trade and movement of oil and major bulks, combined with the fact that they exercise their control mostly by engaging in long-term timecharters and contracts of affreightment, result in an oligopsonistic situation in the market of vessel chartering. Economic theory predicts that in oligopsonies, the quantity of a good produced (in this case ships provided) will be greater than the market clearing quantity under perfect competition. Furthermore, the oligopsonistic price (charter rate) will be lower than that of the competitive equilibrium. In other words, it is to the best interest of the transnational corporations not only to avoid restricting their business association to the traditional long-standing shipping interests, but in fact, to extend their business relationships to new shipowners (including those of developing countries), encouraging in this way investments in ships, which will eventually create oversupply and lasting depression of charter rates (something not unusual in the bulk shipping markets).

Several authors [19,14] have discussed the adverse effects of protectionistic measures (in the form of cargo reservation schemes in favor of the national fleets of importers/exporters), should they be applied to the bulk shipping industry. The main argument is that protectionism will result in inefficient allocation of cargo among shipping companies, leading to increased transport costs, which in turn, will adversely affect international trade. The economic distortions of protectionistic measures in the bulk shipping markets are very similar to those of trade quotas and tariffs, and they will not be discussed any further here, since the subject is outside the scope of this study. There are two arguments, though, applying particularly to the bulk shipping industry, and they are presented below.

In the first place, bulk shipping is economically advantageous only in trades of substantial cargo volume. Therefore, the creation and/or expansion of a national bulk fleet would be a realistic proposition only in the case of a few developing countries with significant foreign trades. Most of the smaller nations would have no chance of developing a sizeable fleet, even if they enjoyed, for one reason or another, a comparative advantage in bulk shipping (as is the case for the traditional maritime countries of Norway and Greece today).

Finally, it would be wrong to think that the existence of a sizeable foreign trade in the case of any particular country would necessarily provide optimum employment opportunities for a national fleet. Optimum utilization of a ship can only be obtained by minimizing ballasted voyages.[8] Cargo reservation schemes will unnecessarily constrain ship operations between the exporting and importing countries only, leading to excessive ballasted sailings, inefficient ship operations, and increased maritime transport costs.

1.2 Study Objectives

The high volatility of freight rates in the oil and dry bulk shipping industry has attracted the attention of many researchers in the past. Zannetos [47] back in 1966 analyzed the structure of the oil tanker market in the 1950s, and formed the "price-elastic expectations" hypothesis. He argued that a substantial increase in the tanker rates creates expectations of even higher rates in the future, driving buyers of tanker services to charter now at high rates instead of waiting and chartering in the near future at new and even higher rates. This hypothesis pulled the trigger for a series of studies on the structure and determinants of freight rates in the liquid and dry bulk markets. The most important among them are those of: (i) Hawdon [25] in 1978, who estimated a system of seven

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[8]Ballast is intentionally added weight (usually sea water for commercial vessels) to an unloaded ship, in order to improve stability characteristics. The term "ballasted voyages" refers to non-revenue-earning repositioning sailings.

equations describing the demand and supply functions of tanker services; (ii) Charemza and Gronicki [7] in 1981, who built and estimated a system of 35 equations describing the formation of short- and long-term rates in the oil and dry bulk markets; and (iii) Glen, Owen, and Van der Meer [20] in 1981, who provided empirical evidence against the "price-elastic expectations" hypothesis.

By contrast, very little attention has been paid to the market for ships as such and the determination of ship prices, although Charemza and Gronicki [7] do report equations in which ship prices allowed to adjust over time to freight rates and trade volume. Beenstock [3] in 1985 looked more closely to the market for newbuilt vessels, and summarized their price determinants in an eight-equation general equilibrium model. He didn't estimate this model however, as his work was focused on a dynamic analysis methodology (based on the rational expectations hypothesis), investigating ship price responses over time to expected and unanticipated shocks in world trade.

All the above studies, however, including that of Beenstock, have totally ignored the second-hand market for ships. This is surprising, given the fact that the resale markets for tankers and bulk carriers are both very active and well documented. One possible explanation might be the belief, shared by many, that first- and second-hand ships are perfect substitutes. Beenstock for instance argues:

> For expositional simplicity we have assumed that new and second-hand ship prices are perfectly correlated, i.e. new and second-hand prices move in unison but second-hand prices will be at a discount reflecting depreciation. Apart from these vintage considerations new and second-hand ships are perfect substitutes. In practice these conditions are unlikely to be fulfilled because while second-hand prices are flexible new prices are relatively sticky, implying that new prices adjust to second-hand prices over time rather than instantaneously as presently assumed.

The only work which deals directly with second-hand ship prices is that of Arnold and Panagakos [2] in 1986, who in an effort to estimate the capital costs of various types of vessels, looked at both the first- and second-hand markets. Their investigation, however, was restricted only to the effects of the ship's physical characteristics on its resale value; financial factors were left out of the study since their effect would be indirectly accounted for by the recommended frequent updating of the model.

The present thesis seeks to fill this gap. The objective is to identify the main factors which affect a ship's resale value, and examine the way the market responds to changes in any of these factors. It is argued that conventional supply and demand analysis is inappropriate in the case of ship prices because a ship is a capital asset of considerable duration. This suggests that one should apply the concepts employed by capital theory, and this is where the theoretical part of the thesis is based on.

Part of the return on a vessel, viewed as a capital asset, is the expected future cash-flow generated by its operation. This leads to two facts. Firstly, there are strong interrelations between the second-hand and the charter market where rates for shipping services are formed, and thus, one interested in the second-hand market should also look at the freight market. Secondly, the way in which both buyers and sellers of shipping services form their expectations on future freight rates is essential in determining second-hand prices. Furthermore, the competitive character of bulk trades discussed in Section 1.1.4 postulates that charter rates are determined by the interaction of demand (world trade) and supply (world fleet) in the market for shipping services. Shipbuilding then comes into the picture, and this is the third market one should consider in analyzing ships' resale prices.

Searching for the factors affecting resale prices, the interactions between these three markets (second-hand, charter, and newbuilding) will be investigated. Regarding the formation of expectations, the "adaptive" and "rational" expectation models will be applied and tested empirically.

The study will cover bulk carriers only. To ensure homogeneity specialized vessels falling under the bulk carrier category (such as cement carriers) will be excluded. The study period will be from January, 1977 to December

1987, including a full cycle in second-hand bulk carrier prices as shown in Figure 2.

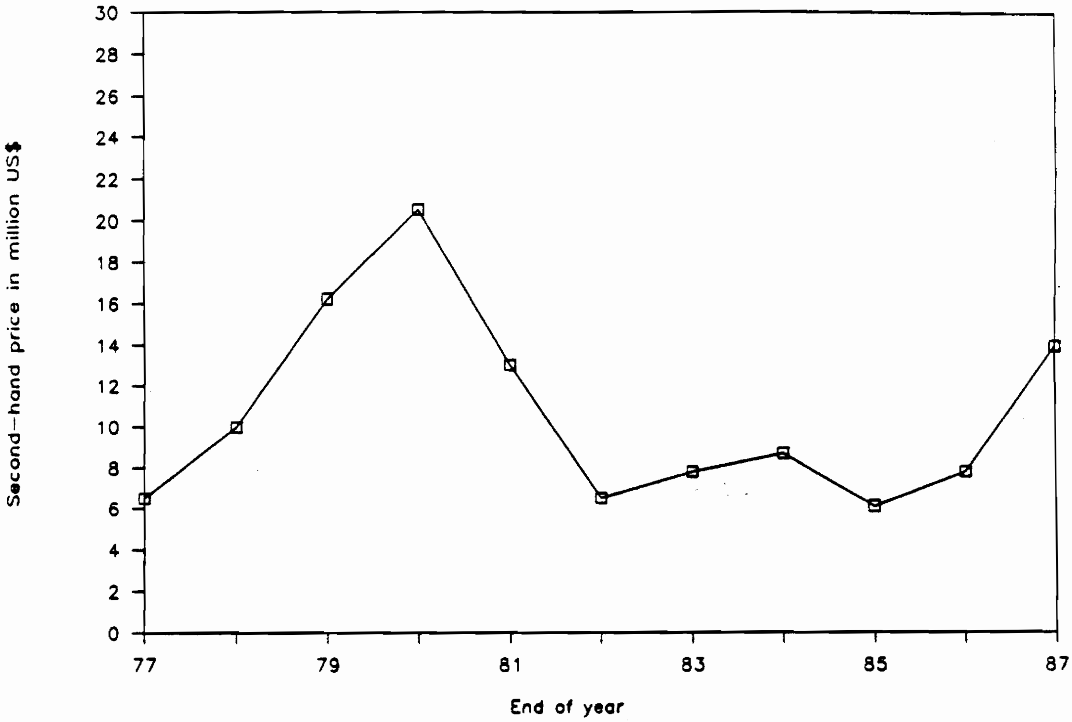

Figure 2. Second-hand price of a five year old bulk carrier of 65,000 DWT

Source: Institute of Shipping Economics and Logistics [27] p. 87, Drewry [13] p. 44, and Lloyd's Shipping Economist [33].

In 1985 an exchange for futures in freight rates (Baltic International Freight Future Exchange, BIFFEX) commenced operations in London. The futures contracts sold and bought in BIFFEX should be a good estimator of expected future freight rates. Their effect on second-hand prices will be estimated for the period January 1985 to December

1987, and the result will be compared to that of the "adaptively" produced freight rate expectations mentioned above.

To summarize, the objectives of the thesis are:

(a) to identify those physical characteristics of a bulk carrier which may affect its resale price;
(b) to explore the interrelations between the second-hand market, the charter market, and the newbuilding market for bulk carriers;
(c) to identify, based on (b), the financial factors affecting resale prices;
(d) to build and test a simple model for the formation of freight rate expectations, based on the "adaptive" and "rational" expectations model;
(e) to explain bulk carrier resale prices by the factors identified under (a) and (c), and estimate elasticities; and
(f) to explain resale prices by using the BIFFEX contract prices in place of the expected freight rates predicted by (d), and compare results with (e).

1.3 Thesis Outlay

The physical characteristics of a ship which may affect its resale value are discussed in the following chapter. The importance of age, size, speed, and type of propulsion system is presented, along with results of previous studies on the subject.

The next two chapters deal with mainly financial factors that have a bearing on a ship's resale value. Chapter 3 analyzes the costs of owning and operating a vessel. It defines the capital, operating, and voyage costs, and discusses the factors that determine their level.

Chapter 4 presents the revenue side of a ship's operation. It is focused on freight rates, which provide the link between the second-hand market and the shipping and shipbuilding markets. The determinants of the demand for shipping services, and the short- and long-run supply of ships are identified, and the results of previous studies are presented. In addition, the chapter provides estimates of the upper and lower limits of resale prices.

The empirical analysis occupies Chapter 5, which provides estimates of the effect that the major physical and financial factors identified in the previous three chapters have on second-hand prices. Freight rate expectations produced by simple "adaptive" and "rational" expectation models are tested as predictors of resale prices. The results are compared with those produced by considering the index of the freight futures exchange. The chapter ends with a summary of the conclusions reached.

CHAPTER 2

PHYSICAL CHARACTERISTICS OF A SHIP

The chapter discusses those physical characteristics of a ship which may have a significant bearing on the resale value. More specifically, the chapter deals with the age, size, design speed, and type of propulsion system of a vessel, as well as with some other factors of lesser theoretical importance. Results of previous studies on the subject will also be presented, if available.

2.1 Age

As in any other durable good, age has a significant impact on a ship's value. There are three reasons for this:

(a) Ships have a finite economic life of about 25 years on average. The older a vessel is, then, the shorter its remaining revenue-earning life would be. This in turn, reduces the price any potential buyer is prepared to pay for its acquisition.

(b) The ship building technology has seen drastic developments during the last thirty years. It is more probable then, for a younger vessel to be equipped with features of the most recent technological vintage, which lead to more efficient operation and higher probabilities of employment. Furthermore, it is most likely that any conversions or installations of additional equipment required by a new international law on safety or environmental protection can be met by a younger vessel at a smaller expense than that of an older one. In fact, the costs imposed on an old ship by similar regulations may as well be higher than the expected profits from its operation, ending prematurely in this way its economic life.

(c) The salt and oxygen content of the water, the strong winds, and the ever-lasting waves of the oceans cause extensive corrosion and fatigue to the hull and machinery of a ship. Old vessels are more vulnerable to the adverse effects of the elements of nature, a fact which results not only in frequent repairs and increased maintenance, spare part, and labor costs, but more importantly, in lower utilization rate of the ship, and given the unpredictability of such failures, in less efficient operation.

The only previous work on the effect of age on the resale price of a ship was done by Arnold and Panagakos [2] in 1986. The regression equation estimated in this study was:

$$(RP/DWT) = a*b^{(AGE)} \quad (1)$$

where RP = resale price in thousand US$;

DWT = deadweight tons in thousands;

AGE = the age of the vessel in years; and

a,b = regression coefficients.[9]

The rationale behind this specification was that the resale value of a ship can be viewed as the new building price discounted by a certain constant percentage rate for each year of its life. Coefficient a in eq. (1) represents the new-building price of the vessel expressed in US$ per DWT ton, while coefficient b is equal to (1-d), where d is the annual depreciation rate. The logarithmic transformation of eq. (1) was estimated for three groups of bulk carriers with respect to size (namely DWT < 25,000; 25,000 < DWT < 60,000; and DWT > 60,000 tons), and the results are presented in Table 4.

The annual depreciation rate was found to be between 7 and 12%, and the estimated newbuilding prices were ranging from 160 to 210 US$ per DWT ton. There were two serious problems, however, regarding these newbuilding prices:

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[9]For simplicity, error terms will be omitted from the equations in the study. The left-hand-side terms should be viewed as expected values.

Table 4. Results of the logarithmic transformation of equation (1)

	DWT < 25,000	25 < DWT < 60,000	DWT > 60,000
- Constant (log a)	4.9963	5.3074	5.1630
- Coefficient (log b)	-0.0717	-0.1105	-0.1239
- t-statistic of coef.	-10.3248	-27.7030	-19.8568
- Standard error of regr.	0.3964	0.2778	0.2450
- R square	0.5652	0.7966	0.8718
- Number of observ.	84	198	60
- Depreciation rate	6.92%	10.46%	11.66%
- Estimated new-building price	159.95	209.77	180.00
- "Real" new-building price	588.08	355.77	174.65

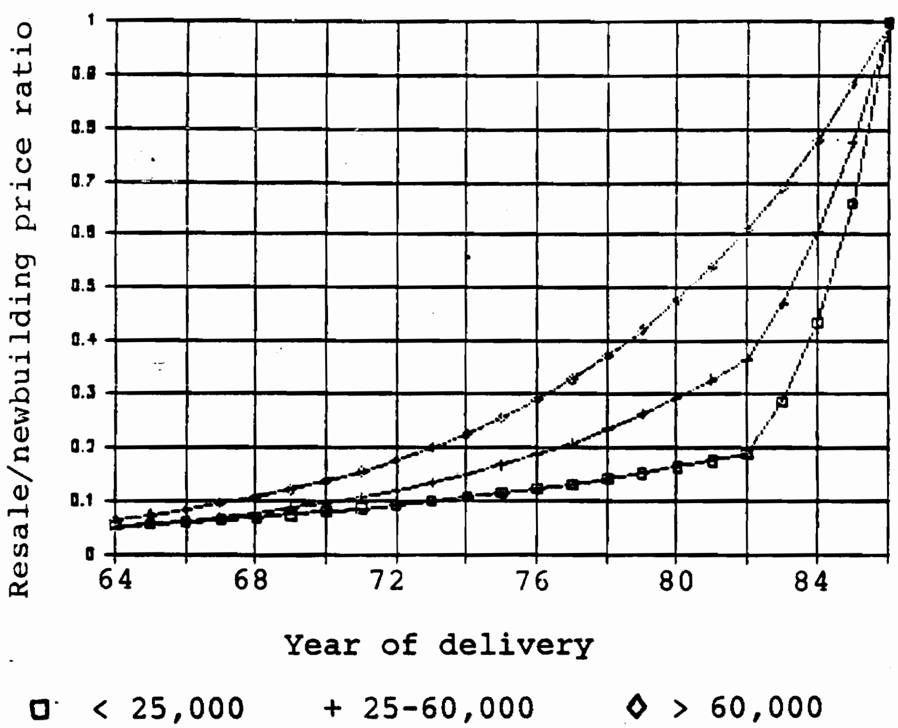

Figure 3. Resale value of bulk carriers

Source: Arnold and Panagakos [2] p. 152.

(a) The prices estimated in this way were much lower than those resulted from regressing directly over a sample of newbuilt vessels (the "real" newbuilding prices are also shown in Table 4, and range from 175 to 588 US$ per DWT ton).

(b) The estimated newbuilding prices were rising from 160 dollars for the smaller vessels to 210 for the medium-size ones, and they were dropping back to 180 US$ per DWT ton for the larger bulk carriers. This is not what one would expect. Although absolute prices should increase with the size of the vessel, unit prices should drop as the size of the vessel increases, the reason being that beyond a certain size, additional capacity is added by extending the middle (parallel) part of the hull, which has uniform cross-section design and relatively low construction cost.

Recognizing these problems, the authors of the study disregarded the newbuilding prices estimated by eq. (1), and relied on the "real" ones instead. In addition, they made the assumption that during the first four years of a ship's life its price is depreciated by a factor higher than the one estimated by eq. (1). In fact they argued, this new rate is the one that if used to depreciate the "real" newbuilding price for four years, results in a resale price equal to the one given by eq. (1). The resale factors (resale price/newbuilding price) for bulk carriers, obtained in this way, are presented in Figure 3 for the three DWT groups, as a function of age.

2.2 Size

The size of a vessel is its second physical characteristic that has a significant effect on the resale value, since it affects the output capacity of a vessel, and thus, its revenue-earning potential.

The most common measure of a ship's size is its deadweight (in metric tons). It is the difference between the vessel's displacement (total weight when fully loaded in salt water) and its lightweight (weight of steel structure and machinery). The size of a vessel is naturally determined also by its principal dimensions (length, beam, draught). However, the standardization in modern ship design is such, that the dimensions of a vessel are almost exclusively specified by its DWT. A recent study by BTE [17] finds that in the case of bulk carriers:

$$\text{LENGTH} = 9.40*\text{DWT}^{0.288} \quad , R^2 = 0.92 \qquad (2)$$

$$\text{BEAM} = 1.00*\text{DWT}^{0.313} \quad , R^2 = 0.92 \qquad (3)$$

$$\text{DRAUGHT} = 0.625*\text{DWT}^{0.275} \quad , R^2 = 0.93 \qquad (4)$$

where all dimensions are measured in meters, and DWT in tons. The very good fit of the equations shows the point.

It is interesting to notice how close the power of DWT is to one-third, for all dimensions.

The holding capacity of a vessel is the maximum amount of cargo that it can hold. By its definition, a vessel's DWT is closely related to its holding capacity. In fact, the maximum amount of cargo a vessel can carry is derived by subtracting the total weight of bunkers, dunnage, provisions, fresh water, stores, spare parts, and crew (all of them put together amount only to a small portion of DWT) from its deadweight. However, this method of estimating a vessel's holding capacity applies only to cargoes heavier than fresh water. For lighter cargoes, the capacity is measured in terms of volume (cubic feet). There are several measurement methods of ship's volume, the most common ones being the "Gross Registered Tonnage" (GRT) and "Net Registered Tonnage" (NRT),[10] both measured in tons.[11] Fortunately, the volume of a vessel is closely related to its DWT. The same BTE study mentioned above finds that for bulk carriers:

$$GRT = 2{,}310 + 0.514*DWT \quad , R^2 = 0.97 \qquad (5)$$

$$NRT = 361 + 0.372*DWT \quad , R^2 = 0.95 \qquad (6)$$

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[10]For definitions refer to [4].

[11]Although the term "ton" is used for a GRT and NRT unit, one GRT or NRT ton is equal to 100 cubic feet.

Now that the relation between DWT and holding capacity is established, the effect of DWT on the resale price of a ship will be investigated. No studies were found to deal directly with this topic. However, the dramatic increase in the size of ocean-going vessels during recent years has tempted many researchers, looking at the scale economies of ships, to investigate the effect of size on the newbuilding cost of a vessel. A study conducted on bulk carriers in 1978 by Jansson and Shneerson [29] finds that:

$$\log NP = -4.236 + 0.655*\log DWT \quad , R^2 = 0.34 \qquad (7)$$

where NP is the newbuilding price of a ship. The results of some previous studies are also presented in this article, and they are reproduced here in Table 5.

Table 5. Size elasticities of ship cost

Ship Type	*Capital Cost*	*Operating Costs (except fuel)*	*Fuel Cost (for propulsion)*
Tramps (Thorburn)	0.67	0.4	1.00
Liner (Getz *et al.*)	0.6	0.6	
Dry bulk carrier (Goss and Jones)	0.7	0.4	0.8
Tanker (Heaver)	0.6	0.3	0.6
Authors' estimate (regression results)	0.6	0.4	0.72

Source: Jansson and Shneerson [29] p. 291.

In a more recent (1987) study, Claessens [8] examines the newbuilding costs of 350 general cargo ships built in Japan, and concludes that:

$$\log NP = \underset{(1.15)}{0.74} + \underset{(9.95)}{0.71}*\log DWT + \underset{(3.75)}{0.04}*DER + \underset{(3.74)}{0.08}*CRN + \underset{(2.01)}{0.003}*MTH \qquad (8)$$

$R^2 = 0.66$, and t-statistics in parenthesis,

where NP = construction cost in million yen;

DWT = deadweight in tons;

DER = number of derricks installed;

CRN = number of cranes installed; and

MTH = months elapsed from January 1975 onwards.

Equations (7) and (8), as well as Table 5, show that the elasticity of newbuilding cost with respect to size falls in the range of 0.6 to 0.7, for all types of ships. The results clearly conform with the "2/3-power rule", which finds great support in engineering studies examining the effect of plant capacity to capital cost. The rule can be explained mainly by a family of geometric relationships that relate the material required for the building of equipment to the capacity of this equipment. The amount of material required to build containers depends on the surface area, whereas container capacity depends on the volume enclosed.

The above relationships hold for newbuilding and not for resale ship prices. We expect the size elasticity of second-hand prices to be less than that predicted by the "2/3-power rule".

2.3 Design speed

The holding capacity of a ship was discussed in the previous section. However, the capacity measure of a vessel which is more closely related to its revenue-earning potential is the so-called hauling capacity, or the maximum number of ton-miles hauled per unit of time. Hauling capacity is the product of holding capacity and hauling speed. This is how speed establishes itself as a factor affecting resale values.

Regarding speed, there are two distinct concepts used in navigation, the "design speed" and the "actual speed", both measured in knots (nautical miles per hour).[12] Design speed is the maximum speed a vessel can achieve and maintain for extended periods of time under normal navigation, when fully loaded in salt water. Actual speed is the speed a vessel is sailing at, at any point of time. Usually the maximum obtainable actual speed exceeds design speed by a small margin of about 5%. However, speeds higher than the design speed are used only in cases of navigational stress, and usually can be maintained only for periods of less than

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[12] A nautical mile is equivalent to one minute of latitude, and is somewhat longer than the statute mile used ashore.

an hour. The actual speed a captain chooses for his/her vessel will be discussed in Chapter 4. The remainder of this section will be devoted to design speed.

No studies were found in the maritime literature, investigating the effect of design speed on the resale value of ships. The relation between design speed and ship's size, however, has been estimated, and is presented below.

A high design speed is very costly, both in terms of required horsepower and in terms of fuel consumption. However, to achieve a certain speed the required horsepower is less than proportional to ship size, so that design speed is expected to increase with size. This phenomenon is explained by the principle that the resistance of the water against the ship's hull does not increase at the same rate as the volume of the hull. According to a time-honored rule-of-thumb of naval architects called the "inch-rule", the design speed should increase with the square root of the length of the ship. This fact, together with eq. (2) showing that length increases with the 1/3-power of DWT, imply that the design speed is a function of deadweight tonnage to the power of 1/6.

Jansson and Shneerson [29] have estimated the design speed of general cargo vessels as a function of DWT, using three samples pertaining to different data sources and different time periods. Their results are as follows:

$$\log SP = 1.3 + 0.16*\log DWT \quad , R^2 = 0.42 \qquad (9)$$

$$\log SP = 1.19 + 0.17*\log DWT \quad , R^2 = 0.35 \qquad (10)$$

$$\log SP = 1.2 + 0.16*\log DWT \quad , R^2 = 0.54 \qquad (11)$$

where SP is the design speed in knots. The results are nearly identical to each other, and conform with the "inch-rule" of naval architecture discussed above.

2.4 Type of propulsion system

There are two types of propulsion systems in commercial use today, diesel engines and steam turbines.[13] Up to the early 1960s, steam turbines were the predominant type of system installed on merchant ships, since there were several factors favoring them over diesel engines:

(a) Diesel engines could not develop more than 16,000 shaft horsepower (SHP). Turbines could go up to 25,000 SHP, being the only alternative for larger vessels.

(b) The fuel oil used by diesel engines was a distillate (diesel oil), which was 50 to 80% more expensive than the residual oil, known as "Bunker C", used by steam turbines.

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[13]Gas turbines is a third type, but they can be found installed only on naval warships today.

(c) Both the weight and area occupied by diesel installations were much greater than those of turbines, and because of their bulkier construction, diesel engines required higher initial investment.

(d) Diesel engines were more delicate than the steam turbines, requiring longer repair times, more crew, and higher maintenance costs.

(e) Since steam was not available in diesel installations, auxiliary units were required for heating, loading, and unloading.

These factors were enough to overwhelm the inherent advantages of diesel engines (better thermal efficiency and higher maneuverability), and made steam turbines superior to diesel engines from the economic point of view.

During the last twenty years, however, the marine diesel engine has seen drastic developments which have fully reversed this trend. The addition of "superchargers" has increased the SHP of diesel engines, and the possibility of attaching two or more engines to the same shaft has made diesel installations a favorable alternative, even for the larger vessels in the industry. The already high thermal efficiency of diesel engines has been further increased, converting a greater percentage of fuel energy into mechanical power at the shaft. It is estimated that the diesel achieves 50% thermal efficiency (it consumes 0.28 lb. of fuel per SHP-hour), while the steam turbine converts only 25% into mechanical power (0.57 lb. per SHP-hour). These data imply that the diesel engine consumes about 50% less fuel than a steam turbine of equal output, thus increasing the vessel's carrying capacity by saving on bunker space. The breakthrough in the design of marine diesel engines, however, has been the installation of special equipment that enables them to use the heavy residual "bunker C" as fuel oil, while the expensive diesel oil is now used only for the warming up. The above-mentioned savings on fuel consumption can, thus, be directly translated into lower fuel oil bills, a fact of great importance during the high oil price era of the '70s and early '80s. Furthermore, the spectacular advances in automation have resulted in one-man engine-room operations, nullifying the previous advantage of turbines with respect to crew requirements. It is these factors, along with the higher controllability of diesel power allowing better maneuverability and easier steering, which have made diesel engines the dominant type of propulsion system for merchant vessels. Today steam installations can be found only on some older very large (more than 200,000 DWT) vessels, usually tankers and OBOs.

2.5 Other factors

Two other factors affect the resale price of a ship; its general condition and the type and capacity of cargo handling equipment installed on-board.

A good indicator of the general condition of a vessel is its "class". Ocean-going vessels of 100 GRT and above are built under the supervision of one of the officially recognized "classification societies", which have established rules and regulations for the classification of steel ships and their machinery, such as main and auxiliary engines, boilers, pumps, and electrical equipment. Classification societies follow a ship from the builders to the breakers, and it is on their recommendation that insurance companies assume "risks". Compliance is recognized by the grant of a "class", which is meant to be a certification of the vessel's seaworthiness and overall character. Compliance is ensured by the classification society's close involvement in the vessel's design and construction, which includes not only approval of plans and specifications, but also continual surveys of the vessel during the building process. The class is maintained during the life of the vessel by scheduled surveys that become more thorough as the vessel ages. Unless the flag of registry insists, a shipowner is not actually compelled to classify the vessel. However, the commercial sanctions against nonclassification are so great, particularly in terms of hull insurance (a prerequisite in almost all cases to obtaining cargo) and any possible sale of the vessel, that compliance is virtually universal.

There are fourteen officially recognized classification societies around the world, the best known among them being the Lloyd's Register of Shipping (British), the American Bureau of Shipping, and Der Norske Veritas (Norwegian). Not all of them have the same rules and regulations, some being stricter than others. Therefore, the classification society and the class of a ship is a good indicator of its construction and maintenance standards, and thus, can affect its resale price. Along these lines, the flag of registry of a vessel may also have a minor role to play. Registry flags impose various requirements, usually regarding life safety equipment.

Finally, the number, type, and capacity of cargo handling equipment installed on a ship can affect its price, since a speedier loading/unloading operation reduces the non-revenue-earning time in port, and the amount of port charges. Claesseus [8] has investigated the effect of the number of derricks and cranes on the newbuilding prices of general cargo ships. Eq. (8) shows that the coefficients of these variables are positive and highly significant. For bulk carriers however, this factor loses some of its importance, since these vessels usually call at specialized bulk terminals which are equipped with cargo handling facilities much more efficient than any possible on-board installations. Cargo handling equipment may be important in some bulk routes, where due to shallow waters, the large bulk carriers cannot enter the port, and the cargo is worked outside the port, where barges or smaller vessels are loaded/unloaded by the ship's own means.

CHAPTER 3

COSTS OF OWNING AND OPERATING A SHIP

The costs of owning and operating a vessel affect its profitability and its resale price. The chapter provides the definitions of the various types of ship costs, and a brief discussion of the factors which determine their level. Ship costs are usually grouped in three categories: capital costs, operating costs, and voyage specific costs. The following three sections discuss these cost types.

3.1 Capital Costs

Capital expenditure in the shipping industry is generally very large, infrequent and provides benefits over an extended period of time. In order to make capital outlays readily comparable to revenues and other costs, they are usually converted into an equivalent period capital charge, where period can be either a calendar year or the duration of a charter, depending on the particular application.

Figure 4(a) shows the capital flows over the expected life of the investment (T periods). V_O is the value of the ship at the time of its acquisition, while EV_T is its expected value at the time of its disposition. The acquisition price, V_O, can be either the newbuilding or the resale price of the ship, depending on whether the vessel

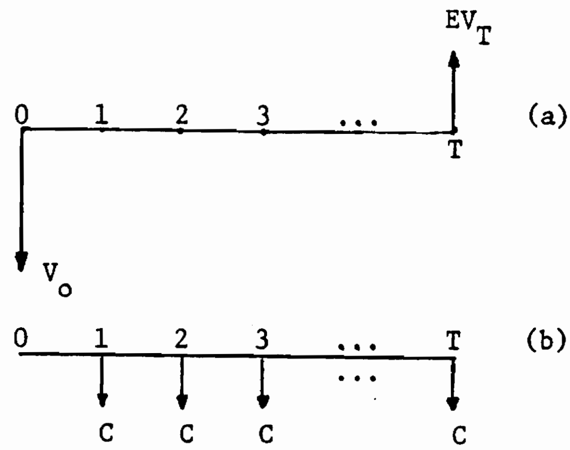

Figure 4. Calculation of the equivalent period capital cost

was bought new or second-hand. The disposition price, V_T, can be either the resale or demolition price, depending on whether the ship is going to be sold for further trading or for scrap. The net present value of capital costs is calculated by subtracting the present value of the expected disposition price from the purchasing price:

$$PV = V_o - \frac{EV_T}{(1+d)^T} \qquad (12)$$

where PV = net present value of capital costs;

V_o = purchasing price;

EV_T = expected disposition price;

T = expected life of investment; and

d = a discount rate reflecting the opportunity cost of the capital invested in the vessel.

The equivalent period capital cost, as shown in Figure 4(b), is then calculated from PV by the annuity formula:

$$PV = C \cdot \left[\frac{1}{d} - \frac{1}{d(1+d)^T} \right] \tag{13}$$

or

$$C = \frac{PV \cdot d \cdot (1+d)^T}{(1+d)^T - 1} \tag{14}$$

Substituting for PV from (12) then gives:

$$C = \frac{d \cdot \left[V_0 \cdot (1+d)^T - EV_T \right]}{(1+d)^T - 1} \tag{15}$$

Assuming that the vessel is bought and sold in the second-hand market, eq. (15) shows that capital charges depend on the present and expected future resale prices of the ship. Since resale prices is the central topic of this study, the notion of capital costs has no merit in the present context, and it will not be pursued any further.

3.2 Operating Costs

These are costs which are associated with the decision to operate a ship and which do not vary immediately or significantly with the route sailed. They include crew costs, provisions for the crew, supplies and parts, repairs, maintenance and survey costs, insurance, and general administration. Operating costs are considered as fixed over a short period of time, even if the vessel remains idle seeking employment.[14]

For indicative purposes only, Table 6 provides a breakdown of total costs into major components for a 25,000 and a 110,000 DWT bulk carrier in 1981. Operating costs account for about one-fifth of the total. Percent estimates of ship costs, however, should always be treated very cautiously because the high volatility in the second-hand and fuel markets can cause dramatic changes in all cost categories even within a few month period.

3.2.1 Crew costs

Table 6 shows that crew costs account for about 50% of all operating costs, and Table 9 indicates that this is only a lower limit. There are many components of crew costs. Viewed from the shipowner's side, they include basic salaries, leave, social security payments, overtime, medical expenses, training, welfare, and relocation expenses. In 1980, a Swedish company estimated that, for each rank, based on basic wage index of 100, the total costs to the owner were 339, as shown in Table 7.

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[14] When the prospects of obtaining cargo at reasonable rates are minimal over longer periods, ship operators can reduce operating costs by laying-up the vessel. For more details refer to Section 4.3.1.3.

Table 6. Percentage of total costs by cost component for a container vessel, a 25,000 dwt and a 110,000 dwt bulk carrier, 1981

	Container vessel 1000 teu (*a*)		25 000 dwt bulk carrier		110 000 dwt bulk carrier	
Capital cost (*b*)		59		40		42
Operating costs (*c*)		20		23		18
Manning	9		12		9	
Lubes, supplies and spare parts	2		3		2	
Repairs and maintenance	4		3		3	
Insurance	3		3		2	
Administration	2		2		2	
Voyage (*d*)		21		37		40
Fuel	19		30		37	
Port	2		4		3	
Canal fees			3			
TOTAL		100		100		100

Notes: (*a*) Vessel size is measured as 1000 twenty foot equivalent units (containers);
(*b*) Based on the price of a vessel ordered in 1979 and financed by 80% debt at 8·5% interest over eight years converted to an annual equivalent amount over 15 years at a return to the owner of 10%;
(*c*) average costs derived from a sample of 4, 13 and 5 vessels for the container, 25 000 dwt and 110 000 dwt bulk carrier, respectively; and
(*d*) averages based on route and port conditions appropriate for each ship type.

Source: Heaver [26] p. 40.

Table 7. Total crew costs to the owner

	Index
Basic wage	100
Paid vacation	125 (1 on, 1 off)
Social security, etc.	75
Overtime	1 (mainly consolidated)
Medical, illness	4
Training	2
Welfare	0·5
Travel (days lost)	4
Travel (fares, hotels, etc.)	27
Miscellaneous	0·5
TOTAL	339

Note: i.e. total cost to owner = 3·4 × basic wage for each rank

Source: Moreby [35] p. 56.

Table 8. The range of operating costs for a sample of bulk carriers, 1981 (U.S. $ per day)

	25 000 dwt bulk carrier (a)	110 000 dwt bulk carrier (b)
Manning	1060–3655	905–3870
Lubes, supplies and spare parts	320– 810	590–1110
Repairs and maintenance	235–1070	495–1400
Insurance	310– 680	370– 795
Administration	245– 540	415–1320
TOTAL	2865–6210	4045–7945

Notes: (*a*) Based on a sample of 13 vessels.
(*b*) Based on a sample of 5 vessels.

Source: Heaver [26] p. 42.

Table 9. Handy-sized bulk carrier, 1982-annual costs in thousand U.S. $

	US	Japan	W. Germany	UK	Greece	FOC
Crew	2768	2705	1460	980	920	547
M & R	510	252	252	252	252	277
Insurance	733	216	216	216	227	227
Overhead	45	100	100	100	100	100
	4056	3273	2028	1548	1499	1151
(Crew %)	(68%)	(82%)	(72%)	(63%)	(61%)	(47%)
Cap.	11458	3958	3958	3958	3958	3958
	15514	7231	5986	5506	5457	5109
(Crew %)	(18%)	(37%)	(25%)	(18%)	(18%)	(11%)
Fuel	1930	1930	1930	1930	1930	1930
TOTAL	17444	9161	7916	7436	7387	7039
(Crew %)	(15%)	(29%)	(18%)	(13%)	(13%)	(8%)

Value – new: $19 000 000 (US built – $55 000 000); second-hand: $7 800 000.
Financing – New: 100%, 8 yrs., 13% = $3 958 000 (U.S. = $11 458 000);
Second-hand: 80%, 8 yrs., 13% = $1 500 000.
Fuel – 300 days/year × 33 tons/day × $195 per ton = $1 930 000.

Source: Moreby [35] p. 57.

The range of operating costs by category for a sample of bulk carriers in 1981, estimated in U.S. dollars per day, is shown in Table 8. The significant variation in the observed total operating costs which is in the region of 100% for both ship sizes, is mostly explained by the variation in crew costs which can be as high as 420%. The reason for such dramatic variation in crew costs is heterogeneity in crew nationality, the country of registry, and management practices.

Crew nationality is crucial in determining crew costs. The annual crew costs to the owner of a ship manned by Indian crew, for instance, can be as low as 18% of the annual bill of a Japanese crew. The country of registry of a ship affects crew costs when it is associated with certain constraints on operations. Most countries determine a minimum number of crew berths for each type and size of ship. Constraints may also exist on the nationality of the crew. The flag of registry, therefore, is an important factor affecting crew costs. In fact, differences in crew costs is the main reason for "flagging-out", switching operations under the so-called Flags of Convenience (FOC), which do not impose restriction on crew nationality. Table 9 shows the difference that the country of registry can make in operating a handy-sized (between 10 and 40 thousand DWT) bulk carrier.

Differences in management practices among firms may also affect crew costs. For example, changing crew arrangements may enable more routine maintenance by the crew, thereby increasing the crew bill but reducing repair and maintenance expenses.

3.2.2 Provisions and supplies

Provision costs are the costs of feeding the crew and any guests on board while in port. Guests may be spouses and children of the crew, company officials, pilots and port officials, agents, surveyors, and other official visitors. In the past, provision costs were varying considerably depending on the ports visited. However, nowadays large amounts of food are carried deep frozen on board the vessel, making it possible to purchase the required food where it is cheapest. The common approach of estimating provision costs is as a constant cost per crew berth per day. The crew size is then the determinant factor of provision costs, and this depends on the ship size and the country of registry as explained in the previous section.

Supplies costs cover a large number of items necessary for running the ship. They may be summarized in the following categories:

(a) marine stores: paints, ropes, wires, safety equipment, cargo equipment, and fresh water;
(b) engine stores: chemicals, gases, electrical consumable items, greases, packing, and tools;

(c) lubricating oils;
(d) stewards supplies: cleaning materials, stationary, linen, cutlery, and soft furnishings;
(e) recreational supplies;
(f) clothing supplies; and
(g) extra handling charges to move supplies to the vessel.

3.2.3 Repairs and maintenance

This item includes both routine repairs and maintenance and an allowance for unexpected repairs. Repairs and maintenance include costs for labor, parts and materials, tools, and equipment. Where maintenance is carried out by the ship crew, the labor cost is usually included under crew costs. In addition, some of the items necessary for maintenance work may be included under supplies costs. Routine maintenance costs can vary with ship and cargo type, ship age, engine type, and trading area. The carriage of particular commodities leads to variations in repairs and maintenance costs on account of: (i) the damage the cargo itself causes to the steel structure of the ship; and (ii) the port and handling conditions with which particular commodities are associated. The sea conditions under which a vessel operates will affect the wear and tear on it. For example, operating for a long period in the North Atlantic region will place greater stresses on a vessel, than would operating in generally calmer areas.

Unexpected repairs, on the other hand, are difficult to cost due to their irregular nature. These costs will vary considerably depending on the nature of the repairs and the location of the ship at the time. The allowance for unexpected repairs is usually expressed as a percentage of the vessel's annual capital cost.

3.2.4 Insurance

Insurance costs include cover for loss and damage to the hull and machinery, protection and indemnity, war risks and in some cases, loss of earnings, crew insurance, strike insurance and liability for oil pollution. Hull and machinery insurance covers loss and damage as well as liability in the case of a collision.

Proctor [40] has identified the following main factors affecting the cost of insurance:

(a) type of vessel, its size, age, propulsion system, flag and classification society;
(b) valuation;
(c) area of operation;
(d) conditions of insurance; and
(e) management and past claims experience.

The type of vessel determines the type of cargo that is to be carried, and the average time the ship will spend in port. Cargo type is important because some commodities are more hazardous than others. Coal, for example, can cause spontaneous combustion, which can have a drastic effect on the hull of a vessel. Ships using port facilities frequently have higher risk of colliding with other vessels or fixed objects than ships which spend most of their lives on the high seas. The size of the vessel provides useful information such as the availability of repair facilities (large vessels are more restricted than smaller ones) or the accessibility to high risk areas (for instance, waterways with restricted draught which could lead to groundings are not accessible to large vessels).

Naturally the age of a vessel is important since any structure over a certain age is susceptible to wear and tear and general deterioration. In addition, heavy weather would cause more damage to an older vessel than to a younger one. The same arguments apply to the propelling machinery. Furthermore, old equipment run the additional risk that the original manufacturers have either gone out of business or changed the range of their products.

The flag of a vessel is of great importance as standards vary between countries, especially regarding safety and crew requirements. It is well known that vessels trading under certain flags have over the years higher percentages of lost tonnage than those of other maritime nations. The class of a vessel granted by the official classification societies is also important, as it is an indicator of the construction and maintenance standards with which the ship has complied.

Unlike most other insurance policies, in hull insurance claims are payable in full up to the insured value, which has to be agreed at the commencement of the risk and usually lasts for 12 months. Naturally the insurance costs depend on the insured value, which is usually somewhere between the current market value and current replacement value. Insured value much higher than the current market value of a ship creates a "moral hazard" problem, while too low insured value means that the owner wishes to save on insurance premium and is unacceptable by the banking institutions usually involved in financing the ship's purchase.

The geographical area within which a vessel may trade also has an effect on insurance premiums. Basically the purpose of area restrictions is to exercise some control over vessels trading in areas which are subject to ice hazards.

The conditions of insurance have the greatest bearing upon the ultimate insurance cost because they determine exactly what risks are covered and what are not. The last important factor is the record of a shipowner. A submission showing a consistently bad record of claims made upon underwriters in the past will not be treated as favorably as one upon which no or very few claims have been made.

3.2.5 General administration

General administration involves maintaining a base or central point from where the ship is managed. Tasks performed include ship support, record keeping, accounting, and communications. Ship support involves planning, chartering, arranging and organizing crew recruitment and training, changing of crews, repairs and maintenance operations, insurance requirements and ordering supplies. These costs depend on the extent to which administration services are subcontracted, the size and structure of the shipping company, and items such as the location of headquarters.

Apportionment of administration costs amongst vessels in a fleet can be difficult since administration costs do not necessarily vary greatly with vessel size. It is also difficult to distinguish between ship management costs and corporate management costs. Often allocation of these types of overhead costs can only be done arbitrarily. The common practice is to specify administration costs as a fraction of vessel operating costs.

In the preceding sections the five major components of operating costs have been discussed. The following factors were found to affect operating costs in general: the physical characteristics of a vessel such as its type, size, age, and propulsion system, the nationality of crew, country of registry and classification society, the type of cargo carried and the trading area. It is interesting to notice that once a vessel is bought, flagged, and staffed, there is very little the owner can do to affect operating costs. Therefore, these costs can be considered as fixed costs in the short- to medium-run, and even if not, they are very much predictable.

3.3 Voyage Costs

The last category of costs include those incurred directly because of a particular voyage of the vessel. Most important in those direct or, in economic terms, marginal costs are expenditures for fuel. Other expenses are port and canal charges, and agency and brokerage fees, if applicable.

3.3.1 Fuel costs

As discussed in Section 2.4, diesel engines are the dominant type of propulsion system installed on merchant ships today. Under this system, energy for tasks other than propulsion (such as lighting, heating, cargo handling, etc.) is produced by auxiliary engines. Total fuel costs, therefore, is the sum of the fueling costs of the main and auxiliary engines. The daily fuel cost of a diesel engine is given by:

$$FC = 24/10^6 * BHP * SFC * FP \qquad (16)$$

where FC = fuel cost in U.S. $ per day;

BHP = brake horsepower of the engine in HP;

SFC = specific fuel consumption in grams of fuel per HP per hour; and

FP = fuel price in U.S. $ per metric ton.

The specific fuel consumption of a diesel engine can be considered as constant or independent of the speed of the engine (in rounds-per-minute).[15]

As far as propulsion machinery is concerned, the horsepower requirements increase exponentially with the ship's speed, and less than proportionally with the ship's size. A shipbuilding rule-of-thumb makes brake horsepower proportional to the 2/3-power of DWT, multiplied by the cube of the design speed:

$$BHP = a*DWT^{2/3}*SP^3 \tag{17}$$

This relationship was tested for a sample of 81 bulk carriers and tankers, and the resulted plot is shown in Figure 5. Equations (16) and (17) indicate that the daily fuel costs for the main engines, which occur only while sailing, depend on the physical characteristics of the vessel and the fuel price. Fuel prices, in turn, depend on the world oil price, the quality of the fuel,[16] and the location of purchase.

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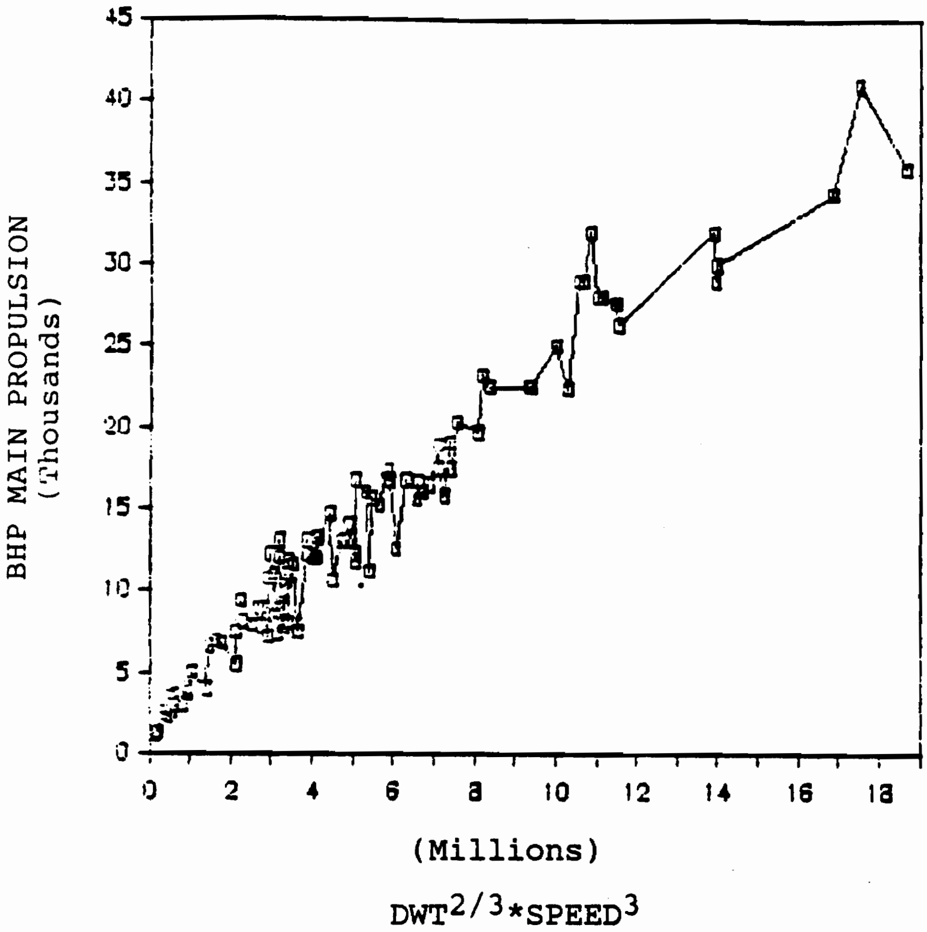
[15]In fact, the specific fuel consumption is a U-curve when plotted against rpm. Under normal conditions, however, the engine is operated in the trough of the curve, which happens to be very flat, and therefore, the assumption of constant specific fuel consumption is justified.

[16]The most important quality characteristics of fuel oil which affect its price are its calorific value (measured in Kcal/Kg), its viscosity (measured in centistokes), and its water and sulphur content.



<u>Figure 5. Propulsion requirements for bulk carriers and tankers</u>

Source: Arnold and Panagakos [2] p. 163.

Although eq. (16) holds for the auxiliary engine fuel cost too, a neat formula in the form of eq. (17) is not available for the auxiliary horsepower requirements. Judging by function though, the required power of the auxiliary machinery should depend on the type and size of the vessel, and the existence and capacity of cargo handling equipment.

Hence, the total fuel costs depend on the physical characteristics of the vessel, the fuel price, and the proportion of the time the ship spends at sea or in port. The later depends on the type of cargo carried and the particular route in which the ship is employed.

Another type of fuel related cost has been mentioned often (see for example Buxton [6]), and this is the reduction in the holding capacity of a ship by an amount equal to the fuel weight. Modern ocean-going vessels have a bunker capacity sufficient for 15,000 to 20,000 miles at full speed, which takes up 2,000 to 5,000 DWT, allowing more bunkers to be loaded at cheaper ports. This opportunity cost, however, should be considered only at the design stage of the ship, and should be ignored once the vessel has been launched.

3.3.2 Port and canal costs

Port charges are levied by national governments, state governments, various public port authorities and privately owned ports. Government charges can relate to navigational aids, lights, and funds established to combat oil spills and other pollution caused by ships. Port authorities are generally responsible for maintaining channels, berths and wharf facilities, and administration of the port including ship movements, provision of pilots and other services.

Private ports are generally involved in the transport of industrial and mining products.

Port charges vary significantly from port to port, but they generally fall into two categories: charges on the vessel, and charges on the cargo. The first category includes tonnage charges, pilotage, tug hire, berthing, harbor and light dues, and incidental charges such as fresh water, electricity, and garbage disposal. Charges on the cargo are generally termed "wharfage" and are based on the type and amount of cargo that is loaded and unloaded at the port.

Table 10. Port and canal costs

	PORT CHARGES (i)						CANAL DUES (ii)			
	Rotterdam			Ras Tanura			Suez			
	20,000	60,000	250,000	20,000	60,000	250,000	60,000 L	60,000 B	250,000 L	250,000 B
	'000 US $						'000 US $			
1983	17	38	120	4	8	26	64	51	166	133
1984	17	39	125	4	8	27	67	52	167	130
1985	17	39	125	4	8	25	66	53	162	129
1986	17	39	125	4	8	25	79	63	188	152
1988—Jan.	25	57	180	4	8	23	94	75	223	181

	New Orleans			Yokohama			Panama	
	20,000	60,000	100,000	20,000	60,000	250,000	20,000 L	60,000 L
	'000 US $						'000 US $	
1983	8	13	15	13	24	57	21 2	49 4
1984	15	22	29	12	24	56	21 2	49.2
1985	19	26	35	12	24	56	21.2	49.2
1986	19	26	35	12	24	68	21 2	49.2
1988—Jan.	19	26	35	13	25	69	21.2	49.2

(i) Port charges for tankers at Rotterdam, Ras Tanura and Yokohama, for dry cargo vessels at New Orleans.
(ii) Suez Canal dues for tankers. A 250,000 dwt tanker can only transit the Canal with a part load of about 130,000 tonnes. Panama Canal dues for dry cargo vessels. L = Laden, B = Ballast.

Source: Lloyd's Shipping Economist [33], March 1988, p. 11.

Canal charges can consist of several items, including tolls, charges for line handlers, launch hire, light dues, and pilotage. The charges for the Panama and Suez canals are based mainly on net tonnages, and also on the length and beam of the vessel.

The port and canal costs, therefore, depend on the physical characteristics of the vessel, the type of cargo, and the particular route on which the ship is employed. As shown in Table 10 port and canal tariffs do not change very frequently, and when they do, the revised tariffs are published well in advance, making this cost item very much predictable.

CHAPTER 4

FREIGHT RATES

4.1 Profitability of a Second-hand Ship

In several cases in the previous chapters, the potential profitability of a second-hand ship was used to justify various factors affecting its price. It is now time to deal with a vessel's profitability in a more formal way.

In analyzing the demand for newbuilt vessels, Beenstock [3] suggested the use of the portfolio selection theory (see e.g. Markowitz [34]), which implies that the demand for ships varies directly with the expected return on ships as capital assets and inversely with returns on competing assets. According to the same theory, the demand for ships also depends on the variance-covariance matrix of the expected returns on ships and other assets.

Although the application of this theory in the newbuilding market is clearly plausible, this is not the case when one looks at the second-hand market for ships. The reason is that in the second-hand market both buyers and sellers are (or at least intend to be) symmetrically placed in the ship operating business, and the factors influencing the industry's profitability affect both of them in the same way. One may ask: why then second-hand ships are traded in the first place. The answer comes from the fundamentals of the microeconomic theory. It is the marginal ship traded which sets the market price. For this marginal unit, the marginal valuation of the seller is equal to the marginal valuation of the buyer, and both are equal to the price. For all inframarginal units, buyers value ships above their market price, and sellers below, which explains the second-hand trading.

There are many factors which may explain differences in the value that various operators put on a single ship. Trade specialization is one of them. For example, an operator specializing in the grain trades, where traditionally handy-sized bulk carriers (10 to 40,000 DWT) are used, places a lower value to a very large vessel (say over 100,000 DWT) than a shipowner specializing in the iron ore trades where the large bulkers are usually employed. Even within the same trade, differences in valuation may result from the comparative advantages some operators enjoy over their competitors. It has been shown in the previous chapter that the flag a ship is flying affects significantly its operating costs, let alone the inevitable differences in the efficiency of operations among various shipping lines.

Government intervention may also play an important role. Most governments in the world today, including those of the developed market-economy nations, have realized the benefits that a national fleet offers to the country (through independence in transportation, employment opportunities, foreign exchange earnings, etc.), and provide various types of direct (such as cargo reservation schemes) or indirect (such as favorable tax treatment) subsidies to the national ship operators. Dramatic differences in a ship's valuation may arise by a government's decision to engage directly in ship operations. Probably the most significant example, in recent years, has been the decision by the government of the People's Republic of China to increase the Chinese fleet to a level where it could participate fully in the projected growth of the country's seaborne trade. From a fleet of less than 7.5 million DWT in the middle of 1978, the Chinese had built up a fleet of almost 13 million DWT by the end of 1980 (mainly through purchases in the second-hand market), at a cost of some U.S. $1,400 million [11].

The differences in the value ship operators put on a ship, as discussed above, are important in explaining the total volume of ships traded in the second-hand market over a specified period of time. This, however, exceeds the limits of this study, which seeks to explain only the resale prices. Thus the focus here is the marginal ship sold, which determines the market price and is equally valued by both buyer and seller. Therefore the analysis to follow refers to a single marginal operator.

The concept of present value used in the discussion of capital costs (Section 3.1), can be employed here once again. Assume for the moment that a ship operator considers buying a second-hand vessel at a price V_o. Given the type, size, and age of the vessel, and based on the best available knowledge of the industry practices and projections of technological advances in ship design, the vessel under consideration is expected to have an active life of T periods, at the expiration of which the ship will be scrapped. Further assume that once the vessel is bought, no alternatives are offered to the operator other than keeping the vessel over its entire expected life and having the vessel continuously employed under the freight rates prevailing in the market for each period. The expected cash-flow generated by the vessel's operation is shown in Figure 6. Each period i results in an operating profit Ri,

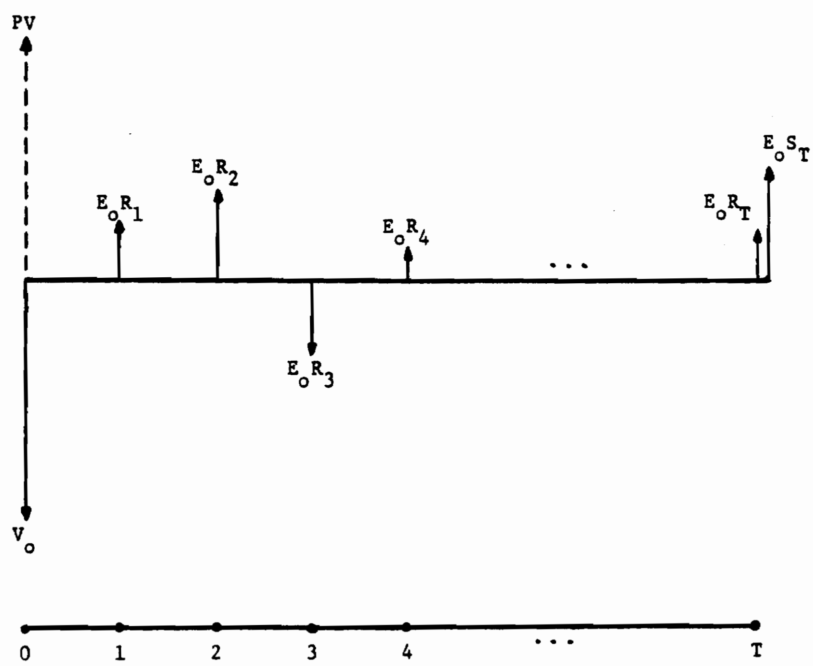


Figure 6. Projected cash-flows from ship operation

which may be positive or negative. At the end of period T the vessel is sold for breaking at a price S_T. At the time of purchase, only estimates of future cash-flows are available. The symbol $E_t(\cdot)$ is the expected value operator at time t. Assume in addition that the operator has a constant equivalent period discount rate d reflecting the appropriate opportunity cost of capital.

The expected future cash-flow is then equivalent to the present value PV given by:

$$PV = \sum_{i=1}^{T} \frac{E_o(R_i)}{(1+d)^i} + \frac{E_o(S_T)}{(1+d)^T} \tag{18}$$

To simplify notation, define w_i as:

$$w_i = \frac{1}{(1+d)^i} \tag{19}$$

Equation (18) then becomes:

$$PV = \sum_{i=1}^{T} w_i E_o(R_i) + w_T E_o(S_T) \tag{20}$$

According to the efficient market hypothesis, the marginal buyer is not willing to pay more than PV, while the marginal seller is not willing to accept a price less than PV. Thus, the resale price of the ship V_o can only be equal to PV, which gives:

$$V_o = \sum_{i=1}^{T} w_i E_o(R_i) + w_T E_o(S_T) \tag{21}$$

Equation (21) shows that the resale value of a ship is a weighted average of the expected future profits from its operation and the expected demolition price at the end of its life.

The assumption that the buyer of the vessel can only keep the ship over its entire life can now be relaxed. Assume instead that at the end of any period t ($t \neq T$), the operator can either keep the vessel or sell it for further trading. It will be shown that the original value of the ship, V_o, is still given by eq. (21).

Following the same line of thought as above, it is easy to show that a resale of the vessel at the end of period t results in:

$$V_o = \sum_{i=1}^{t} w_i E_o(R_i) + w_t E_o(V_t) \qquad (22)$$

where $E_o(V_t)$ is the expected resale value at time t. According to eq. (21), the value of the vessel at time t is given by:

$$V_t = \sum_{s=1}^{T-t} w_s E_t(R_{t+s}) + w_{T-t} E_t(S_T) \qquad (23)$$

Taking expectations of both sides of eq. (23) gives:

$$E_o(V_t) = \sum_{s=1}^{T-t} w_s E_o[E_t(R_{t+s})] + w_{T-t} E_o[E_t(S_T)] \qquad (24)$$

Assuming that expectations are rational in the sense of Muth [36], the terms $E_o[E_t(R_{t+s})]$ and $E_o[E_t(S_T)]$ become $E_o(R_{t+s})$ and $E_o(S_T)$ accordingly. Multiplying both sides of eq. (24) by w_t gives:

$$w_tE_o(V_t) = \sum_{s=1}^{T-t} w_tw_sE_o(R_{t+s}) + w_tw_{T-t}E_o(S_t) \qquad (25)$$

or

$$w_tE_o(V_t) = \sum_{s=1}^{T-t} w_{t+s}E_o(R_{t+s}) + w_TE_o(S_T) \qquad (26)$$

By using the transformation t+s=i, eq. (26) becomes:

$$w_tE_o(V_t) = \sum_{i=t+1}^{T} w_iE_o(R_i) + w_TE_o(S_T) \qquad (27)$$

Substitution of the term $w_tE_o(V_t)$ in eq. (22) from eq. (27) leads to equation (21). The option, therefore, of resaling the vessel in the future does not affect its present resale price, which still depends on expected future profits and scrapping prices.

The profits a ship operator realizes in any period of time is the difference between the freight (or charter) rate earned and the cost incurred during this period. It has been shown in Chapter 3 that this cost is the sum of operating and voyage costs. Then:

$$R_i = F_i - (OC_i + VC_i) \quad (28)$$

where F_i = the freight rate in period i;

OC_i = operating costs in period i; and

VC_i = voyage costs in the same period.

Substituting R_i from eq. (28) in eq. (21) results in:

$$V_o = \sum_{i=1}^{T} w_i E_o(F_i) - \sum_{i=1}^{T} w_i E_o(OC_i) - \sum_{i=1}^{T} w_i E_o(VC_i) + $$

$$+ w_T E_o(S_T) \quad (29)$$

Equation (29) indicates the dependence of the resale price of a vessel on the expected future freight rates, operating and voyage costs, and scrap prices. It also establishes the link between the second-hand and freight markets.

The determinants of operating and voyage costs were discussed in the previous chapter. It was also concluded there, that operators have some control over costs and are able to form reliable expectations, with the exception of fuel costs. The remaining sections of the chapter will discuss shortly the factors determining the level of freight rates in the short and long run. In addition, an effort will be made to relax the unrealistic assumption, made above, of always keeping the vessel employed regardless of the level of freight rates. A proper treatment of the shipowner's profit-maximizing decision on whether a cargo will be accepted or not should employ advanced dynamic programming techniques and exceeds the limits of this study.

4.2 Demand for Shipping Services

In section 1.1.4 several arguments were presented supporting the competitive character of the dry bulk shipping markets. In a competitive environment, the freight rates are determined by the interplay of demand and supply forces. Factors affecting the demand for shipping services are briefly discussed in this section.

The volume of international trade (measured in terms of tons or ton-miles) is the most important determinant of demand for shipping. In fact the significance of trade is such, that the demand for shipping services is considered as derived from the demand for imports and exports. All econometric models of world shipping place emphasis on this relationship. Some of them go even further and attempt to explain demand for shipping by including exogenous variables affecting trade (such as the GNP of developed countries). Since world foreign trade has been thoroughly investigated elsewhere, it will be treated here as an exogenous variable.

Charemza and Gronicki [7] have analyzed yearly data for the period 1961-77, and estimated the following equation:

$$QDT = 0.221 + \underset{(2.1)}{0.294*QDT_{-1}} + \underset{(5.2)}{0.660*W} \quad , R^2=0.991 \qquad (30)$$

where QDT = dry cargo shipments in million tons; and

W = the U.N. index of volume of world exports (1970 = 100).

The high value of the coefficient of determination, along with the significant (t-statistics in parenthesis) positive parameter of the export volume index, establish the relation between world trade and demand for shipping services.

While some authors describe demand for shipping only as a function of trade volume (such as eq. (30) above), others take into consideration the negative effect transport costs (or freight rates) may have on the level of world trade. Zepeda-Bermudez [48] provides a review of the literature on this topic. A departure point is Samuelson's[17] "transport demand theory", which deals with two spatially separated markets of a single good. Assuming constant unit transport costs, Samuelson developed a model determining the final competitive equilibrium prices in both markets, the amounts supplied and demanded at each place, and the amount exported/imported. The central point of this theory is presented in Figure 7.

Before trade, the equilibrium prices are P_1 in market 1 and P_2 in market 2, where supply and demand are equal in

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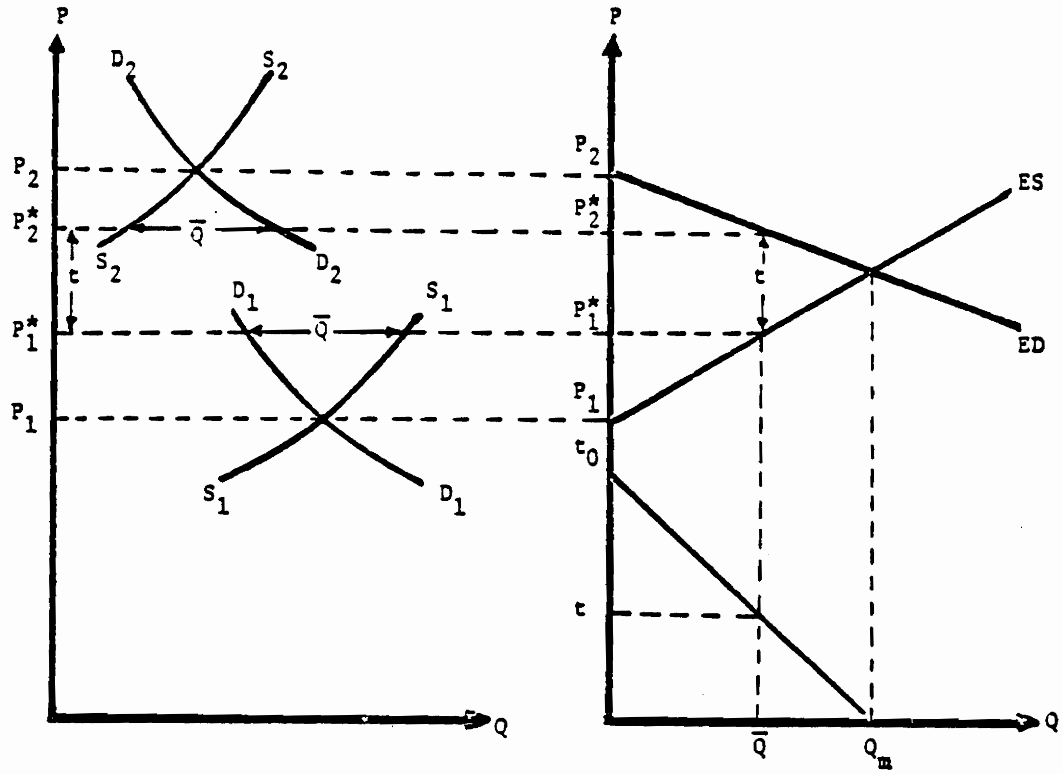
[17] Samuelson, Paul A., "Spatial price equilibrium and linear programming," American Economic Review, Vol. 42, June 1952.



P = commodity price

Q = commodity quantity

P_1, P_2 = market equilibrium prices without trade

P_1^*, P_2^* = market equilibrium prices when trade occurs

D_1, D_2 = demand curves for each market

S_1, S_2 = supply curves for each market

ES = excess supply curve

ED = excess demand curve

$\overline{Q}$ = quantity traded

Q_m = maximum quantity traded, when transport costs are zero

t = unit transport cost

$t_0 = P_2 - P_1$ = limiting transport cost, above which no trade will occur

Figure 7. Derivation of transport demand curve from trade between spatially separated markets

Source: Zepeda-Bermudez [48] p. 58a.

each market separately. At those initial equilibrium prices, the right-hand-side graph shows that both Excess Supply (ES) and Excess Demand (ED) curves are at their zero points. The ES and ED curves are obtained by taking at every price the lateral difference between the supply and demand curves.

Since the pre-trade price is lower in 1 than 2, trade will not flow from 2 to 1 for the commodity considered. If it is assumed that goods can move from 1 to 2 for t dollars per unit, there will be a positive flow of exports from 1 to 2 because the initial differential in prices exceeds the transport costs. That is, (P_2-P_1) is greater than t. The new equilibrium prices will be P_1^* and P_2^*, whose difference exactly equals the transport costs t. At this final equilibrium, the excess supply and excess demand curves will also differ vertically by the transport costs, t. This same equilibrium determination of trade flows $(\bar{Q})$ is shown in the lower part of the right-hand-side graph by the curve "t_oQ_m", which represents the vertical difference between the ES and ED curves. The final equilibrium is where the "t_oQ_m" curve intersects the value of constant unit transport costs, t. It is interesting to notice that for positive transport costs (or freight rates in a competitive market), the traded quantity, $\bar{Q}$, is less than Q_m, which corresponds to the export quantity when transport costs are zero.

Other authors, such as Prewo[18] and Shneerson,[19] have produced formulas and estimated the price elasticity of transport, but they are mainly concerned with liner shipping, and their results will not be presented here. Beenstock [3] has also hypothesized that the demand for shipping services varies directly with the volume of world trade and inversely with freight rates, and that view will be accepted here.

Although the connection between freight rates and transport demand has been established in the preceding paragraphs, one expects the demand schedule for shipping services to be relatively inelastic. The following reasons support this argument:

(a) All dry bulk cargoes are either raw materials or intermediate products requiring further processing. The demand for such products is usually inelastic. Since shipping is an input to a production factor the demand for which is inelastic, the demand for shipping services should also be inelastic.

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[18]Prewo, W., "The structure of transport costs on Latin American exports," Weltwirtschäftliches Archiv (Review of World Economics), Journal of the Kiel Institute of World Economics, 1978.

[19]Shneerson, D., "The structure of liner freight rates" Journal of Transport Economics and Policy, January 1976.

(b) The production plans of the mines and farms, where the major bulk commodities are originated from, are relatively independent of the cost of inputs, especially in the short run.

(c) Ocean transportation is very specialized. Therefore, the substitution of other input factors for it is technically almost impossible.

(d) The cost of shipping is only a small fraction of the total cost of the final product that uses it as an input.

4.3 Supply of Shipping Services

There are many factors affecting the supply of ships. The best way to describe them is to distinguish between short and long run. A definition of the duration of "short run" is then due. It is obvious that the short run cannot extend over a period of time long enough to allow for new entry or permanent exit of capacity, in response to shifts in demand that have occurred during the same time period. On the other hand, in the shortest of all possible short runs, the supply schedule will be almost vertical, with deviations from the vertical occurring because of pure speculation and not because of marginal costs. The time duration of the short run, then, will be defined as the period in between those two extremes, during which the capacity is fixed in terms of quantity and quality, with the exception of new capacity that has been initiated by conditions independent of the present level of freight rates.

4.3.1 Ship supply in the short run

Once ship deliveries and retirements have been excluded from the short-term analysis, the factors which may affect ship supply are:

(a) the magnitude of ship idleness;
(b) the magnitude of ship lay-ups;
(c) the speed of existing vessels;
(d) the inflow of other vessel types in the bulk trades; and
(e) the amount of ballasted traffic.

The amount of total losses and extensive damages (due to groundings, collisions, fire, etc.) also affect the supply of ships, but since it is not intentional and does not depend on market forces, it will not be considered here.

Zannetos [47] has made an attempt to estimate the short-term supply schedule of tankers during the '50s and his results are shown in Figure 8. There is no apparent reason to believe that the supply schedule of dry bulk carriers will have a different shape than that of tankers. It is clear form Figure 8 that the supply curve consists of two parts. The upper part, which corresponds to high

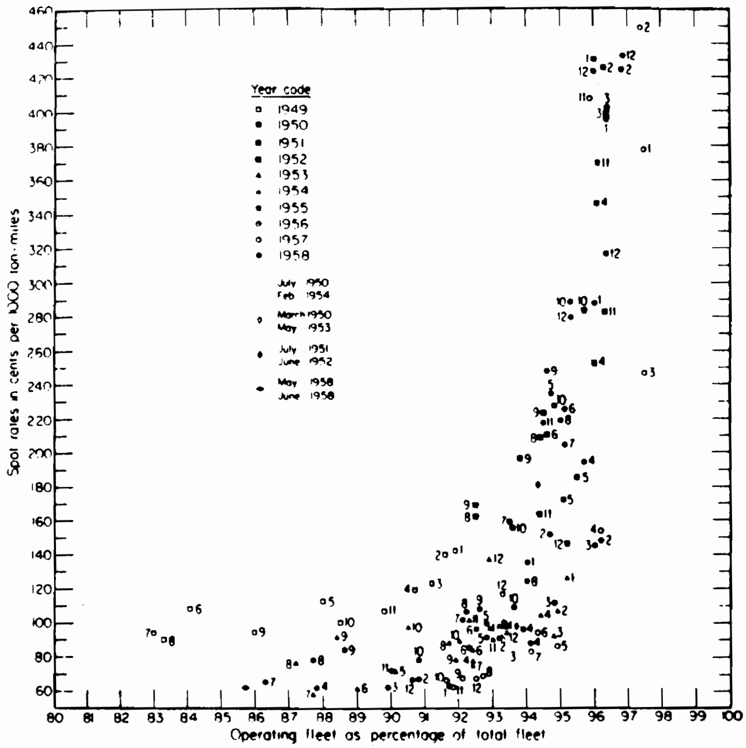

Figure 8. Scatter diagram of operating fleet as percentage of total fleet versus index of spot rates, 1949-1958 (monthly)

Source: Zannetos [47] p. 170.

freight rates,[20] is very inelastic, indicating that there is very little a shipowner can do during periods of capacity shortages.

During such times, one expects to find very few idle or laid-up vessels. Furthermore, it has been shown in Section 2.3 that the actual speed of a given vessel is bounded from above by its design speed. Thus, the only factors that can ease a ship shortage situation in the short-run are the

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[20]The freight rates, used in Figure 8, are the single voyage charter rates or "spot" rates.

employment of other types of vessels and the company's policy towards ballasted voyages.

Leaving ship conversions out of consideration in the short-term analysis, the only types of vessels that are able of operating in the dry bulk trades are tankers and combis. Tankers can be employed only in the grain trades, and even there, at a very high cost (due to their specialized design for liquid cargo, and the requirement for thorough cleaning of their tanks), which limits significantly their employment opportunities. Combination carriers can operate efficiently in the bulk trades, but in addition to the fact that their capacity is limited too, their short-term contribution is constrained because:

(a) combis are usually very large vessels and can be fully employed only in the iron ore and coal trades; and

(b) these vessels are usually hired on a long-term basis, which further limits their responsiveness to short-term shortages.

Ballasted traffic does affect capacity, but its importance is greater during periods of depressed market conditions, when operators are hard pressed to make ends meet. During periods of high rates, it is more profitable for vessels to hurry back to the main loading ports than to waste valuable time at the unloading area attempting to find new cargo which in addition may be unrenumerative, since the shippers, knowing that the vessels will have to go back in ballast, naturally try to strike a bargain based on out-of-pocket costs.

The preceding paragraphs have explained the inelastic part of the supply schedule during periods of high rates. In contrast, as shown in Figure 8, the supply curve becomes very elastic during periods of low freight rates. The options available to the operators of reducing the speed of the vessels, keeping them idle, or laying them up, can explain this behavior of the supply schedule. The following subsections briefly discuss these factors.

4.3.1.1 Slowsteaming

As in any other industry, the shipowners' incentives for cost reductions are greater during periods of depressed market conditions. It follows from the discussion of ship costs in Chapter 3, that the only cost item that can be reduced in the short-run (while the vessel is still in operation) is the fuel cost. During periods of low rates, ship operators take advantage of this alternative by reducing the actual speed of their vessels or "slowsteaming" in the maritime language.

Let S represent the actual speed of a vessel in knots, M the round-trip distance in nautical miles, K the number of days in port per round trip, N the number of trips per year, F the fuel consumption in tons per day at sea, and f the fuel consumption per day in port. Then, on a basis of 335 operating days per year,[21] the capacity of a vessel is 335*S*24 miles; and the number of trips is:

$$N = \frac{335*S*24}{M + (24*S*K)} \tag{31}$$

The number of sailing days D is:

$$D = 335 - N*K \tag{32}$$

and the yearly fuel consumption C is:

$$C = (335-N*K)*F + N*K*f \tag{33}$$

or

$$C = 335*F - N*K*(F-f) \tag{34}$$

It has been shown in Section 3.3.1 that the propulsion horsepower requirements increase with the cube of the speed (refer to eq. (17)), which also means that fuel consumption at sea is proportional to the 3-power of speed. A percentage reduction in speed r, then, leads to the reduced daily fuel consumption at sea $F*(1-r)^3$, and the new yearly fuel consumption C' becomes:

$$C' = 335*F*(1-r)^3 - N'*K*[F*(1-r)^3 - f] \tag{35}$$

where

$$N' = \frac{335*S*(1-r)*24}{M + [24*S*(1-r)*K]} \tag{36}$$

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[21]It is assumed that an average 30 days per year are needed for scheduled and unscheduled repairs, maintenance, and surveys.

The savings from slowsteaming then are equal to the difference of $(C-C')$ multiplied by the cost of fuel p.

$$(C-C')p = p*[335*F*[1 - (1-r)^3] - \\ - K*F*[N - N'(1-r)^3] + K*f*(N-N')] \tag{37}$$

Fewer trips per year also means lower yearly port and canal charges. If P is the port and canal charges per trip, the yearly savings, Y, are:

$$Y = p*[335*F*[1 - (1-r)^3] - K*F*[N - N'(1-r)^3] + \\ + K*f*(N-N')] + (N-N')*P \tag{38}$$

If T is the cargo carrying capacity of the vessel, slowsteaming causes a yearly loss in capacity

$$L = T*(N-N') \tag{39}$$

For a voyage rate per ton of cargo R, the yearly loss in revenues is R*L. Therefore, if the freight rate R is

$$R < Y/L \tag{40}$$

savings exceed losses, and the ship operator will choose to slow down the vessel, resulting in a yearly loss in capacity L.

4.3.1.2 <u>Ship idleness</u>

The microeconomic theory predicts that a production unit will "shut-down" operations whenever the market price of the product drops below the marginal cost of producing it. The same principle applies in shipping. Let VC_m be the minimum voyage cost that the so far marginal operator can achieve by sailing the vessel at its minimum economical speed,[22] and along the longest possible route (in order to economize in canal costs). If the short-term (or spot) rate drops below VC_m, the operator will not accept the charter and will keep the vessel idle. The previously marginal operator will now become extramarginal, while a more efficient one will be the new marginal operator.

Differences in efficiency explain the fact that among the first vessels to drop out of the market are the older ones (which have higher operating costs)[23] and the smaller ones (which cannot take advantage of scale economies, depending of course on the particular trade route).

The criterion $R < VC_m$ discussed above is not always operative in the decision on whether to accept a charter or not. Ballasted traffic is a case where the shipowner may carry a cargo at a rate even lower than VC_m. During periods of low rates, if a vessel happens to be located in an area where the chances of finding cargo are minimal, the operator will consider relocating the ship (in ballast) to a place of

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[22]There is a limit in speed reduction, beyond which fuel consumption starts increasing again due to the thermal efficiency of the engine which drops at low speeds.

[23]A very good discussion of the inefficiency of older vessels is given by Goss in [21].

higher employment opportunities. In this case a cargo moving towards the relocation area can be accepted at a rate as low as the difference between voyage costs when loaded and voyage costs when ballasted.

While waiting for the rates to improve, idle vessels usually undertake any necessary repairs, which are extended as long as hope for a reversal exists. Once such hope is lost, the vessels are laid-up.

4.3.1.3 Ship lay-ups

Both slowsteaming and ship idleness, discussed above, are ways of reducing voyage costs. Lay-ups aim at reducing operating costs as well. By laying-up a vessel, the operator reduces operating costs to a minimal amount by giving up, in exchange, the operational readiness of the ship and its immediate earning potential. The full crew is replaced by a watchman, the provisions, supplies, repairs and maintenance costs are no more applicable, and the insurance policy is significantly downscaled. A single payment is required, however, to prepare the vessel for laying-up, and a similar expense will incur in the future for its reactivation.

If OC and OC' are the operating costs of the vessel before and after its lay-up respectively, LA is the total cost of lay-up preparation and reactivation, VC_m is the minimum voyage cost, and R the prevailing spot rate, the operator will lay-up the vessel if:

$$LA + OC' < OC + VC_m - R \qquad (41)$$

or

$$R < VC_m + (OC-OC') - LA \qquad (42)$$

Equation (42) is only a first approximation. The vessel will be laid-up only if the rates are not expected to improve over the following several periods.

Zannetos [47] has looked at the laid-up tankers during the period 1949-58, and estimated the following equation:

$$y = 0.1 + 41.1/x^2 \quad , R^2 = 0.6 \qquad (43)$$

where y = lay-ups in T-2 equivalents;[24] and

x = an average rate expressed in dollars per 1,000 ton-miles.

In a more recent study, Haralambides [24] explained the laid-up tonnage of Greek-owned ships by the equation (yearly data for the period 1961-81):

$$\underset{(2.98)}{LU = 2222} + \underset{(2.6)}{10.03*W} - \underset{(-2.6)}{16.3*FR} + \underset{(0.46)}{0.09*LU_{-1}} - \underset{(-1.76)}{7.1*W_{-1}} \quad , R^2 = 0.49 \qquad (44)$$

[24]A T-2 equivalent unit is a tanker of approximately 16,500 DWT, achieving speeds of 14.5 to 14.6 knots.

where LU = laid-up tonnage in thousand GRT;

W = a weighted average of the basic wage rates of Greek seamen, for various ranks; and

FR = a weighted average of two freight rate indices.

Both studies find laid-up tonnage to be a decreasing function of freight rates, as expected.

4.3.2 Ship supply in the long run

Slowsteaming, idling, and lay-ups as discussed in the preceding sections do not affect the long-term ship supply. Instead, this depends on additions to and deletions from the fleet. The capacity of the fleet at any point of time is described by the identity:

$$VT_t = VT_{t-1} + ND_t - SC_t \tag{45}$$

where VT_t = the stock of existing vessels at the end of period t;

ND_t = deliveries of new tonnage during period t; and

SC_t = tonnage scrapped during the same period.

The factors affecting deliveries and scrappings are presented in the following two subsections.

4.3.2.1 Shipbuilding

The length of time required to build and deliver a ship ranges between one and three years depending on the availability of building capacity. The production cycle, which determines the level of deliveries of new tonnage, is usually described by a system of distributed lag equations.

Hawdon [25] has studied the tanker market for the period 1950-73, and has used annual data to estimate the following equation:

$$
\begin{aligned}
ND_t = \underset{(3.28)}{1.99} + \underset{(2.52)}{0.07} \cdot O_{t-1} + \underset{(1.10)}{0.03} \cdot O_{t-2} + \underset{(5.00)}{0.16} \cdot O_{t-3} + \\
+ \underset{(0.50)}{0.002} \cdot \Delta R_t
\end{aligned}
$$

$R^2 = 0.95$, t-statistics in parenthesis (46)

where ND_t = deliveries in year t;

O_{t-1} = orders placed in t-1;

$\Delta R_t = R_t - R_{t-1}$; and

R_t = tanker voyage (spot) freight index.

Orders in t-3 seem to be more significant in explaining ND_t than orders in t-2. This may reflect the continuous shortening of the production period since 1950 so that O_{t-3} was more important in the early years and O_{t-1} in the more recent years. The ΔR_t variable was included to measure the impact of economic conditions in the freight market on the pattern of deliveries. Its coefficient is small and insignificant, although positive. This may indicate that deliveries are speeded up slightly in times of rising freight rates.

In a more sophisticated model, Charemza and Gronicki [7] explain deliveries of dry-cargo tonnage by the following system of equations (using yearly data from the period 1961-77):

$$ND_t = -0.275 + \underset{(10.9)}{0.705 \cdot LD_t} + \underset{(5.2)}{0.339 \cdot LD_{t-1}} \quad , R^2 = 0.991 \tag{47}$$

$$LD_t = -0.00449 + \underset{(6.5)}{0.484 \cdot CD_t} + \underset{(6.9)}{0.499 \cdot CD_{t-1}} \quad , R^2 = 0.986 \tag{48}$$

$$CD_t = 3.025 + \underset{(3.0)}{0.187 \cdot O_{t-1}} + \underset{(3.7)}{0.260 \cdot O_{t-2}} + \underset{(5.3)}{0.318 \cdot O_{t-3}}$$

$$R^2 = 0.943 \tag{49}$$

where ND_t = deliveries of new tonnage in year t;

LD_t = tonnage launched in t;

CD_t = tonnage commenced in t; and

O_{t-1}= orders placed in year t-1 (all variables are measured in million GRT).

The above equations describe the lag structure of the ship production cycle, and provide the link between deliveries of new tonnage and orders placed. The determinants of the number of orders will be discussed in the remaining of the section.

Assuming profit maximizing firms, a ship's profitability is the single most important factor in a company's decision to place an order. Several studies in the past have connected the volume of orders placed to different measures of ship profitability.

Zannetos [47] in 1966 analyzed the structure of the tanker market during the 1950s, and observed a significant positive correlation between the number of orders placed and the spot freight rate. He argued that a substantial increase in tanker rates creates expectations of even higher rates in the future, driving shipping companies to increase their fleet in order to be able to take advantage of the favorable conditions in the market. He used quarterly data from the period 1954-58 to estimate the following equation :

$$O_t = -55.75 + 1.36 \cdot X_t \quad , R^2 = 0.78 \qquad (50)$$

where O_t = tanker orders placed in quarter t measured in T-2 equivalent units; and

X_t = tanker spot freight rate in cents per 1,000 ton-miles.

Twelve years later Hawdon [25] improved the above equation by considering in addition the volume of oil trade, the price of new ships, and the movement in freight rates. He assumed that shipowners order new capacity if the volume of oil trade increases, if the freight rate increases, or if the price of new ships falls. He used annual data from the period 1950-73 to estimate the following linear equation:

$$O_t = \underset{(5.22)}{-48.53} + \underset{(2.34)}{0.18 \cdot PS} + \underset{(11.34)}{5.09 \cdot TR} + \underset{(1.05)}{0.05 \cdot R_t} + \underset{(1.34)}{0.05 \cdot \Delta R_t}$$

$$R^2 = 0.90 \qquad (51)$$

where O_t = orders placed in million DWT during year t;

PS = price of new tankers in US dollars per DWT ton;

TR = world international seaborne trade in oil in million metric tons;

$\Delta R_t = R_t - R_{t-1}$; and

R_t = tanker voyage freight index.

ΔR_t was included to test the extent to which orders respond to anticipated rates rather than merely to current observed rates. In fact, equation (51) shows that ΔR_t is of greater significance in explaining orders than is R_t; ΔR_t being significant at the 10 percent level, while R_t is not. Trade has the expected sign, and is the most important influence on orders. The PS coefficient has not the expected sign however. One would expect ordering to decline as new ships prices rise. The positive coefficient may be due to collinearity between PS and R_t ($r = 0.67$), in which case the PS effect may represent part of the total rate effect.

Charemza and Gronicki [7] follow an indirect approach, linking new orders of dry-cargo vessels to the supply and demand conditions prevailing in the freight market. Using yearly data from the 1961-77 period, they have estimated the equation:

$$O_t = -40.443 - \underset{(-2.6)}{0.0766} \cdot VT_{t-1} + \underset{(5.8)}{2.310} \left[\frac{QDW_t}{VT_t} \right], \quad R^2 = 0.743 \qquad (52)$$

where O_t = new orders of dry-cargo ships in million GRT during year t;

VT_t= the world dry-cargo fleet in million GRT at the beginning of year t; and

QDW_t= dry-cargo shipments in 1000 million ton-miles.

Both variables of eq. (52) have the expected sign. Orders are negatively related to the fleet existing at the beginning of year t-1, and positively related to the ratio QDW_t over VT_t, which serves as an indicator of the demand-supply balance in the beginning of period t.

The most satisfactory theoretical analysis of the demand for new ships is presented by Beenstock [3] in 1985. He makes the hypothesis that ship owners regard vessels as capital assets which must compete with other capital assets in portfolios. The theory of portfolio selection implies that the share of ships in total wealth (W) varies directly with the expected return on ships as capital assets (R), and inversely with returns on competing assets (R^*). Thus:

$$\frac{O_t \cdot PS_t}{W_t} = f_1(\overset{+}{R_t}, \overset{-}{R_t^*}) \tag{53}$$

Eq. (53) implies that as real wealth rises the orders for new ships will rise ceteris paribus, i.e. independently of ship prices, freight rates, etc. It also implies that for given rates of return and wealth, the orders placed vary inversely with the price of ships (PS).

Furthermore, Beenstock presents the expected return on a ship as consisting of two components: net income and capital gains. He defines it as:

$$R_t = \frac{a_t(F_t - C_{1t}) - (1-a_t)C_{2t}}{PS_t} + \frac{E(PS_{t+1}) - PS_t}{PS_t} \qquad (54)$$

where R_t = the expected rate of return on ships;

PS_t = price of ship in period t;

$E(PS_{t+1})$ = the current expected value of the price of a ship in period t+1;

a_t = the probability that the ship will not be laid up during period t;

F_t = the market freight rate in period t;

C_{1t} = operating costs while in service; and

C_{2t} = ship costs while laid up.

Eq. (54) implies that the return on a ship varies directly with both the freight rate and the probability of remaining in service, and inversely with ship costs. It also varies directly with the expected ship price and inversely with the current price. Equations (53) and (54) are summarized in:

$$O_t = f_2(\overset{+}{a_t}, \overset{+}{F_t}, \overset{-}{C_{1t}}, \overset{-}{C_{2t}}, E(\overset{+}{PS_{t+1}}), \overset{-}{PS_t}, \overset{-}{R_t^*}, \overset{+}{W_t}) \qquad (55)$$

A general observation on all the models presented above [eq. (50), (51), (52), and (55)] is that they attempt to explain the volume of orders placed by using measurable substitutes of the unobserved expected future freight rates. One expects a shipowner to place an order if the present value of the stream of expected future revenues generated by the ship is greater than or equal to the newbuilding price. Thus, estimates of expected future freight rates and costs, along with current newbuilding prices should be the determinants of additions to the fleet. In the absence of those estimates, Zannetos is using current spot rates [eq. (50)], Hawdon is using world oil trade and first differences of freight rates [eq. (51)], Charemza and Gronicki are using current supply of and demand for shipping services [eq. (52)], and Beenstock is suggesting the vague $E(PS_{t+1})$ variable. Time charter rates, if available, and the recently introduced future freight rate index (BIFFEX) should be much more reliable predictors.

Finally, a factor, influencing orders for new vessels, which has not been mentioned so far, is the government subsidization of shipyards. In recent years, particularly since the depression which followed the oil prices' explosion of 1973-74, most countries have introduced substantial shipbuilding subsidies in order to attract orders in a period of chronic shortage of work, thereby preventing closures and politically unacceptable large-scale unemployment. As might be expected, this has had a disruptive effect not only on the newbuilding market, but also on other aspects of the shipping industry. Unfortunately, quantitative substantiation of the subsidy effect on ship orders is very hard to obtain.

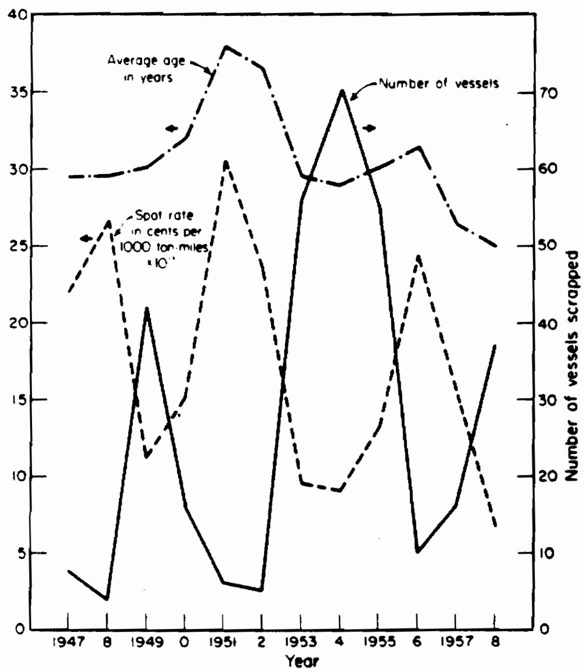
4.3.2.2 Scrapping

The level of ship scrapping is determined mainly by four factors:

(a) the capacity of existing fleet;
(b) freight rates;
(c) scrap prices; and
(d) technological changes in ship design.

Naturally world fleet capacity is a factor affecting the extent of aggregate ship demolition if the latter is measured in absolute tonnage (DWT or GRT). Scheduled capacity replacement alone causes the volume of ships scrapped to increase as the total world tonnage goes up, and vice versa. Of course fleet capacity is no longer a factor when scrapping is measured as a percentage of total tonnage.

Freight rates are probably the single most important factor influencing the level of scrappings. Past experience has shown a clear negative correlation between the number of vessels scrapped and the freight rates. Figure 9 shows that when the market is weak and shows little sign of recovery scrapping of unwanted tonnage becomes far more pronounced. Conversely, when the freight market does improve, a rapid fall in demolition sales soon becomes apparent.



<u>Figure 9.</u> <u>Number and average age of vessels scrapped and spot rates, 1947-1958</u>

Source: Zannetos [47] p. 121.

Quantitative evidence on the influence of world fleet capacity and freight rates on scrapping levels is presented below. Hawdon [25] used annual data from the period 1950-73 to explain tanker demolition with the equation:

$$SC_t = \underset{(2.54)}{1.12} - \underset{(2.17)}{0.003 \cdot R_t} - \underset{(2.55)}{0.004 \cdot R_{t-1}} + \underset{(2.49)}{0.11 \cdot F_t} - \underset{(2.25)}{0.59 \cdot T} \quad , R^2 = 0.78 \qquad (56)$$

where SC_t = scrapping of tankers during year t in million DWT;

R_t = tanker voyage freight index;

F_t = world tanker fleet in million GRT; and

T = world international seaborne trade in oil in million metric tons.

Charemza and Gronicki [7] explain scrappings of dry-cargo ships by the following equation (using yearly data from the period 1961-77):

$$SC_t = -0.496 + \underset{(4.3)}{0.040 \cdot VT_{t-1}} - \underset{(2.2)}{0.878 \cdot FDL_t} - \underset{(4.9)}{0.469 \cdot ST_t}$$

$$R^2 = 0.669 \qquad (57)$$

where SC_t = scrappings and losses of dry-cargo ships in million GRT;

VT_{t-1} = the world dry-cargo fleet at the beginning of year t-1 in million GRT;

FDL_t = an index of time freight rates; and

ST_t = scrappings and losses of tankers in million GRT.

In a more recent study, Drewry Consultants [15] used quarterly data from the period 1982-86 to estimate the following equation:

$$SC_t = 78.257 - 3.717 \cdot R_t \quad , R^2 = 0.586 \qquad (58)$$

where SC_t = scrappings of handysized bulk carriers during quarter t in million DWT; and

R_t = spot freight rate ($/DWT) for shipping grain from U.S. Gulf to Japan on 20 to 40,000 DWT bulkers.

Scrap prices is the third factor affecting the volume of ship demolition. One expects the tonnage scrapped to increase with scrap prices. Scrap prices are a function of a number of different factors. These include supply of and demand for vessels for demolition. However, demand for ship scrap is only part of a wider demand for ferrous scrap in general. Scrap prices vary widely with the location of the breaker, reflecting mainly labor costs (shipbreaking is a labor-intensive industry), and the proximity to steel plants (the major consumers of scrap steel). Scrap prices may also vary with the type and size of the ship to be scrapped. For example, the construction of very large tankers involves use of much steel plate which is suitable for rerolling. In the newly industrialized countries of Far East this may then be used in other construction projects. In reflection of this, scrap prices of these vessels are higher than others. Finally, the competition between individual shipbreaking countries to increase their respective market shares also influences scrap prices.

Drewry Consultants [15] have used quarterly data from the period 1981-86 to estimate the following rather simplistic equations:

Handysized bulk carriers:

$$\Delta SC_t = -2.511 + 0.065 \cdot SP_t \quad , R^2 = 0.436 \qquad (59)$$

$$\Delta SC_t = -2.484 + 0.079 \cdot SP_{t-2} \quad , R^2 = 0.482 \qquad (60)$$

Panamax bulk carriers:

$$\Delta SC_t = -1.880 + 0.040 \cdot SP_t \quad , R^2 = 0.543 \qquad (61)$$

$$\Delta SC_t = -2.835 + 0.054 \cdot SP_{t-2} \quad , R^2 = 0.613 \qquad (62)$$

where $\Delta SC_t = SC_t - SC_{t-1}$ = change in scrappings between quarters in million DWT; and

SP_t = quarterly average Far Eastern bulker scrap price in US$/ldt.

The fourth factor affecting scrapping is technological advances in ship design and equipment, which fundamentally weaken the trading prospects of a particular type of vessel. A good example of this is provided by the oil crisis of the 1970s. The sudden higher oil prices have had very important implications for the relatively low fuel-efficiency ship designs prevailing before 1973. Much higher bunkering costs caused many vessels to become unprofitable (unless re-engined), and thereby prompted early scrappage.

Finally, vessel age has a bearing on its scrapping decision, due to the general effects of wear and tear on the ship's condition and the increasing cost of ship maintenance. This factor, however, becomes irrelevant when one considers the aggregate level of deletions from the world fleet.

4.4 Upper and lower limits in resale prices

Following the discussion of newbuilding and scrapping rates, we can now define boundaries for the second-hand prices of ships. Figure 10 exhibits the newbuilding (in Japanese yards) and demolition (in Taiwan) prices series of a 70,000 DWT bulk carrier. It also shows the resale prices of a 5-year old 70,000 DWT bulker from Oct. 1980 to Apr. 1988. At any point of time a ship's second-hand price lies between the newbuilding and demolition prices of a vessel of the same type and size.

There is no evidence of any close relation between newbuilding prices and the values of second-hand tonnage. Following the discussion on the profitability of a second-hand ship, one expects resale values to follow closely any developments in the freight market. Newbuilding prices, on the other hand, are determined primarily by the cost of materials and labor, and they are stickier than resale values. We do not imply that newbuilding prices are constant. As demonstrated in Figure 10, they generally move in the same direction as the resale prices. In times of increased freight rates, when shipowners rush to place new orders, shipyards: (i) work at or above capacity levels in order to meet the long order books, which implies increased production costs (i.e. overtime wages), and (ii) are in a better position to exploit the shipowners' expected surplus. In times of low rates and shipbuilding over capacity, competition among yards and government subsidization push prices down. Even in the absence of subsidies, it may be less costly for the yards to accept contracts below cost than to keep their employees idle (most shipyard workers are unionized, and usually employed under long-term contracts).

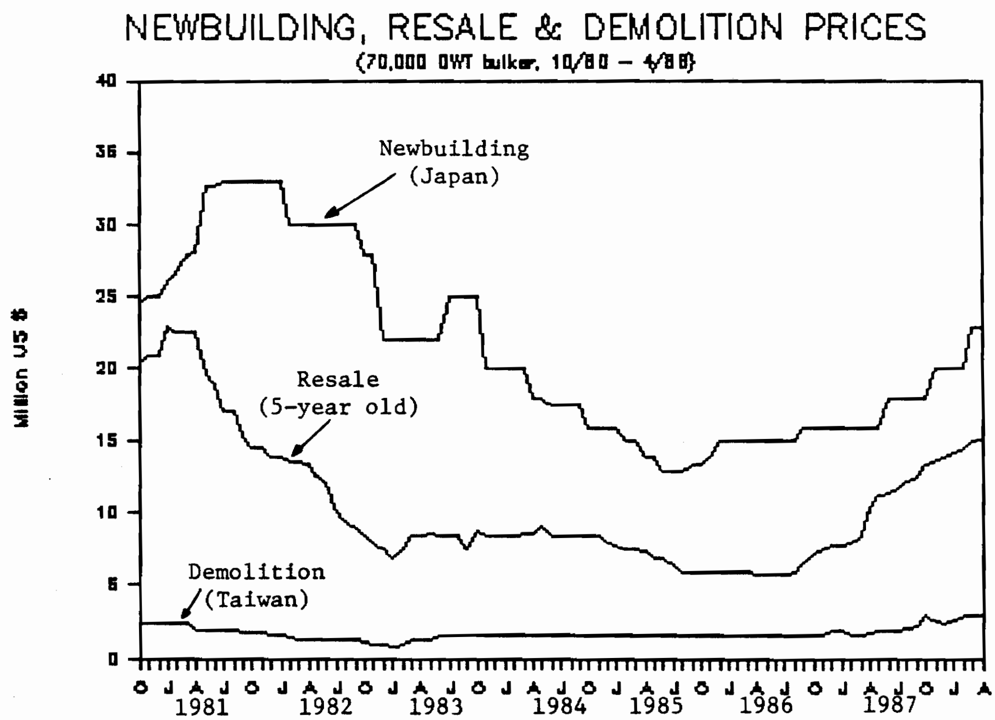


Figure 10. Newbuilding, resale and demolition prices for a 70,000 DWT bulk carrier

Source: Data are extracted from various monthly issues of Lloyd's Shipping Economist [33].

However, newbuilding prices move slower and in narrower ranges than those of second-hand ships.

It is generally true that the prevailing rate of a newbuilding contract at any one time acts as a constraint upon the upper limit of resale values. A buyer is not usually willing to pay more for a second-hand vessel than it would cost him to purchase a new one, which in addition would be built according to his own specifications and would be more economical to run with lower operating costs and a slower rate of obsolescence. There are, however, exceptions to this general rule due to the immediate availability of a second-hand vessel. Timing is of the utmost importance when buying a vessel, and a newbuilding with a one to two year delivery schedule, ordered when the freight market is moving upwards, may be delivered into a declining market with poor prospects for employment. Therefore, an owner may be prepared to pay a higher price for a vessel only two to three years old and which has been maintained in very good condition, rather than wait eighteen months for delivery of a new vessel.

Figure 10 shows that in Jan. 1981 a 5-year old 70,000 DWT bulk carrier was prices at US $23 million, only 3 million less than the newbuilding price of a similar ship. Having in mind that the Japanese newbuilding prices quoted here are not the lowest ones available in the market, it is easy to imagine the US $3 million differential being eliminated for a 2-year old bulker. Drewry Consultants [11] report:

> It is about the middle of 1980 that we find secondhand values catching up and even at times overtaking newbuilding prices, which had been depressed by subsidies. As early as Feb. 1980, the 36,071 DWT bulk carrier "Amax Mariner", which was built in 1978, was sold for $16.5 million, when newbuildings were being contracted for the same price, or even in a few cases less. In May, the 64,481 DWT Panamax bulk carrier "Gedeh", which had been delivered in Sep. 1977, was sold for $21.5 million. In the same month, a 63,000 DWT bulker had been contracted with Hitachi for only US $22.8 million, and two 64,000 tonners were even

> reported as contracted with Namura shipyard for $18.5 million each, presumably of a standardized design and simpler specifications.

Such cases, however, are rare and tend to occur only on a rapidly rising market because newbuilding prices move in a less volatile manner than either freight rates or second-hand values.

Whereas the newbuilding market acts as a constraint on the upper end of the second-hand price scale when the freight rates are up, the demolition market acts in much the same manner at the bottom end of the resale market when the rates are down, as it picks up vessels which have no future in active trading. Therefore, scrap prices have a restraining influence on prices of older vessels being offered at the resale market, and resale values act as a similar restraint on scrap prices. In April 1986, the resale value of a 5-year old 70,000 DWT bulker was only $4.2 million above its demolition price. The only type of case where the resale price may be lower than the scrap price is when the owner of a vessel, which is ready for scrap, cannot afford to sail it to the breaker's yard. He may then sell it at a very low price to someone who can put a cargo on board for a destination close to the breaker's yard, and so make the vessel pay for its last journey.

The upper limit of a ship's resale value is then its newbuilding price, and the lower limit is the scrap price. This general rule can be broken only when extraordinary circumstances exist.

CHAPTER 5

EMPIRICAL ANALYSIS

The purpose of the chapter is to substantiate the theoretical analysis presented in the previous chapters with actual data. In the last section, upper and lower limits for a ship's resale price were established. The main objective of this chapter is to develop a model that explains resale price movements within those limits. Emphasis will be placed on testing the hypothesis that a vessel's second-hand price is the present value of the expected future cashflow generated by its operation.

The model will be developed in three steps. In the first one, cross-sectional analysis will be employed to investigate the impact of a ship's physical characteristics on its resale value. Various measures of current and future freight rates will be tested in step two. A number of hypothesis regarding the formation of rate expectations will also be tested. In the last step, the model will be completed with the introduction of cost variables. The chapter concludes with the application of the model in explaining recent second-hand prices.

The statistical package MICROSTAT developed by Ecosoft, Inc. was used in the analysis. The OLS method was applied for all the regressions. The sources of data used in the analysis and the required data manipulation are described in

Appendix I. Descriptive statistics for the equations of the chapter are presented in Appendix III. Appendix IV contains the correlation matrices for all the regressions of the chapter.

5.1 Physical characteristics

The section aims to provide empirical evidence on the impact that a ship's physical characteristics have on its resale value. We have found in Chapter 2 that the following factors affect a ship's second-hand value:

(a) age;
(b) size;
(c) design speed;
(d) type of propulsion system;
(e) class;
(f) flag of registry; and
(g) type and capacity of cargo-handling equipment.

Previous studies suggest that a close relationship exists between a ship's design speed and its size (refer to section 2.3). There is no reason, then, to introduce a speed variable to an equation explaining resale values, when this equation already includes size as an explanatory variable. Regarding the type of propulsion system, all bulk carriers in service today are diesel powered. Exceptions to this rule (steam-powered vessels) are very few in number to deserve investigation, and these ships have been excluded from the analysis. Data on the class, flag of registry, and cargo-handling equipment of vessels sold in the second-hand market are not readily available. No attempt will be made to evaluate their impact on resale value, which in any event is expected to be minimal. The analysis therefore, will be limited to the effect of age and size on a ship's second-hand price.

We expect a negative effect of age on a ship's price because of: (i) the shortening of its expected economic life; and (ii) the increased maintenance costs due to general wear and tear. On the other hand, price should be positively related to size as: (i) for given freight rates, revenues from a ship's operation increase proportionally to its carrying capacity, while operating costs increase in a less than proportional manner; and (ii) at the eventual scrapping of the vessel, the amount of steel recovered is a positive function of its size. However, the unit price of a vessel should decrease with size due to economies of scale in shipbuilding.

In order to isolate the effect of age and size from disturbances due to changes in other factors affecting prices, a cross-sectional analysis is in order. A one-month period is short enough to serve this purpose. Unfortunately, the number of ships reported sold in any single month is very low to produce reliable results, and a longer period should be considered. Figure 10 in Chapter 4 shows that the resale price of a 5-year old 70,000 DWT bulk carrier was fairly constant during the period March 1983 to November 1984. Prices of other ship sizes are expected to behave in the same way. Thus, the 21-month period Mar. 83 to Nov. 84 was decided to be used for this stage of the study.

The monthly "Shipping Statistics and Economics" published by H.P Drewry (Shipping Consultants) Ltd. in London was used as the source of data. Each issue reports the second-hand sales for further trading (as opposed to sales for scrap), occurred during the previous month. Sales are presented by vessel type. For each sale the following information is provided: name of ship, selling company, buying company, year built, DWT, type of propulsion system, speed, fuel consumption, price in US $, and price per DWT tonne.

All bulk carriers sold during the examination period were equipped with diesel engines. Ships sold on "as is" basis (usually meaning that they have not been inspected by a classification society), sold in damage condition, sold "en bloc" (together with other vessels), or sold while under time-charter contract expected to continue after the change of ownership were excluded from the analysis for apparent reasons. Sale of the same ship by the same owner appearing in more than one monthly reports means that the earlier sales have failed and only the latest reported sale was included in the sample. This screening left us with a sample of 381 bulk carriers sold in the second-hand market during the period Mar. 83 to Nov. 84.

Resale price (PR) is specified in million US $, deadweight (DWT) in thousand metric tons, and AGE in years. Since the month of the year a vessel has been built is not reported, in calculating AGE we assumed that all buildings took place at the end of June of the reported year.

We first plotted PR against AGE and against DWT, in order to decide on the form in which these three variables should enter the equation. However, both AGE and DWT have such a strong impact on PR, that ignoring one of them and plotting against the other made the plots inconclusive. The trial-and-error method was employed, and eleven regressions were run altogether.

The first set of four regressions includes only linear variables. The specifications, together with their results are shown in Table 11. Equation (63) is a linear regression of PR on AGE and DWT, and the results are not surprising. The coefficient of AGE is negative, showing the existence of depreciation; and the coefficient of DWT is positive indicating that a ship's price increases with its size. Both coefficients are very significant as implied by the corresponding t-statistics. Equation (64) investigates the

Table 11. Effect of AGE and DWT on the Resale Price (PR) of Bulk Carriers - Set One

(t-statistics in parentheses)

Equation number	(63)	(64)	(65)	(66)
Study period	3/83-11/84	3/83-11/84	3/83-11/84	3/83-11/84
Dependent variable	PR	PR/DWT	PR	PR/DWT
Explanatory variables				
AGE	-0.4896	-12.9382	-0.4868	-13.6504
	(-27.711)	(-26.233)	(-27.960)	(-33.799)
DWT	0.0419		0.0708	-0.9500
	(14.140)		(8.325)	(-14.011)
DWT squared			-1.9593E-04	
			(-3.612)	
Constant	8.0835	265.2069	7.3649	311.7335
Number of observations	381	381	381	381
R squared	0.7414	0.6449	0.7500	0.7663
Adjusted R squared	0.7400	0.6449	0.7480	0.7650
Std. error of est.	1.6236	45.6907	1.5984	37.1169
F-statistic	541.805	688.161	377.064	619.561
Error sum of squares	996.4667	791217.155	N/A *	520757.296
Durbin-Watson stat.	1.7504	1.7553	N/A *	1.8387

* Not available due to numeric overflow error.

effect of AGE on the unit price (PR/DWT), which again was found to be significantly negative.

The next two regressions consider the effect of size on the unit price. Equation (65) is a replication of eq. (63) with the addition of DWT squared as an explanatory variable. Its coefficient is negative as expected meaning that although price is increasing with the size of the vessel, it does so in decreasing increments. The coefficient is significant at the 5% level. Equation (66) reaffirms this result, as it shows that DWT has a significant negative effect on the unit price PR/DWT.

The next set of regressions involve logarithmic transformations. The results are presented in Table 12. Equation (67) is the loglinear form of eq. (63). Although the signs of the coefficients have remained the same, slightly lower t-statistics indicate a deterioration of the goodness of fit. In equation (68) the variable Ln(AGE) has been replaced by AGE. The logic behind equation (68) is that the price of a vessel is discounted by a constant rate for each year of its age. This change has caused t-statistics to improve substantially, indicating better fit. In addition, $\bar{R}^2$ has jumped from 0.6622 to 0.8680, reflecting improvement in the explanatory power of the model. In equation (69) the same trick was applied to DWT, but the deterioration of the fit and explanatory power of the model

Table 12. Effect of AGE and DWT on the Resale Price (PR) of Bulk Carriers Set Two

(t-statistics in parentheses)

Equation number	(67)	(68)	(69)	(70)	(71)	(72)	(73)
Study period	3/83-11/84	3/83-11/84	3/83-11/84	3/83-11/84	3/83-11/84	3/83-11/84	3/83-11/84
Dependent variable	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR/DWT)	Ln(PR/DWT)	Ln(PR/DWT)	Ln(PR/DWT)
Explanatory variables							
Ln(AGE)	-0.8198 (-22.323)			-0.8198 (-22.323)			
Ln(DWT)	0.5339 (12.661)	0.5133 (19.486)		-0.4661 (-11.052)	-0.4867 (-18.474)		
AGE		-0.1331 (-43.184)	-0.1341 (-39.366)		-0.1331 (-43.184)	-0.1329 (-42.666)	-0.1258 (-29.877)
DWT			0.0089 (15.549)			-0.0094 (-18.054)	
Constant	1.1416	0.8643	2.3257	8.0493	7.7721	6.4360	5.9738
Number of observations	381	381	381	381	381	381	381
R squared	0.6639	0.8687	0.8395	0.5991	0.8434	0.8400	0.7020
Adjusted R squared	0.6622	0.8680	0.8386	0.5970	0.8425	0.8391	0.7020
Std. error of est.	0.4529	0.2831	0.3130	0.4529	0.2831	0.2862	0.3900
F-statistic	373.392	1250.433	988.417	282.453	1017.676	991.930	892.617
Error sum of squares	77.5355	30.2934	37.0348	77.5355	30.2934	30.9539	57.6448
Durbin-Watson stat.	1.6858	1.8099	1.8201	1.6858	1.8099	1.8282	1.6995

signifies that Ln(PR) is better explained by Ln(DWT) than by DWT.

There is not much to be said for the last four regressions of Table 12. The purpose of these regressions was to check whether the use of unit price instead of absolute price as the dependent variable can improve the power of the model. Equation (71) is the most powerful among them. A closer look at the results shows that equations (68) and (71) are identical. The coefficients of AGE in the two regressions are the same, and the coefficient of Ln(DWT) in (71) is equal to 1 minus the coefficient of Ln(DWT) in (68).[25] This is something we should have expected by examining the two specifications. The same is true for equations (67) and (70).

To conclude, among the eleven regressions of Tables 11 and 12, the equation which explains better the effect of age and size on the resale price of bulk carriers is:

$$\text{Ln(PR)} = 0.8643 - \underset{(-43.184)}{0.1331 \cdot \text{AGE}} + \underset{(19.486)}{0.5133 \cdot \text{Ln(DWT)}},$$

$$\bar{R}^2 = 0.8680 \qquad (68)$$

A Durbin-Watson (DW) statistic of 1.8099 indicates that no

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[25] Although identical, the two regressions have different constants, $\bar{R}^2$, R^2, and F-statistics because the dependent variables are different.

serial correlation is present, and the correlation matrix of Appendix IV shows no evidence of multicollinearity.

The coefficient of AGE in eq. (68) leads to an estimate of a constant annual depreciation rate for bulk carriers. If d is the depreciation rate, then:

$$PR = A*(1-d)^{AGE} \tag{74}$$

or

$$Ln(PR) = Ln(A) + AGE*Ln(1-d) \tag{75}$$

Equation (75) when compared with eq. (68) gives:

$$Ln(1-d) = -0.1331 \tag{76}$$

or

$$(1-d) = e^{-0.1331} = 0.8754 \tag{77}$$

and

$$d = 1-0.8754 = 0.1246 \tag{78}$$

Equation (68), then, results in a yearly depreciation rate of 12.46% for bulk carriers during the period Mar. 1983 to Nov. 1984.

The coefficient of Ln(DWT) is the size elasticity of second-hand prices, and its 0.5133 value is lower than the 0.67 predicted by the "2/3-power rule" which is valid for newbuilding prices (refer to section 2.2).

The adjusted R^2 of 0.8680 shows that age and size explain most of the variation in resale prices, and the omission of other variables is not of great expense.

5.2 Freight rates

Although eq. (68) is valid for a cross-sectional analysis, it is meaningless when applied over a time period long enough to allow for changes in the market for shipping services. In the previous chapter, we have expressed resale price as a function of expected future freight rates among others [refer to eq. (29)]. If our hypothesis is correct, we expect future freight rates to have a significant influence on second-hand prices. Estimates of expected future rates, however, are not readily available in the literature (not until very recently); various substitutes will be tried in this section.

5.2.1 Short-term rates

We begin by assuming that shippers and ship operators cannot do better than simply expecting freight rates to remain at their present level. Current rates, then, should be able to explain the movement of resale values over time. As explained in the introduction, the type of freight rates which best illustrates the present conditions in the market is the voyage charter rate, because of its short duration. Several voyage rate indices will be tested below.

The first, VID, is an index published by Drewry Consultants in their monthly "Shipping Statistics and Economics" since early 1970s. It is based on three bulk trades: (i) grain moving from US Gulf to Japan on 20 to 40,000 DWT bulk carriers; (ii) coal from Hampton Roads to Japan on 50 to 60,000 DWT ships; and (iii) iron ore moving from Brazil to NW Europe on 60 to 80,000 DWT bulkers. A time series of the VID index (Jan. 1975=100) is shown in Figure 11.

The analysis covers the period Dec. 1976 to Dec. 1987. For this and all the subsequent regressions of the chapter, the sample is constructed in the following way: Each ship sale constitutes one observation. Observation i, corresponding to ship i sold during month j, consists of the resale price $PR_{i,j}$, the AGE_i, the DWT_i, and a set of other variables pertinent to the jth month, such as VID_j. All ships reported sold during month j and which have passed the screening described in the previous section are included in the sample. For all those observations, the month-related variables are identical. Monthly sales are ordered chronologically, while ships sold during the same month are ordered alphabetically based on their name. The structure of the sample is illustrated in Figure 12.

The sample structure resembles pooling of cross-sectional and time-series data. However, it is not exactly so because the total number of ships sold during each month is not constant, and it is not that the same set of ships are sold every month.

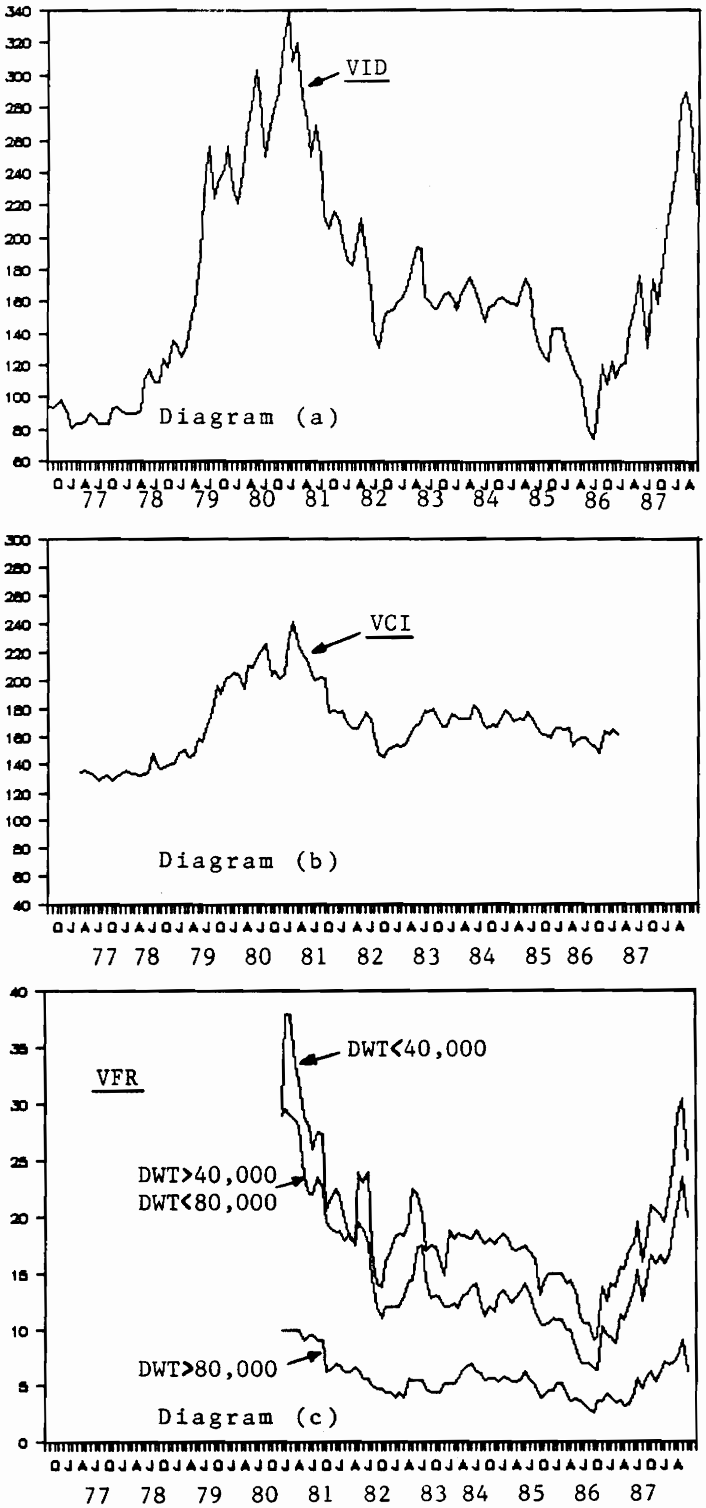

Figure 11. Short-term (voyage) freight rates, 1976 - 1988

	Dependent Variable		Variables pertinent to individual ships		Variables pertinent to sale month
month 1	$PR_{1,1}$	$=f($	AGE_1	; DWT_1	; $VID_1;\ldots)$
	$PR_{2,1}$		AGE_2	; DWT_2	; $VID_1;\ldots$
	$\vdots$		$\vdots$	$\vdots$	$\vdots$
	$PR_{n_1,1}$		AGE_{n_1}	; DWT_{n_1}	; $VID_1;\ldots$
month 2	$PR_{n_1+1,2}$		AGE_{n_1+1}	; DWT_{n_1+1}	; $VID_2;\ldots$
	$\vdots$		$\vdots$	$\vdots$	$\vdots$
	$PR_{n_1+n_2,2}$		$AGE_{n_1+n_2}$	; $DWT_{n_1+n_2}$	; $VID_2;\ldots$
	$\vdots$		$\vdots$	$\vdots$	$\vdots$
	$PR_{i,j}$		AGE_i	; DWT_i	; $VID_j;\ldots$
	$\vdots$		$\vdots$	$\vdots$	$\vdots$
month T	$PR_{n_1+n_2+\ldots+n_{T-1}+1,T}$		$AGE_{n_1+n_2+\ldots+n_{T-1}+1}$	; $DWT_{n_1+n_2+\ldots+n_{T-1}+1}$	; $VID_T;\ldots$
	$PR_{n_1+n_2+\ldots+n_{T-1}+2,T}$		$AGE_{n_1+n_2+\ldots+n_{T-1}+2}$	; $DWT_{n_1+n_2+\ldots+n_{T-1}+2}$	; $VID_T;\ldots$
	$\vdots$		$\vdots$	$\vdots$	$\vdots$
	$PR_{n_1+n_2+\ldots+n_{T-1}+n_T,T}$		$AGE_{n_1+n_2+\ldots+n_{T-1}+n_T}$	; $DWT_{n_1+n_2+\ldots+n_{T-1}+n_T}$	; $VID_T;\ldots$

Figure 12. Sample structure

Eight regressions involving the VID index were run. The specifications and results are presented in Table 13. Before running the regressions we were afraid that the nesting feature of the sample, namely that of having several observations with identical month-related variables, might produce insignificant estimates for those variables. The results contradicted our worries, apparently because of the long period covered by the analysis.

Equation (79) regresses Ln(PR) on AGE, Ln(DWT) and Ln(VID). The coefficients of AGE and Ln(DWT) confirm those of the previous section. The coefficient of Ln(VID) is positive and significant, showing that resale prices follow the movements of the voyage freight rates. It is interesting to notice that the elasticity of resale prices with respect to voyage rates (1.1011) is greater than one. The adjusted R^2 of 0.7954 is adequate.

In eq. (80) we have included the variable $Ln[VID_t/VID_{t-1}]$ in the right-hand-side of the regression hoping to capture the effect of current market trend on resale prices. We were expecting that a ratio VID_t/VID_{t-1} of over one would signify an upward trend of freight rates, and this should have positive reactions in the second-hand prices. The results came to our surprise. The coefficient of $Ln[VID_t/VID_{t-1}]$ is negative and significant. Trying to explain this result we noticed the following: Firstly,

Table 13. Effect of Drewry Voyage Rate Index (VID) on the Resale Price (PR) of Bulk Carriers
(t-statistics in parentheses)

Equation number	(79)	(80)	(81)	(82)	(83)	(84)	(85)	(86)
Study period	12/76-12/87	12/76-12/87	12/76-12/87	12/76-12/87	12/76-12/87	12/76-12/87	12/76-12/87	12/76-12/87
Dependent variable	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)
Explanatory variables								
AGE	-0.1130 (-68.569)	-0.1131 (-69.499)	-0.1133 (-70.269)	-0.1134 (-69.941)	-0.1135 (-69.707)	-0.1134 (-69.315)	-0.1133 (-68.889)	-0.1133 (-70.070)
Ln(DWT)	0.5278 (34.550)	0.5339 (35.321)	0.5389 (35.957)	0.5364 (35.624)	0.5332 (35.318)	0.5303 (34.981)	0.5299 (34.772)	0.5392 (35.954)
Ln(VID)	1.1011 (46.594)	1.1317 (47.742)	1.1467 (48.674)	1.1473 (48.139)	1.1515 (47.543)	1.1498 (46.436)	1.1342 (45.245)	
Ln[(VID)t/(VID)t-1]		-0.5860 (-7.472)						
Ln[(VID)t/(VID)t-2]			-0.5340 (-10.071)					
Ln[(VID)t/(VID)t-3]				-0.3916 (-8.762)				
Ln[(VID)t/(VID)t-4]					-0.3225 (-7.738)			
Ln[(VID)t/(VID)t-5]						-0.2388 (-6.111)		
Ln[(VID)t/(VID)t-6]							-0.1457 (-3.861)	
Ln(VID)ma								1.1458 (48.425)
Constant	-4.9626	-5.1257	-5.2098	-5.2054	-5.2157	-5.2012	-5.1263	-5.2076
Number of observations	2245	2245	2245	2245	2245	2245	2245	2245
R squared	0.7957	0.8007	0.8045	0.8025	0.8010	0.7990	0.7970	0.8034
Adjusted R squared	0.7954	0.8003	0.8042	0.8021	0.8006	0.7987	0.7967	0.8032
Std. error of est.	0.3881	0.3834	0.3796	0.3817	0.3831	0.3850	0.3869	0.3806
F-statistic	2909.103	2249.164	2304.950	2274.800	2254.118	2226.546	2199.093	3053.275
Error sum of squares	N/A *	329.2704	322.8589	326.2927	328.6908	331.9430	335.2459	N/A *
Durbin-Watson stat.	N/A *	1.1369	1.1543	1.1468	1.1373	1.1281	1.1176	N/A *

* Not available due to numeric overflow error.

$Ln[VID_t/VID_{t-1}]$ is no different than $Ln(VID)_t - Ln(VID)_{t-1}$. Secondly, the regression coefficient is a measure of the change in the dependent variable caused by a unit change in the explanatory one, everything else being held constant. This means that $Ln(VID)_t$, too, is held constant, since it is a separate explanatory variable. Then:

$$\Delta Ln[VID_t/VID_{t-1}] = \Delta [Ln(VID)_t - \Delta Ln(VID)_{t-1}] =$$
$$= \Delta Ln(VID)_t - \Delta Ln(VID)_{t-1} = -\Delta Ln(VID)_{t-1}$$

In other words, a unit increase in $Ln[VID_t/VID_{t-1}]$ is nothing but a unit decrease in $Ln(VID)_{t-1}$. Eq. (80) is identical to one regressing Ln(PR) on AGE, Ln(DWT), $Ln(VID)_t$ and $Ln(VID)_{t-1}$. In this latter specification, the coefficient of $Ln(VID)_t$ would have been 1.1317 - 0.5860 = 0.5457 and the coefficient of $Ln(VID)_{t-1}$ would have been 0.5860. We expect multicollinearity to be a hidden issue in eq. (80), since VID_{t-1} cannot be dramatically different than VID_t. Nevertheless, eq. (80) shows that ship operators do not just look at the current level of voyage rates, but they also remember the rates of the previous month.

In equations (81) to (85) lagged VID variables from two to six months behind have been tried with similar results. The elasticities of resale prices with respect to lagged voyage rates are graphed in Figure 13. It seems that ship operators have at least a six-month memory of freight rates, but the weight they place on past rates is decreasing as the lag is lengthened.

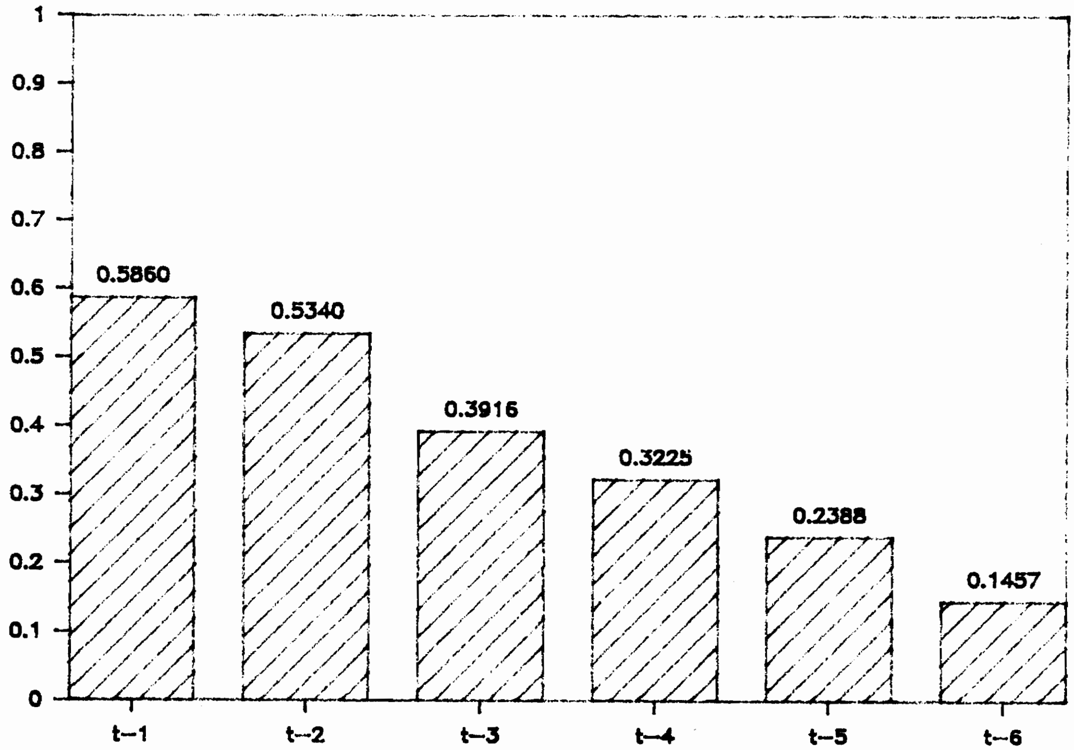

Figure 13. Elasticity of resale prices with respect to lagged freight rates

In eq. (86) we have tried to take advantage of the significance of past freight rates discussed above. We have replaced the Ln(VID) variable of eq. (79) with what we call Ln(VID)ma, the natural logarithm of a moving average of VID. VIDma is the arithmetic mean of the three most recent values, or:

$$VID_{ma} = \frac{VID_t + VID_{t-1} + VID_{t-2}}{3} \qquad (87)$$

Resale prices exhibit an elasticity of 1.1458 with respect to VID_{ma}, the t-statistics of all coefficients have improved, and the adjusted R^2 has increased from 0.7954 to 0.8032, signifying an improvement in the explanatory power of the equation. This improvement may partly reflect the fact that the moving average variable takes care of the seasonality in freight rates. As shown in Figure 11, freight rates usually drop during the summer and winter months, and improve again in spring and autumn.

The next freight rate index to be tested is the Voyage Charter Index (VCI), produced by the Norwegian Shipping News and reprinted in the yearly OECD publication "Maritime Transport". VCI is based on tramp voyage rates on 28 routes, arranged in five bulk commodity groups with approximate weight aimed to give worldwide coverage. The base year is July 1965 to June 1966 (=100). The index includes tankers employed in the grain trade. A time-series of VCI is presented in Figure 11 (second diagram).

The study period extends from Mar. 1977 to Dec. 1986. The results are presented in Table 14 along with equations (79) and (86) of Table 13 in order to compare notes. In eq. (88) the Ln(VID) variable has been replaced with Ln(VCI). Its coefficient is positive and significant as expected, but the elasticity of resale prices with respect to freight

Table 14. Comparison between the VID and VCI Indices in explaining Resale Prices

(t-statistics in parentheses)

Equation number	(79)	(86)	(88)	(89)
Study period	12/76-12/87	12/76-12/87	3/77-12/86	3/77-12/86
Dependent variable	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)
Explanatory variables				
AGE	-0.1130 (-68.569)	-0.1133 (-70.070)	-0.1151 (-57.350)	-0.1157 (-58.394)
Ln(DWT)	0.5278 (34.550)	0.5392 (35.954)	0.4743 (24.316)	0.4792 (24.883)
Ln(VID)	1.1011 (46.594)			
Ln(VID)ma		1.1458 (48.425)		
Ln(VCI)			2.6659 (36.286)	
Ln(VCI)ma				2.7527 (37.430)
Constant	-4.9626	-5.2076	-12.8538	-13.2964
Number of observations	2245	2245	1894	1894
R squared	0.7957	0.8034	0.7516	0.7580
Adjusted R squared	0.7954	0.8032	0.7514	0.7577
Std. error of est.	0.3881	0.3806	0.4391	0.4335
F-statistic	2909.103	3053.275	2861.471	2961.543
Error sum of squares	N/A *	N/A *	N/A *	N/A *
Durbin-Watson stat.	N/A *	N/A *	N/A *	N/A *

* Not available due to numeric overflow error.

rates (2.6659) has more than doubled.[26] On the other hand, the coefficient of Ln(DWT) has slightly dropped from 0.5278 to 0.4743. The reason for these changes in elasticities is not clear. Probably one should look at differences in the construction of the VID and VCI indices, and the difference in the study periods.[27] In eq. (89) the use of the moving average variable Ln(VCI)ma once again produces better results. Judging by the t-statistics and the R^2 values, it seems that VID explains resale prices better than VCI.

In the next set of regressions the VID and VCI indices will be replaced by actual voyage freight rates. The

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[26]The reader may have noticed that we refer to the elasticity of resale price with respect to the VCI index (E_{VCI}) as the elasticity of resale price w.r.t. freight rates (E_F). Furthermore, we directly compare elasticities w.r.t. indices with different base years. The following proof may be helpful. If F is the current freight rate, and F_B was the rate at the base year, then:

$$E_{VCI} = \frac{d\ln(PR)}{d\ln(VCI)} = \frac{\frac{1}{PR}\cdot dPR}{\frac{1}{VCI}\cdot dVCI} = \frac{VCI}{PR} \cdot \frac{dPR}{dVCI} =$$

$$= \frac{\frac{F}{F_B}x100}{PR} \cdot \frac{dPR}{\frac{100dF}{F_B}} = \frac{F}{PR} \cdot \frac{dPR}{dF} = \frac{\frac{1}{PR}dPR}{\frac{1}{F}\,dF} =$$

$$= \frac{d\ln(PR)}{d\ln(F)} = E_F.$$

[27]A closer look at the two indices in Figure 11 shows that movements of VCI lag behind those of VID by one to two months; presumably because of the selection of trade routes in the construction of the two indices.

monthly periodical "Lloyd's Shipping Economist" publishes a monthly time-series of single voyage (spot) rates for three dense trade routes: (i) grain from the US Gulf Coast to Japan on 30,000 DWT ships; (ii) coal from Hampton Roads to Japan on 55,000 DWT carriers; and (iii) iron ore from Brazil to NW Europe on 120,000 tonners. The rates are specified in US $ per tonne of cargo, and are presented in Figure 11 (bottom diagram).

In order to run these regressions we have categorized the sample ships sold during the period Feb. 1980 to Dec. 1987 into three size groups, namely: (i) DWT <= 40,000; (ii) 40,000 < DWT <= 80,000; and (iii) DWT > 80,000. Each one of the freight rates mentioned above is used to explain resale prices in the corresponding vessel group.

The results are presented in Table 15. The variable Ln(VFR) and its moving average version Ln(VFR)ma represent different freight rates across the three size groups. The results confirm the relations picked up in the previous equations. All coefficients have the expected sign and are significant at the 5% level. Table 15 offers, though, a basis for comparison of elasticities among the DWT groups.

The coefficient of AGE remains very stable among the three groups. However, this is not the case for the elasticity of resale prices with respect to DWT, which drops significantly from 0.7055 for the smaller vessels to 0.5503

Table 15. Effect of Voyage Freight Rate (VFR) on the Resale Price (PR) of Bulk Carriers

(t-statistics in parentheses)

	DWT <= 40,000		40,000 < DWT <= 80,000		DWT > 80,000		ALL SHIPS	
Equation number	(90)	(91)	(92)	(93)	(94)	(95)	(96)	(97)
Study period	2/80-12/87	2/80-12/87	2/80-12/87	2/80-12/87	2/80-12/87	2/80-12/87	2/80-12/87	2/80-12/87
Dependent variable	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)
Explanatory variables								
AGE	-0.1110 (-55.849)	-0.1135 (-51.489)	-0.1142 (-36.075)	-0.1132 (-33.791)	-0.1155 (-14.842)	-0.1174 (-14.242)	-0.1072 (-54.386)	-0.1086 (-52.412)
Ln(DWT)	0.7055 (20.195)	0.6998 (18.045)	0.5503 (6.261)	0.5301 (5.691)	0.5125 (2.745)	0.5130 (2.584)	1.0844 (47.678)	1.0510 (43.943)
Ln(VFR)	1.6382 (48.513)		1.0805 (24.896)		1.0492 (9.744)		1.1288 (39.994)	
Ln(VFR)ma		1.5408 (40.974)		1.0608 (22.546)		0.9988 (8.525)		1.0701 (35.757)
Constant	-4.7646	-4.3936	-2.2777	-2.1364	-0.9975	-0.8729	-4.5208	-4.2019
Number of observations	1245	1245	405	405	106	106	1756	1756
R squared	0.8305	0.7914	0.8279	0.8068	0.8040	0.7790	0.7836	0.7607
Adjusted R squared	0.8301	0.7909	0.8266	0.8053	0.7983	0.7725	0.7834	0.7604
Std. error of est.	0.3530	0.3917	0.3064	0.3268	0.3124	0.3317	0.4108	0.4320
F-statistic	2027.245	1569.103	642.928	558.108	139.486	119.871	3173.987	2786.137
Error sum of squares	N/A *	N/A *	N/A *	N/A *	9.9527	11.2214	N/A *	N/A *
Durbin-Watson stat.	N/A *	N/A *	N/A *	N/A *	2.0286	1.9651	N/A *	N/A *

* Not available due to numeric overflow error.

for the medium-sized and to 0.5125 for the larger ones. We can think several reasons for this. Firstly, as we have explained before, by regressing Ln(PR) on AGE we assume that the resale price of a vessel is its newbuilding price discounted by a constant rate for every year of its life. Newbuilding prices, then, are remotely reflected on second-hand values, and building prices increase less than proportionally with the size of the vessel due to economics of scale in construction. Of course all three groups exhibit this relationship as all elasticities are less than unity, but still one expects the elasticity to drop as we move to a group of larger ships.

Secondly, a percentage point increase in DWT may further reduce the employment opportunities of the ships belonging to the second and third groups, because of restrictions imposed by ports and canals. This inflexibility may be reflected in prices.

Yet, another reason might be the fact that not all of a ship's DWT tonnage is revenue-earning capacity. A small but by no means negligible part of it is devoted to the storage of bunkers, water and other provisions. This space requirements increase with the size of the vessel in a less than proportional way. As a result, a percentage point increase in DWT represents a higher percentage increase of revenue-earning capacity in a smaller than in a larger ship.

Table 15 shows that the t-statistics of the Ln(DWT) coefficients drop as well. This is partly due to the size of the sample, which is getting thinner as we move to larger vessels. Another reason may be the fact that the variation in Ln(DWT) - measured by the ratio of standard deviation over the mean - drops from 0.092 for the smaller vessels to 0.044 for the medium-sized to 0.035 for the larger ones (for descriptive statistics refer to Appendix III).

Once again the coefficients of Ln(VFR) are found to be greater than one, showing elastic reactions of the resale prices to changes in the freight rates. These coefficients, too, drop across the three size groups. We believe that this occurs because larger vessels are usually engaged in chartering arrangements of longer duration, which results in lower price sensitivity to spot rates.

One surprising result of Table 15 is that the use of the moving average variable Ln(VFR)ma produces worse results in all three ship categories than the corresponding Ln(VFR). This shows that a ship's resale value responds to the most recent freight rate developments in the particular trade the vessel is engaged, while on an industry-wide basis, inter-trade frictions create a short lag in the prices' response. This view gains ground also by the fact that the use of actual freight rates instead of indices, increases the explanatory power of the model (measured by the R^2).

The samples used for the segmented analysis by size group were put together for equations (96) and (97). The sample constructed in this way suffers from an inherent problem. Figure 11 shows that spot rates (VFR) expressed in US $ per tonne are much lower for larger vessels. This introduces collinearity between Ln(VFR) and Ln(DWT), whose correlation factor is 0.615. Eq. (96) and (97), then, suffer from multicollinearity, which reduces the reliance that we can place on the estimates.

5.2.2 Long-term rates

The analysis of the preceding section is based on the assumption that ship operators and shippers expect future freight rates to remain at their current level. Although this assumption will not be relaxed until the next section, there is still a way of obtaining some valuable insight on the market's rate expectations for the near future.

We have seen in the introduction that under time charter arrangements, the shipowner puts vessel and crew at the disposal of the charterer for a specified period of time at a specified rate. The duration of a time charter usually extends from several months to several years. On the equilibrium, a shipowner should be indifferent between accepting a time charter and taking a sequence of voyage charters which last the same number of periods as the time charter fixture. Time charter rates, then, should be a positive function of expected future voyage rates and a negative function of expected voyage costs.[28] Risk should also be an issue here, since under time chartering the owner eliminates the risk of having the vessel idle for one or more of the periods covered by the time charter.[29] Nevertheless, what is important for our application is that current time charter rates, being a positive function of expected future rates, should explain better resale prices than current voyage rates.

Indices of time charter rates are produced by the Norwegian Shipping News and the General Council of British Shipping. A combination of the two indices (TCI) is published by OECD in their yearly "Maritime Transport." TCI is based on average rates for all time charter fixtures for oil-fired steamers and motor vessels in the 10,000 to 50,000 DWT range. It excludes charters of more than a year, and its base year is 1971 (1971 = 100). TCI is presented in Figure 14 along with the VID index.

The analysis covers the period Mar. 1977 to Dec. 1987. The results are presented in Table 16. Equations (79) and

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[28]Remember from Figure 1 of the introduction that voyage costs are for the owner's account under voyage chartering, but they are for the charterer's account under time chartering.

[29]An insightful theoretical analysis of time charter rates is presented by Glen, Owen and Van der Meer [20].

Table 16. Comparison between the VID and TCI Indices in explaining Resale Prices

(t-statistics in parentheses)

Equation number	(79)	(86)	(98)	(99)
Study period	12/76-12/87	12/76-12/87	3/77-12/87	3/77-12/87
Dependent variable	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)
Explanatory variables				
AGE	-0.1130 (-68.569)	-0.1133 (-70.070)	-0.1080 (-74.582)	-0.1080 (-77.133)
Ln(DWT)	0.5278 (34.550)	0.5392 (35.954)	0.5783 (42.848)	0.5899 (45.116)
Ln(VID)	1.1011 (46.594)			
Ln(VID)ma		1.1458 (48.425)		
Ln(TCI)			1.4577 (59.433)	
Ln(TCI)ma				1.5012 (62.653)
Constant	-4.9626	-5.2076	-7.4343	-7.6933
Number of observations	2245	2245	2213	2213
R squared	0.7957	0.8034	0.8447	0.8547
Adjusted R squared	0.7954	0.8032	0.8445	0.8545
Std. error of est.	0.3881	0.3806	0.3390	0.3279
F-statistic	2909.103	3053.275	4005.542	4330.167
Error sum of squares	N/A *	N/A *	N/A *	N/A *
Durbin-Watson stat.	N/A *	N/A *	N/A *	N/A *

* Not available due to numeric overflow error.

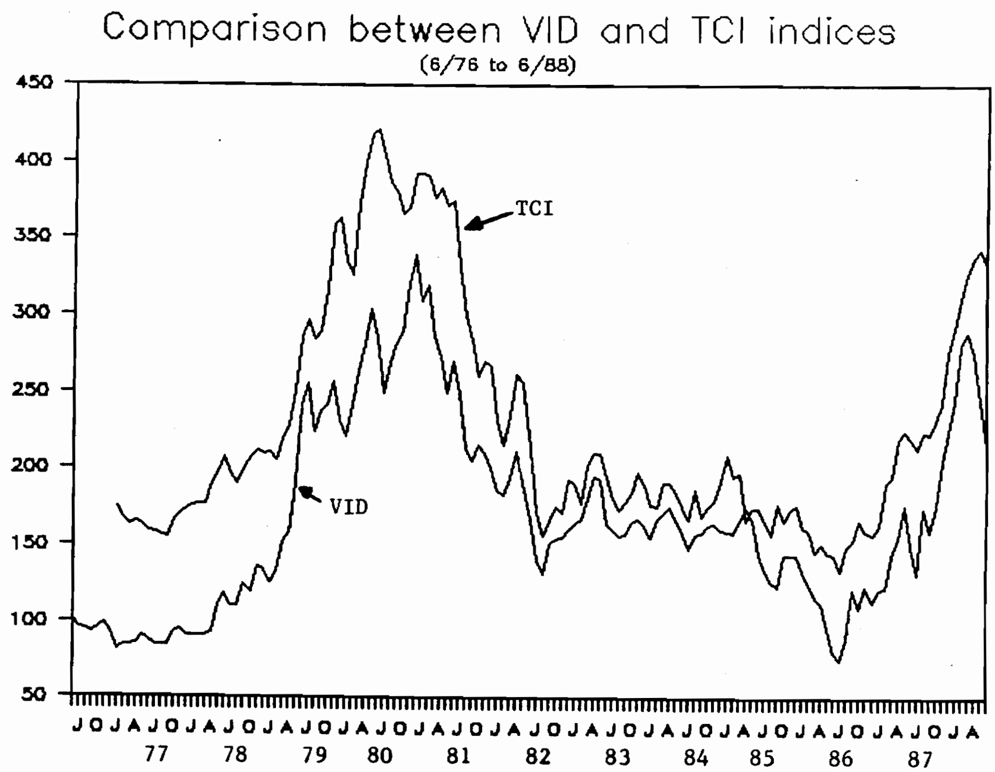

Figure 14. The TCI and VID indices

(86) of the previous section are re-printed for comparisons. The results came out as expected. The coefficient of Ln(TCI) in eq. (98) shows a stronger response of resale prices to changes in time charter rates, than to changes in voyage rates. The substantial improvement in t-statistics and R^2 indicates the superiority of the time charter rate index in explaining resale prices. Once again, the moving average variable Ln(TCI)ma is producing better results in eq. (99).

5.2.3 Formation of freight rate expectations

It is now time to relax the assumption that future rates are expected to remain at their current level. But, then, how are expectations formed? In the next two subsections we will assume adaptive and rational expectations, and we will attempt to explain resale prices using these expectations.

5.2.3.1 Adaptive expectations

In our discussion on shipbuilding, it was mentioned that it takes one to three years for a new ship to be built. The current capacity of the world fleet, then, inflated by the existing order book is a good indicator of the ship supply during the following year. On the other hand, under normal circumstances (not during periods of crises) changes in demand for shipping services are slow and predictable.

Therefore, the expected level of next year's freight rates can be explained by the current supply over demand ratio (S/D). If F^*_{t+1} is the expected freight rate one year ahead, the above relationship is expressed by the equation:

$$F^*_{t+1} = a' + b' \cdot S/D_t \qquad (100)$$

In any given period, the actual rate F_{t+1} may not adjust completely to obtain the expected level F^*_{t+1}. Lack of knowledge in forming the expectations, and unexpected developments in the demand might be responsible for the partial adjustment. According to a variation of the classic "adaptive expectations model" known as "stock adjustment model",[30] this adjustment process is defined by:

$$F_{t+1} - F_t = \Theta \cdot (F^*_{t+1} - F_t), \quad 0 < \Theta < 1 \tag{101}$$

The equation specifies that the change in F will respond only partially to the difference between the expected level of F and the past value of F, the rate of response being a function of the adjustment coefficient Θ. Substituting for F^*_{t+1} from eq. (100) in eq. (101), we get:

$$F_{t+1} - F_t = \Theta \cdot (a' + b' \cdot S/D_t - F_t) \tag{102}$$

Solving for F_{t+1} yields:

$$F_{t+1} = \Theta \cdot a' + \Theta \cdot b' \cdot S/D_t + (1 - \Theta) \cdot F_t \tag{103}$$

or simply:

$$F_{t+1} = a + b \cdot S/D_t + c \cdot F_t \tag{104}$$

In eq. (104) coefficient b is expected to be negative since an increase in S/D signifies increased excess capacity which leads to depressed rates. The c coefficient should be

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[30]The estimation of the "stock adjustment model" is discussed by Pindyck and Rubinfeld [39], p. 235.

positive due to the expected positive correlation between current and future rates.

The "Lloyd's Shipping Economist" publishes monthly data on supply and demand for bulk carriers. The demand figure is calculated by subtracting from the world fleet capacity (supply) the laid up and idle tonnage, as well as the equivalent tonnage lost due to slow steaming. Monthly estimates of the S/D ratio are then possible.[31] The same source also provides data enabling us to calculate S/D ratios which take into consideration the tonnage of combined carriers active in the dry bulk trades. Both ratios were tested. In place of the freight rate (F) variable of eq. (104) we have used both the voyage (VID) and time charter (TCI) indices. Both linear and loglinear specifications of eq. (104) were tried.

The best results covering the period Dec. 1978 to June 1987 were obtained for the linear specifications, the TCI index, and the S/D ratio excluding combis. We found:

$$TCI_{t+12} = 1375.80 - \underset{(-9.974)}{908.87} \cdot S/D_t - \underset{(-0.423)}{0.035} \cdot TCI_t \qquad (105)$$

with $R^2 = 0.6412$, $\bar{R}^2 = 0.6341$, $N = 103$, and $DW = 0.2634$.

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[31]It was mentioned above that outstanding orders should also be accounted for. Data on the order book are available from several sources. However, since the main subject of this work is second-hand prices and not freight rates, we did not take the time to get into this.

The coefficient of S/D is negative and significant as expected. This is not so, though, for the coefficient of TCI. We believe that the strong correlation (-0.68916) between S/D and TCI is the underlying reason. In addition, the very low Durbin-Watson statistic indicates strong serial correlation, not acceptable for an equation with lagged dependent variable in the right-hand side. We thought that this is due to the construction of the sample which consists of monthly observations, while the lagged TCI variable refers to twelve months back. Driven by this observation, we run the same regression using yearly data (monthly data were averaged over a year) for the period 1979-1987. The results were:

$$TCI_{t+1} = 1851.20 - \underset{(-3.389)}{1235.43} \cdot S/D_t - \underset{(-0.911)}{0.3083} \cdot TCI_t \quad (106)$$

with $R^2 = 0.7623$, $\bar{R}^2 = 0.6831$, $N = 9$, and $DW = 1.5807$

Although the Durbin-Watson statistic has improved to a point that we can accept the null hypothesis of no serial correlation, the coefficient of TCI remains negative and not significant at the 10% level due to the high correlation (0.78170) between TCI and D/S. Therefore, we are forced to drop the TCI variable from the right-hand side of eq. (106), which results in:

$$TCI_{t+1} = 1455.43 - \underset{(-4.345)}{975.78} \cdot S/D_t \qquad (107)$$

with $R^2 = 0.7295$, $N = 9$, and $DW = 1.3826$

Lets come back now to resale prices. So far we have expressed resale prices as a function of AGE, DWT, and TCI [refer to eq. (98) of Table 16]. We can now add to this specification a second freight-rate-related variable (TCI1), the charter rate one year ahead, or:

$$Ln(PR) = a + b \cdot AGE + c \cdot Ln(DWT) + d \cdot Ln(TCI) + \\ + e \cdot Ln(TCI1) \qquad (108)$$

Resale prices are, then, explained by the recursive system of equations (107) and (108). The estimated eq. (107) - by the OLS method - remains as is. TCI1 values are obtained from eq. (107), and their natural logarithms are then used in estimating eq. (108).

The analysis covers the period Feb. 1979 to Dec. 1987. The results are presented in Table 17. Equations (98) and (99) of Table 16 have been re-estimated here for the same study period - as eq. (109) and (112) respectively - in order to obtain readily comparable results. In eq. (110) the variable Ln(TCI1) has been added. Contrary to our expectations its coefficient is negative. The reason is the high degree of correlation (0.60931) between Ln(TCI) and Ln(TCI1). When the Ln(TCI) variable is omitted, the

Table 17. Effect of Next Year's Time Charter Rate (TCI1) on the Resale Price (PR) of Bulk Carriers

(t-statistics in parentheses)

Equation number	(109)	(110)	(111)	(112)	(113)	(114)
Study period	2/79-12/87	2/79-12/87	2/79-12/87	2/79-12/87	2/79-12/87	2/79-12/87
Dependent variable	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)
Explanatory variables						
AGE	-0.1080	-0.1091	-0.1075	-0.1080	-0.1090	-0.1072
	(-72.711)	(-74.550)	(-45.955)	(-75.394)	(-77.044)	(-46.600)
Ln(DWT)	0.6227	0.6230	0.5465	0.6353	0.6353	0.5547
	(45.008)	(45.881)	(25.295)	(47.524)	(48.306)	(26.087)
Ln(TCI)	1.4902	1.6476				
	(61.349)	(54.921)				
Ln(TCI1)		-0.2766	0.7903			
		(-8.643)	(19.423)			
Ln(TCI)ma				1.5315	1.6817	
				(64.717)	(56.417)	
Ln(TCI1)ma					-0.2604	0.8764
					(-8.071)	(21.384)
Constant	-7.7598	-7.0924	-3.7772	-8.0127	-7.3933	-4.2784
Number of observations	1938	1938	1938	1938	1938	1938
R squared	0.8623	0.8674	0.6606	0.8719	0.8761	0.6720
Adjusted R squared	0.8621	0.8672	0.6601	0.8717	0.8758	0.6715
Std. error of est.	0.3266	0.3206	0.5128	0.3151	0.3100	0.5041
F-statistic	4037.804	3162.419	1254.766	4386.837	3415.543	1320.546
Error sum of squares	206.3025	198.6273	508.5756	191.9914	185.7317	491.5525
Durbin-Watson stat.	1.4623	1.5226	0.6087	1.5706	1.6265	0.6267

coefficient of Ln(TCI1) becomes positive and significant, as shown in eq. (111). As expected the elasticity of resale prices with respect to future rates (0.7903) is less than that with respect to current ones (1.4902), indicating that much more weight is placed on current than future rates. These results are confirmed by the last three regressions of Table 17, where the Ln(TCI) and Ln(TCI1) variables have been replaced by their moving average counterparts.

By considering the system of equations (107) and (108) one may wonder whether the supply over demand ratio (S/D) could be used directly (as an instrumental variable) in explaining resale prices. This is done in eq. (116) of Table 18. The results are very similar to those of eq. (110). The coefficient of Ln(S/D) has the wrong sign because of the collinearity between Ln(S/D) and Ln(TCI) (-0.67336). The omission of Ln(TCI) once again corrects the sign of the Ln(S/D), but the fit and the explanatory power of the equation drop significantly. One reason for this deterioration is that by regressing against Ln(S/D) we force the coefficients of LnS and LnD to take values of equal magnitude and opposite signs, without any apparent reason. We resolve this problem in eq. (118), where LnS and LnD are included as two individual explanatory variables. Although the model improves dramatically, the coefficient of LnD has the wrong sign. The reason is the correlation between LnD

Table 18. Effect of the Supply over Demand Ratio (S/D) on the Resale Price (PR) of Bulk Carriers

(t-statistics in parentheses)

Equation number	(115)	(116)	(117)	(118)	(119)
Study period	12/78-12/87	12/78-12/87	12/78-12/87	12/78-12/87	12/78-12/87
Dependent variable	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)
Explanatory variables					
AGE	-0.1078 (-73.210)	-0.1091 (-75.030)	-0.1062 (-47.313)	-0.1053 (-57.206)	-0.1053 (-57.329)
Ln(DWT)	0.6231 (45.442)	0.6218 (46.168)	0.5618 (27.101)	0.6353 (37.020)	0.6352 (37.036)
Ln(TCI)	1.4899 (61.464)	1.6742 (52.149)			
Ln(S/D)		1.4389 (8.557)	-4.4443 (-23.076)		
LnS				-2.5110 (-14.786)	-2.5432 (-41.834)
LnD				-0.0436 (-0.203)	
Constant	-7.7601	-9.0469	1.4205	13.2879	13.2391
Number of observations	1965	1965	1965	1965	1965
R squared	0.8624	0.8674	0.6834	0.7873	0.7873
Adjusted R squared	0.8622	0.8671	0.6829	0.7868	0.7869
Std. error of est.	0.3260	0.3202	0.4946	0.4055	0.4054
F-statistic	4097.776	3204.836	1410.824	1813.337	2418.951
Error sum of squares	N/A *	N/A *	N/A *	322.2625	N/A *
Durbin-Watson stat.	N/A *	N/A *	N/A *	0.9458	N/A *

* Not available due to numeric overflow error.

and LnS (0.93517). In eq. (119) the LnD variable is dropped without any important changes in the model.

The conclusions of the section are: (i) although we were able to predict the freight rates of the following year with eq. (107), those rates cannot be used in explaining resale prices because of strong correlation with the current ones; and (ii) the time charter index remains the superior explanator of second-hand prices.

5.2.3.2 <u>Rational expectations</u>

According to the rational expectations theory, expectations on a random variable are formed based on the actual probability distribution of this variable. In empirical studies this hypothesis is usually applied by assuming omniscient buyers and sellers. In other words, it is assumed that the ex ante expectations are equal to the ex post value of the random variable. In the following, we will apply this hypothesis in forming freight rate expectations. We assume that shipowners have prior knowledge of future freight rates. If this hypothesis is valid, resale prices should reflect current and future freight rates.

The current value of the Time Charter Index (TCI), and those of one and two years ahead (TCI+1 and TCI+2 respectively) will be tested in explaining resale prices.

The analysis covers the period Jan. 1977 to June 1986. The results are presented in Table 19. In eq. (121) only the Ln(TCI) and Ln(TCI+1) variables are included. The high correlation coefficient between Ln(TCI) and Ln(TCI+1) (0.63268) results in negative coefficient for Ln(TCI+1). In eq. (122) the Ln(TCI+2) variable has been added. The coefficient of Ln(TCI+1) turns into positive, but the coefficient of Ln(TCI+2) is significantly negative. This time collinearity is not a problem. Equations (123) to (125) of Table 19 show that the use of 3-month moving averages produces very similar results.

From this analysis we can reach the following conclusions. Firstly, shipowners are not omniscient as the rational expectations hypothesis wants. In fact, it seems that their forecasting horizon stops in two years. Secondly, the next year's freight rates are closely related to the current ones; therefore, they cannot be used in explaining resale prices. This last conclusion is in agreement with what we have found in the previous section.

5.2.4 The BIFFEX exchange

In May 1985 the Baltic International Freight Futures Exchange (BIFFEX) commenced operations in London, in order to provide shippers and shipowners with the opportunity to hedge against the risk induced by the highly volatile

Table 19. Effect of Future Charter Rates on the Resale Price (PR) of Bulk Carriers

(t-statistics in parentheses)

Equation number	(120)	(121)	(122)	(123)	(124)	(125)
Study period	1/77-6/86	1/77-6/86	1/77-6/86	3/77-6/86	3/77-6/86	3/77-6/86
Dependent variable	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)
Explanatory variables						
AGE	-0.1067 (-65.429)	-0.1103 (-66.512)	-0.1116 (-69.435)	-0.1089 (-67.475)	-0.1096 (-67.504)	-0.1112 (-70.546)
Ln(DWT)	0.5119 (31.119)	0.5106 (31.421)	0.5007 (31.831)	0.5285 (33.004)	0.5270 (33.024)	0.5186 (33.604)
Ln(TCI)	1.3835 (51.006)	1.5301 (44.194)	1.2202 (28.036)			
Ln(TCI+1)		-0.2309 (-6.683)	0.1711 (3.479)			
Ln(TCI+2)			-0.4177 (-11.132)			
Ln(TCI)ma				1.4488 (54.042)	1.5338 (43.599)	1.2046 (26.779)
Ln(TCI+1)ma					-0.1291 (-3.712)	0.2984 (5.859)
Ln(TCI+2)ma						-0.4315 (-11.171)
Constant	-6.7679	-6.2876	-4.4768	-7.1800	-6.9250	-5.0762
Number of observations	1748	1748	1748	1728	1728	1728
R squared	0.8377	0.8418	0.8523	0.8493	0.8505	0.8606
Adjusted R squared	0.8376	0.8414	0.8519	0.8491	0.8502	0.8602
Std. error of est.	0.3532	0.3488	0.3371	0.3411	0.3399	0.3283
F-statistic	4504.631	2318.538	2010.424	4860.966	2450.519	2126.215
Error sum of squares	N/A *	212.0785	197.9936	N/A *	199.0343	185.5857
Durbin-Watson stat.	N/A *	1.4498	1.5579	N/A *	1.5287	1.6427

* Not available due to numeric overflow error.

freight rates. The operation of BIFFEX is based on the Baltic Freight Index (BFI), an index covering voyage freight rates on thirteen dense trade routes for a variety of bulk commodities. BFI is calculated daily. The hedging operation is achieved by buying or selling the BFI for a forward settlement date. In each trading day, futures contracts can be exchanged for eight pre-specified future settlement dates, separated by three-month intervals. More details on the BIFFEX operation can be found in Appendix II.

For our application, BIFFEX is important not just because it produces the BFI index, but because it provides estimates of the market expectations of future freight rates for up to eight quarters ahead. These estimates will be used in explaining resale prices.

Daily values of the BFI index, as well as closing values of the expected level of BFI for the eight future dates are reported in the weekly "Fairplay". Monthly estimates are calculated by taking the arithmetic mean of the daily figures over a month. Monthly BFI estimates are graphed in Figure 15. The close relationship between BFI and the already discussed VID index is apparent.

The effect of BFI and its moving average version on resale prices for the period Sep. 1984 to Dec. 1987 are demonstrated by equations (128) and (129) of Table 20. Both variables produce very good results. A comparison between

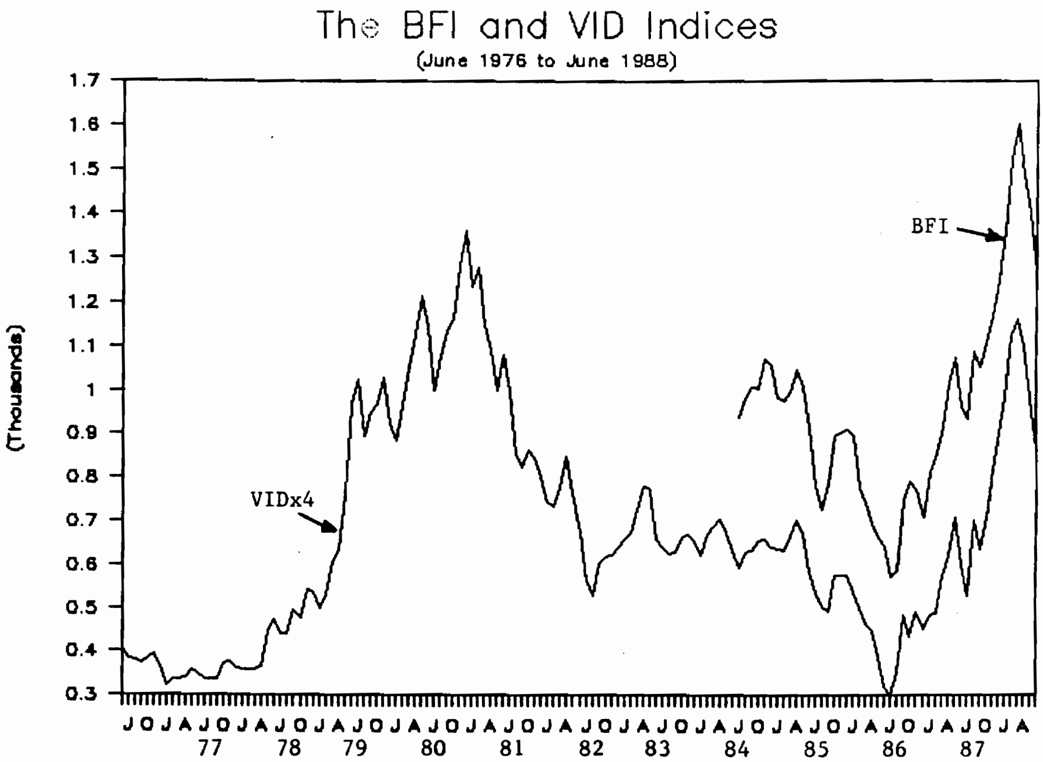

Figure 15. Comparison between the BFI and VID indices.

BFI and TCI shows that the Time Charter Index is slightly better in explaining second-hand values, apparently because of the longer duration of the time charter arrangement.

In equations (131) to (138) of Tables 21 and 22, the current values of BFI have been replaced by its expected future values for each of the eight following quarters. The notation BIF+n is used for the expected value of BFI n quarters ahead. The coefficients of the Ln(BIF+n) variables have the expected sign and are all significant and greater than unity in value. Their magnitude is shown graphically in Figure 16. Clearly the expected rates exactly one and two years ahead show higher elasticities. A possible

Table 20. Comparison between the TCI and BFI Indices in explaining Resale Prices

(t-statistics in parentheses)

Equation number	(126)	(127)	(128)	(129)
Study period	9/84-12/87	9/84-12/87	9/84-12/87	9/84-12/87
Dependent variable	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)
Explanatory variables				
AGE	-0.1059 (-55.339)	-0.1067 (-56.597)	-0.1086 (-54.598)	-0.1088 (-53.870)
Ln(DWT)	0.7649 (45.245)	0.7711 (46.366)	0.7734 (44.275)	0.7787 (43.951)
Ln(TCI)	1.6255 (29.440)			
Ln(TCI)ma		1.8311 (30.388)		
Ln(BFI)			1.4056 (27.471)	
Ln(BFI)ma				1.4959 (26.614)
Constant	-9.0848	-10.1381	-10.1620	-10.7640
Number of observations	883	883	883	883
R squared	0.8845	0.8882	0.8766	0.8730
Adjusted R squared	0.8841	0.8878	0.8762	0.8726
Std. error of est.	0.2778	0.2734	0.2871	0.2913
F-statistic	2244.296	2326.733	2081.420	2014.031
Error sum of squares	N/A *	N/A *	N/A *	N/A *
Durbin-Watson stat.	N/A *	N/A *	N/A *	N/A *

* Not available due to numeric overflow error.

Table 21. **Effect of BIFFEX Futures Contracts on the Resale Price (PR) of Bulk Carriers**

(t-statistics in parentheses)

Equation number	(130)	(131)	(132)	(133)	(134)
Study period	5/85-11/87	5/85-11/87	5/85-11/87	5/85-11/87	5/85-11/87
Dependent variable	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)
Explanatory variables					
AGE	-0.1067 (-48.434)	-0.1062 (-47.135)	-0.1056 (-46.116)	-0.1055 (-45.722)	-0.1059 (-47.540)
Ln(DWT)	0.7725 (39.209)	0.7709 (38.237)	0.7750 (37.817)	0.7649 (36.987)	0.7728 (38.770)
Ln(BFI)	1.4177 (24.497)				
Ln(BIF+1)		1.3871 (23.252)			
Ln(BIF+2)			1.3783 (22.335)		
Ln(BIF+3)				1.4144 (21.888)	
Ln(BIF+4)					1.7440 (23.861)
Constant	-10.2571	-10.0674	-10.0423	-10.2671	-12.5420
Number of observations	738	738	738	738	738
R squared	0.8732	0.8673	0.8628	0.8605	0.8702
Adjusted R squared	0.8727	0.8667	0.8622	0.8600	0.8697
Std. error of est.	0.2915	0.2982	0.3032	0.3056	0.2949
F-statistic	1684.667	1598.677	1538.255	1509.642	1640.174
Error sum of squares	62.3498	65.2584	67.4700	68.5704	63.8216
Durbin-Watson stat.	1.5109	1.4449	1.3949	1.3726	1.4676

Table 22. Effect of BIFFEX Futures Contracts on the Resale Price (PR) of Bulk Carriers

(t-statistics in parentheses)

Equation number	(130)	(135)	(136)	(137)	(138)
Study period	5/85-11/87	5/85-11/87	5/85-11/87	5/85-11/87	5/85-11/87
Dependent variable	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)
Explanatory variables					
AGE	-0.1067 (-48.434)	-0.1054 (-44.216)	-0.1041 (-40.981)	-0.1041 (-41.204)	-0.1046 (-44.259)
Ln(DWT)	0.7725 (39.209)	0.7697 (36.058)	0.7805 (34.279)	0.7714 (34.048)	0.7822 (36.938)
Ln(BFI)	1.4177 (24.497)				
Ln(BIF+5)		1.5783 (20.091)			
Ln(BIF+6)			1.2855 (16.255)		
Ln(BIF+7)				1.3734 (16.619)	
Ln(BIF+8)					1.9870 (20.487)
Constant	-10.2571	-11.4302	-9.4992	-10.1031	-14.3591
Number of observations	738	738	738	738	738
R squared	0.8732	0.8513	0.8305	0.8325	0.8534
Adjusted R squared	0.8727	0.8507	0.8298	0.8318	0.8528
Std. error of est.	0.2915	0.3156	0.3369	0.3349	0.3134
F-statistic	1684.667	1400.533	1198.921	1216.216	1423.791
Error sum of squares	62.3498	73.1179	83.3296	82.3431	72.0987
Durbin-Watson stat.	1.5109	1.2886	1.1288	1.1470	1.3008

explanation is the seasonal character of freight rates. Another observation from Tables 21 and 22 is that the t-statistics of the Ln(BIF+n) variables are generally decreasing as the expectation refers to a date further ahead into the future. The reason should be the decreasing variation in the expectations, as measured by the ratio of standard deviation over the mean.

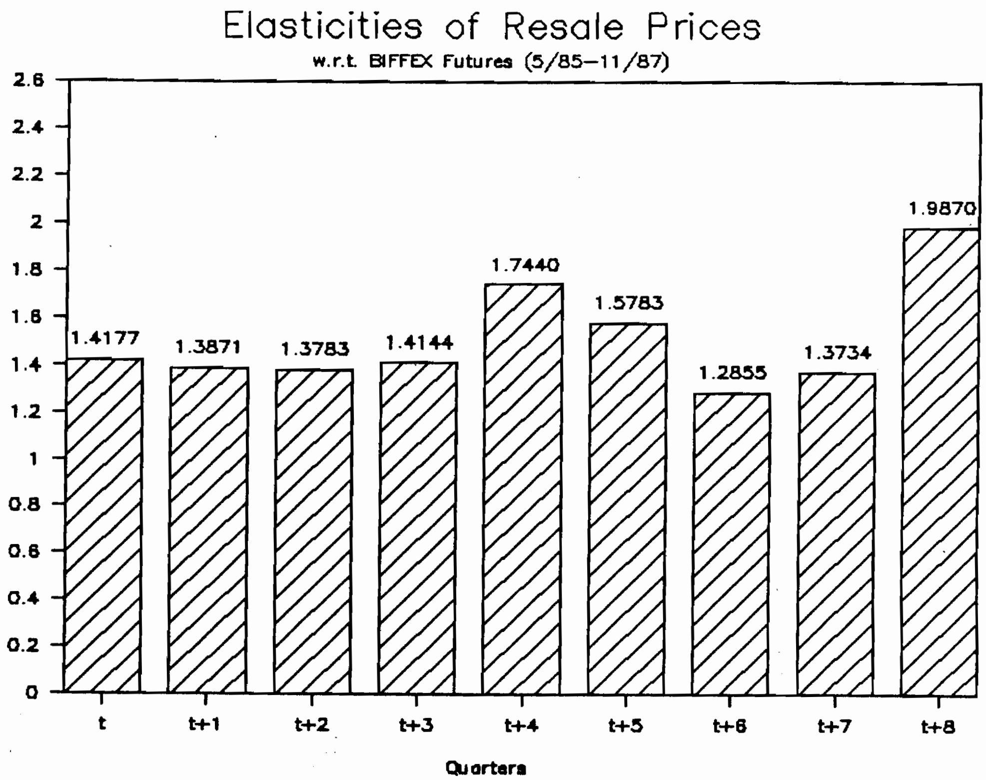

Figure 16. Elasticities of resale prices with respect to expected rates.

Unfortunately the high degree of correlation between current and expected values of BFI does not allow the introduction of more than one BFI-related variables into the equation. We can conclude, therefore, that expected freight rates do matter, but they cannot be used together with current rates in explaining resale prices.

Before closing the section and because the data were already in hand, we decided to test the "price-elastic expectations" hypothesis of Zannetos [47]. According to this hypothesis, an increase in freight rates creates expectations of even higher rates in the near future, or in economic terms, the elasticity of expected freight rates with respect to current ones is greater than one. The availability of expected BFI values from BIFFEX allows for a straight-forward test of this hypothesis. Our test covers the 31-month period May 1985 to Nov. 1987. Monthly estimates of expected BFI values for each one of the eight forthcoming quarters are regressed on current BFI values. The results are shown in Table 23. All elasticities are below one, contradicting the "price-elastic expectations" hypothesis. Of course, the low Durbin-Watson statistics indicate the existence of positive serial correlation and corrective measures should be taken. However, we do not expect the results to change drastically. Our conclusion, then, is in agreement with that of Glen, Owen and Van der Meer [20], who have provided evidence against the "price-elastic expectations" hypothesis by using a different approach.

Table 23. Test of the Price Elastic Expectations Hypothesis

(t-statistic in parenthesis)

Equation number	(139)	(140)	(141)	(142)	(143)	(144)	(145)	(146)
Study period	5/85-11/87	5/85-11/87	5/85-11/87	5/85-11/87	5/85-11/87	5/85-11/87	5/85-11/87	5/85-11/87
Dependent variable	Ln(BIF+1)	Ln(BIF+2)	Ln(BIF+3)	Ln(BIF+4)	Ln(BIF+5)	Ln(BIF+6)	Ln(BIF+7)	Ln(BIF+8)
Explanatory variable								
Ln(BFI)	0.9050	0.8377	0.7349	0.6782	0.6297	0.5764	0.5120	0.5075
	(13.972)	(9.406)	(6.706)	(9.892)	(7.125)	(5.176)	(4.274)	(6.956)
Constant	0.6503	1.1187	1.8211	2.2201	2.5563	2.9266	3.3816	3.4344
Number of observations	31	31	31	31	31	31	31	31
R squared	0.8707	0.7531	0.6079	0.7714	0.6364	0.4802	0.3865	0.6252
Adjusted R squared	0.8707	0.7531	0.6079	0.7714	0.6364	0.4802	0.3865	0.6252
Std. error of est.	0.0661	0.0909	0.1119	0.0700	0.0902	0.1137	0.1223	0.0745
F-statistic	195.206	88.468	44.964	97.844	50.765	26.790	18.270	48.383
Error sum of squares	0.1268	0.2397	0.3630	0.1421	0.2361	0.3748	0.4336	0.1608
Durbin-Watson stat.	1.3557	0.8785	0.6257	0.6276	0.6494	0.4343	0.4939	0.4407

5.3 Interest rates and fuel prices

So far we have attempted to explain resale price by the age and size of the vessel and the prevailing freight rates in the market. The best results obtained are those of eq. (127) of Table 20, which regresses resale prices on age, deadweight, and the moving average of the time charter index. In this section, we will try to improve eq. (127) by considering two other variables, interest rates and fuel prices.

We expect interest rates to affect second-hand prices for two reasons. Firstly, the interest rate is to some extent a measure of the opportunity cost that the shipowners face, since this is the return they would have earned on their capital should they had invested elsewhere. Resale prices, then, should be a negative function of interest rates. Secondly, nominal interest rates are closely related to the inflation rate. In fact according to the Fisher's equation, nominal interest rates are composed of real rates and inflation. Resale prices are positively related to inflation, and this relationship should also be reflected in the effect that nominal rates have on resale values. Therefore, interest rates should influence resale prices in two ways, contradicting to each other. Which one is dominating, remains to be seen from the results.

Among the many different interest rates reported in various places, we have selected two to be tested mainly because of their popularity. The first one, INT, is the yield on US Government medium-term bonds. Monthly estimates of INT are printed in the IMF publication, "International Financial Statistics" [28]. The second one, LIB, of a more international character, is the London Interbank Offer Rate (or LIBOR) on one-year US dollar deposits. The same publication mentioned above, provides monthly estimates of LIB since January 1982. The close relationship between those two rates is apparent in Figure 17.

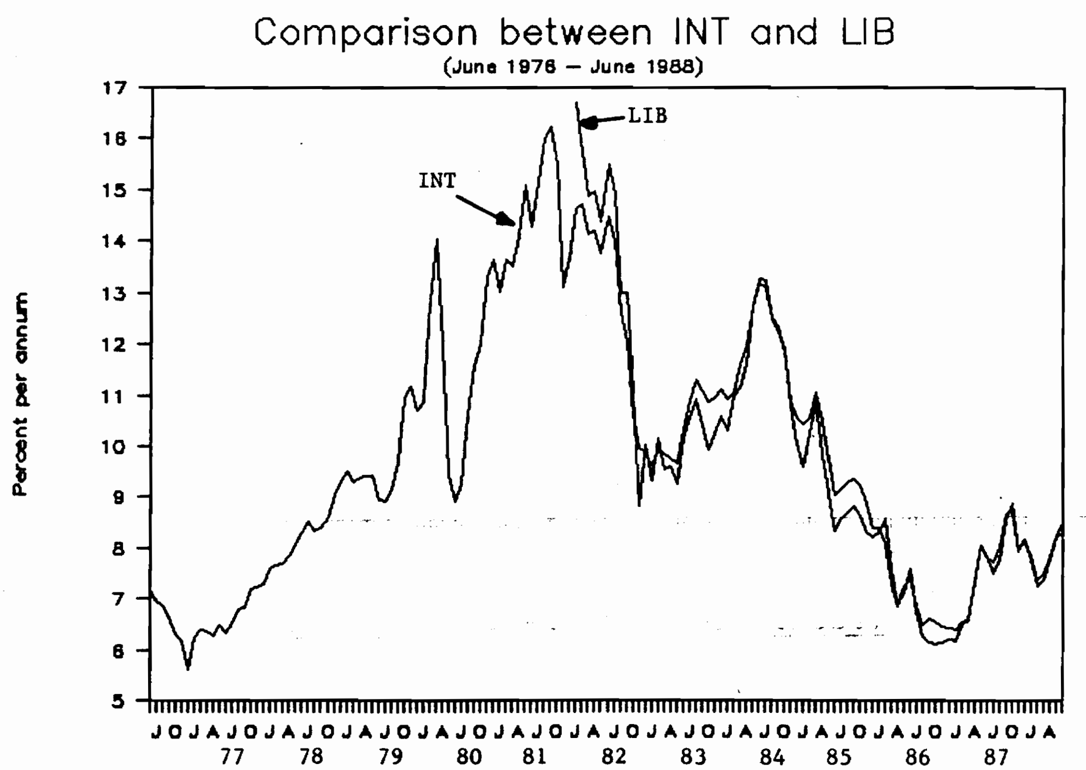

Figure 17. Movement of the INT and LIB interest rates.

The effects of INT and LIB on resale prices are presented in Table 24. In eq. (148) the Ln(INT) variable

Table 24. Comparison between INT and LIB in explaining resale prices
(t-statistics in parentheses)

Equation number	(147)	(148)	(149)
Study period	3/82-12/87	3/82-12/87	3/82-12/87
Dependent variable	Ln(PR)	Ln(PR)	Ln(PR)
Explanatory variables			
AGE	-0.1158 (-65.960)	-0.1168 (-68.136)	-0.1167 (-67.963)
Ln(DWT)	0.6456 (41.497)	0.6517 (42.942)	0.6513 (42.836)
Ln(TCI)ma	1.8485 (30.138)	1.6072 (24.384)	1.5954 (23.775)
Ln(INT)		0.3435 (8.677)	
Ln(LIB)			0.3181 (8.351)
Constant	-9.6119	-9.1233	-9.0009
Number of observations	1401	1401	1401
R squared	0.8474	0.8552	0.8547
Adjusted R squared	0.8471	0.8549	0.8544
Std. error of est.	0.3209	0.3127	0.3133
F-statistic	2585.991	2750.586	2738.443
Error sum of squares	N/A *	N/A *	N/A *
Durbin-Watson stat.	N/A *	N/A *	N/A *

* Not available due to numeric overflow error.

has been added to our familiar eq. (147). The elasticity of resale prices with respect to INT turns out positive and significant, showing the domination of the inflation effect. The coefficient of Ln(TCI)ma loses some of its magnitude and significance, apparently because of a certain degree of correlation between freight and interest rates. This should not be surprising since freight rates, too, are affected by inflation. Nevertheless, the correlation coefficient of 0.42431 is well below prohibitive levels. The addition of the Ln(INT) variable has improved the fit and explanatory power of the model.

In eq. (149) the Ln(LIB) variable has replaced Ln(INT), with almost identical results. In the remaining of the section we will focus on the bond yield variable (INT), mainly because data are readily available for the entire decade covered by the study.

We have hoped to capture the effect of opportunity cost to resale prices by the introduction of a real interest rate variable into the equation. Time series of real interest rates cannot be found in the literature, because they are not readily observable. We can create an estimate of real rates by subtracting inflation from nominal interest rates. However, a worldwide measure of inflation is not available. As a proxy, we have used the average change in the US Consumer Price Index (CPI) over the preceding two years.

Values of CPI are regularly reported in "International Financial Statistics" [28].

The produced in this way real interest rate, RINT, has replaced the Ln(INT) variable in eq. (151) of Table 25. Logarithmic transformation of RINT is not possible because of the negative values of real interest rates in the late 1970s. The results are not satisfactory. The effect of RINT on resale prices is so weak that even a low correlation between Ln(INT) and RINT (0.20435) results in a positive coefficient of RINT when the Ln(INT) variable is absent. In the presence of Ln(INT), RINT resumes its negative coefficient [eq. (152)]. Its t-statistic (-0.532) is not significant at the 10% level, but this doesn't matter very much because of the size of the sample (N = 2213). Nevertheless, the results of equations (151) and (152) show that either shipowners do not pay much attention to real interest rates, or more likely, our estimate of real rates is a bad one.[32]

Our next concern is the effect of expected operating costs on the resale value. However because of lack of data, the only cost variable we can test on is the fuel cost. Fuel prices depend on the type and quality of fuel and the location of bunkering. We have selected the price of bunker "C" in Rotterdam as being representative of the movements of

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[32]Better results on RINT are expected when the resale price PR is expressed in constant dollars.

Table 25. Effect of Interest Rates and Fuel Prices on Resale Prices of Bulk Carriers

(t-statistics in parentheses)

Equation number	(99)	(150)	(151)	(152)	(153)
Study period	3/77-12/87	3/77-12/87	3/77-12/87	3/77-12/87	3/77-12/87
Dependent variable	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)	Ln(PR)
Explanatory variables					
AGE	-0.1080 (-77.133)	-0.1092 (-79.417)	-0.1093 (-77.962)	-0.1092 (-78.810)	-0.1093 (-79.173)
Ln(DWT)	0.5899 (45.116)	0.5917 (46.249)	0.5825 (44.792)	0.5926 (45.895)	0.5917 (46.248)
Ln(TCI)ma	1.5012 (62.653)	1.3418 (47.326)	1.5916 (57.784)	1.3234 (29.597)	1.3423 (47.325)
Ln(INT)		0.3359 (9.993)		0.3531 (7.557)	0.3052 (5.739)
RINT			0.0201 (6.476)	-0.0023 (-0.532)	
Ln(FUEL)					0.0257 (0.744)
Constant	-7.6933	-7.5880	-8.2158	-7.5237	-7.6453
Number of observations	2213	2213	2213	2213	2213
R squared	0.8547	0.8610	0.8574	0.8610	0.8610
Adjusted R squared	0.8545	0.8607	0.8571	0.8607	0.8607
Std. error of est.	0.3279	0.3208	0.3249	0.3209	0.3209
F-statistic	4330.167	3417.932	3318.292	2733.514	2733.904
Error sum of squares	N/A *	227.2874	N/A *	N/A *	N/A *
Durbin-Watson stat.	N/A *	1.5940	N/A *	N/A *	N/A *

* Not available due to numeric overflow error.

fuel prices. A time series of FUEL is published in the "World Tanker Fleet Review" [46], and is presented in Figure 18. Fuel prices are quoted in US $ per long tonne.

In eq. (153) of Table 25, the Ln(FUEL) variable has been added to eq. (150). Contrary to our expectations, its coefficient is positive and insignificant. At the same time

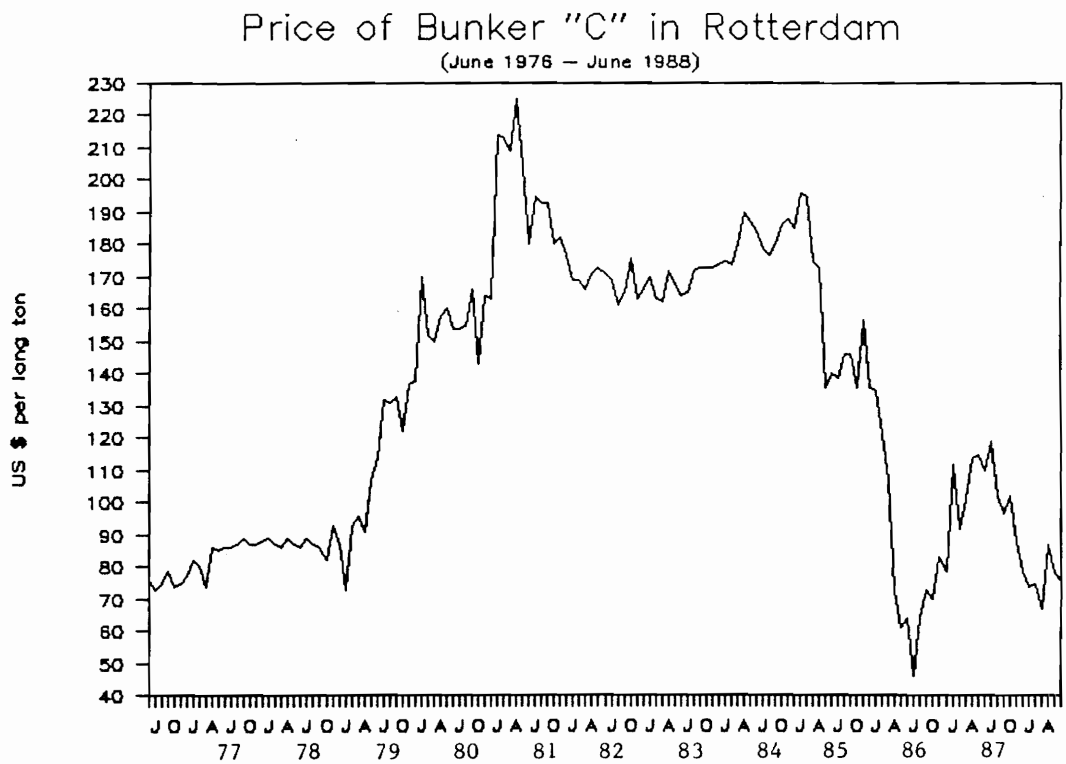


Figure 18. Movement of fuel prices.

the coefficient of Ln(INT) has dropped form 0.3359 to 0.3052 indicating a positive correlation between the two variables. In fact, the correlation coefficient between Ln(INT) and Ln(FUEL) (0.82810) is so high that Ln(FUEL) should be dropped from the equation.

5.4 Model evaluation

After the above analysis we can conclude that equation (150) of Table 25 is the one which best explains resale prices. In this section we will apply this equation on the ship sales occurred during March 1988 (not included in the sample which ends in December 1987).

Before doing that we will search for possible outliers. The residuals of eq. (150) have been plotted against the explanatory variables AGE, DWT, TCI and INT in Figures 19 to 22. The observations marked with A and B clearly fall into this category, and they have been dropped form the sample.

Our final equation, then, for the period Mar. 1977 to Dec. 1987 is:

$$\begin{aligned} Ln(PR) = -7.5849 - &\underset{(-81.607)}{0.1107} \cdot AGE + \underset{(47.231)}{0.5915} \cdot Ln(DWT) + \\ &+ \underset{(48.443)}{1.3444} \cdot Ln(TCI)ma + \underset{(10.197)}{0.3355} \cdot Ln(INT) \qquad (154) \end{aligned}$$

with $R^2 = 0.8667$, $\bar{R}^2 = 0.8664$, $S = 0.3140$, $F = 3586.172$, $ESS = 217.5556$ and $DW = 1.57$

The t-statistics of the coefficients and the R^2 have improved. The Durbin-Watson statistic of 1.57 shows the existence of weak positive correlation, but we will not attempt to correct for this, as the construction of the sample requires advanced techniques similar to those applied in Generalized Least Squares (GLS), which are not available in the software package we have used.

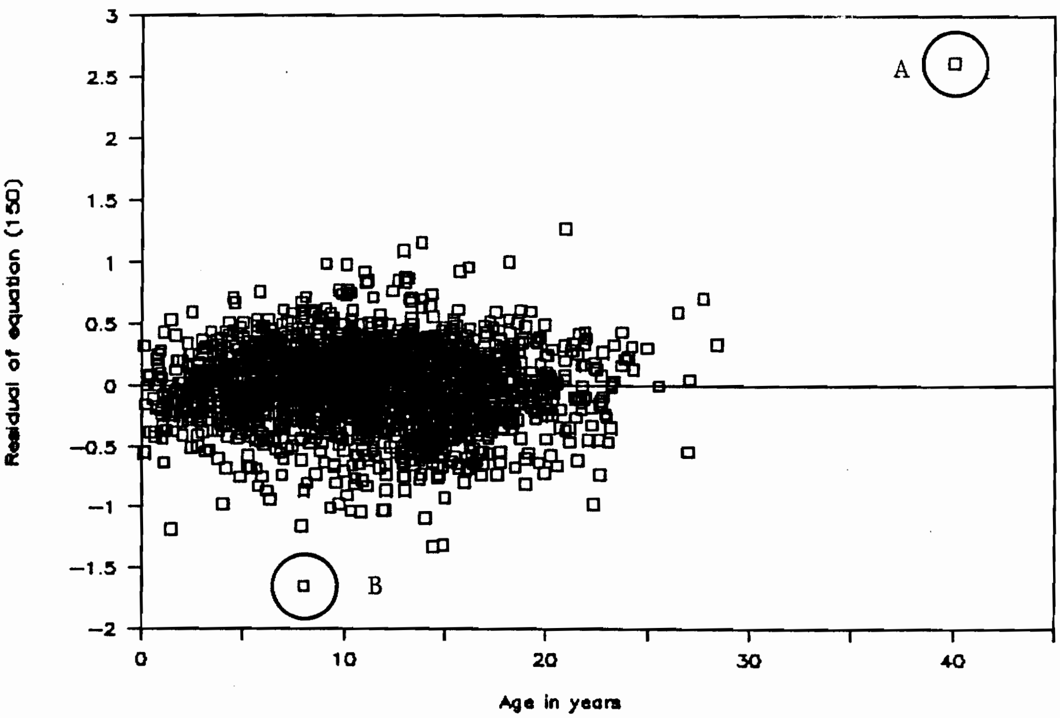


Figure 19. Residuals of eq. (150) against age

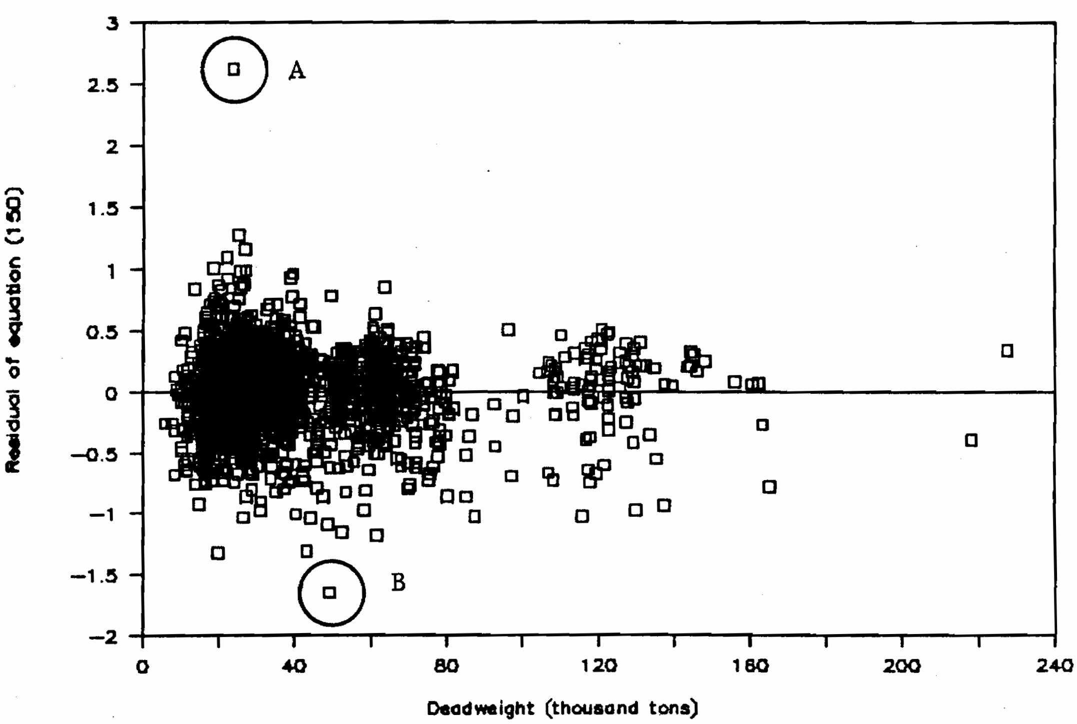


Figure 20. Residuals of eq. (150) against deadweight

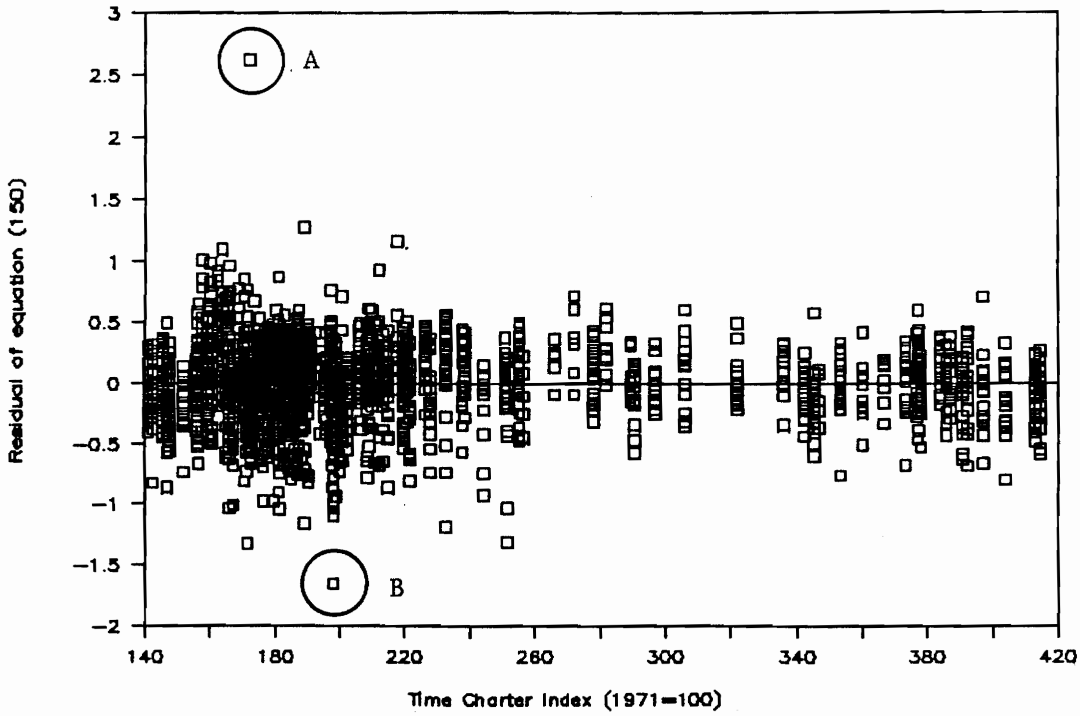


Figure 21. Residuals of eq. (150) against time charter index

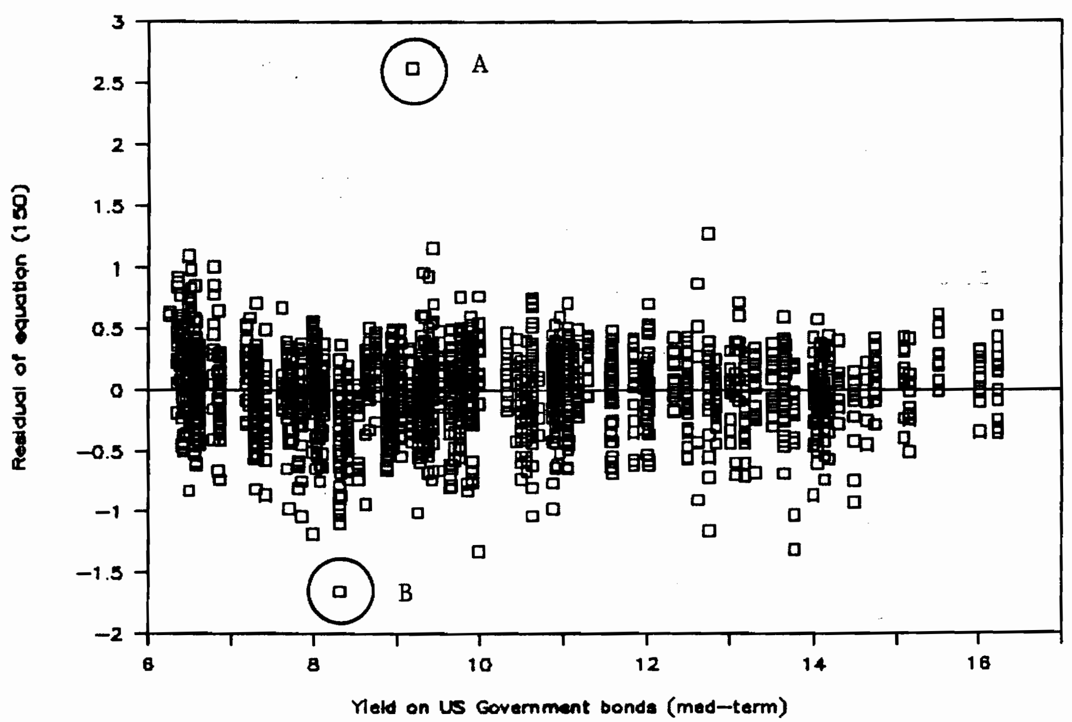


Figure 22. Residuals of eq. (150) against interest rate

Equation (154) was then applied to the 41 bulk carriers reported sold during March 1988. The results are presented in Table 26. In addition to the expected price, confidence intervals were calculated for the 95% level. The results look handsome. Out of the 41 ships sold, the price of only one falls outside the confidence range produced by the model. It seems that the model slightly underestimates prices, but this is due to the identified serial correlation mentioned above. In March 1988 freight rates were at the peak of a very steep upward movement started in the summer of the previous year.

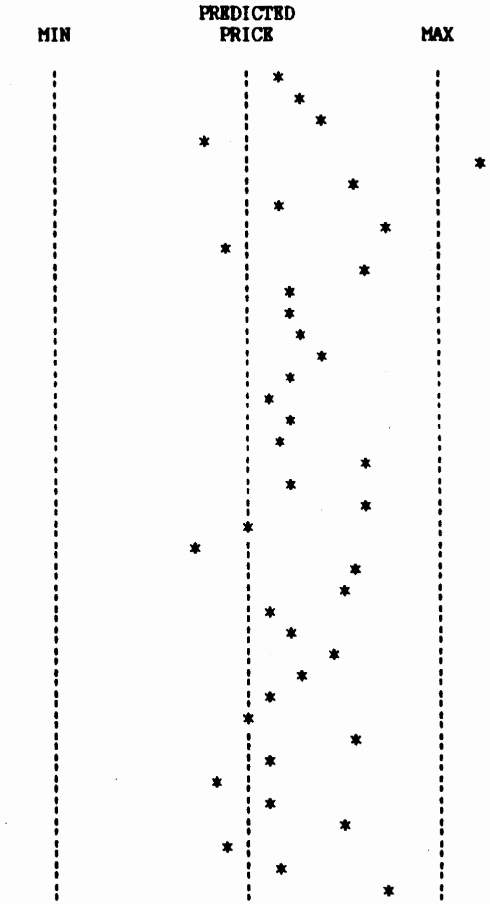
5.5 Conclusions

The results of the previous section indicate that we were successful in explaining the resale prices of bulk carriers. Four variables are used in explaining price movements within its upper (newbuilding price) and lower (scrap price) bounds.

The age and size of the vessel are the two physical characteristics that explain variation in resale prices at any point of time. Based on the regression results we were able to estimate a yearly depreciation rate of about 12.5% in a period of low rates. The size elasticity of resale price was found to be between 0.5 and 0.6, lower than the

Table 26. Evaluation of the model on the ships sold during March 1988

NAME	YEAR BUILT	DWT	ACTUAL RESALE PRICE	MODEL RESULTS MINIMUM PRICE	MODEL RESULTS PREDICTED PRICE	MODEL RESULTS MAXIMUM PRICE
AHRANTI	1972	27,048	3.175	1.066	2.899	4.732
AMERICAN TRADER	1977	26,684	5.900	1.841	5.002	8.164
ANARIS	1979	35,105	9.100	2.701	7.341	11.982
ASIAN THISTLE	1984	63,494	15.750	6.663	18.130	29.596
BOGLIASCO	1970	51,540	6.000	1.250	3.403	5.555
BULKVOLTRI	1976	60,920	9.800	2.683	7.298	11.912
CAPE ANTIBES	1972	24,090	3.000	0.996	2.707	4.419
CAPETAN V	1968	42,148	3.500	0.889	2.421	3.953
CHENNAI HUYARCHI	1973	52,600	4.500	1.765	4.800	7.835
CHIHROSAN	1973	110,906	10.250	2.738	7.463	12.188
CHILIARMENOUSA	1976	34,474	6.000	1.917	5.211	8.504
CLIVIA	1974	39,714	5.100	1.670	4.541	7.411
DALTON	1981	133,361	23.500	7.402	20.177	32.952
DENISH	1970	19,654	2.400	0.707	1.924	3.140
DIAMOND GLORIOUS	1971	145,092	8.000	2.568	7.012	11.456
EASTERN WISEMAN	1972	25,920	3.000	1.040	2.827	4.615
EXPORTAZUL	1971	145,092	8.000	2.568	7.012	11.456
FINNFURY	1975	34,995	5.200	1.731	4.706	7.681
GREGOS	1977	61,523	11.500	3.015	8.199	13.384
GULL	1970	26,765	2.600	0.849	2.309	3.770
HANDY QUEEN	1977	27,032	7.150	1.855	5.041	8.227
HELLESPONT DARING	1984	27,622	11.250	4.074	11.081	18.088
HELLESPONT DEFIANT	1985	27,601	10.000	4.548	12.372	20.197
HUNTER BOW	1973	67,628	7.500	2.046	5.569	9.093
JEANNIE II	1969	29,171	2.900	0.799	2.175	3.551
LEILA	1969	22,240	1.980	0.681	1.853	3.025
MARILY	1971	27,365	3.000	0.961	2.614	4.266
MONTCALM	1977	123,125	15.800	4.535	12.361	20.186
NIKAS	1973	34,640	4.400	1.379	3.749	6.119
OLYMPIC CONFIDENCE	1976	23,947	4.500	1.545	4.201	6.856
ORCHID PARK	1977	74,104	9.100	3.364	9.153	14.943
OSTRIA	1977	60,767	11.000	2.993	8.140	13.286
PACIFIC ENTREPRENEUR	1975	18,954	3.500	1.204	3.275	5.345
PANTELIS KALLIKIS	1980	22,280	5.600	2.304	6.264	10.223
PEONIA	1977	23,757	5.000	1.718	4.670	7.622
SPITHA	1976	39,772	7.500	2.086	5.671	9.255
STENA FORTUNA	1983	60,005	14.350	5.770	15.696	25.622
STENA TRUST	1981	60,101	14.000	4.630	12.591	20.552
VANCOUVER	1977	60,847	11.750	2.995	8.146	13.297



0.67 predicted by the "2/3-power rule" which is valid for newbuilding prices.

The section on freight rates provided strong support for our hypothesis that a ship's resale price is the present value of the expected future cashflow generated by its operation. We made various assumptions regarding the formation of freight rate expectations. The simplest one was that shipowners expect freight rates to remain at their present level. Several indices of freight rates were used. Among the indices of short-term (voyage) rates, the VID index published by Drewry Consultants, seem to be the best explanator of resale values. In all cases we found elastic reactions of resale prices to changes in freight rates. The use of actual freight rates made it possible to segregate the analysis in three size groups. The larger vessels exhibit lower resale price elasticity with respect to voyage rates. The use of long-term (time-charter) rates resulted in higher elasticities - in the range of 1.5 - and improved the explanatory power of the model.

We next assumed adaptive freight rate expectations. The supply over demand ratio proved to be a good predictor of next year's rates. However, the predicted rates cannot be used in explaining resale values because of their strong correlation with present rates. The same conclusion was reached twice again. Firstly, when we assumed rational expectations or "omniscient shipowners", and secondly, when we used actual market expectations as measured by the futures contracts exchanged in BIFFEX. As a by-product of our work with futures contracts, we were able to provide evidence that the "price-elastic expectations" hypothesis of Zannetos (i.e. the elasticity of expected freight rates with respect to current ones is greater than one) is not valid.

Finally we found changes in nominal interest rates to have an effect on resale prices. We estimated an elasticity of between 0.32 and 0.34. Our brief dealing with real interest rates did not result in anything spectacular. Fuel prices cannot be used due to their very strong correlation with interest rates.

The software used, although very user-friendly, proved to be marginally acceptable for this application, since it cannot handle effectively large samples.

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APPENDIX I

Data Description and Sources Used

	VARIABLE	DESCRIPTION
1.	PR	Resale price in million US $. Source: "Shipping Statistics and Economics" [42]. Period: June 1976 to June 1988. All bulk carriers reported sold during this period are included in the sample. Combination carriers are excluded. Ships equipped with steam turbines are excluded. Ships sold on "as is" basis, "en bloc", or sold while under time-charter contract expected to continue after the change of ownership are excluded. Sale of the same ship by the same owner appearing in more than one monthly reports means that the earlier sales have failed and only the latest reported sale is included in the sample.
2.	AGE	Age of the vessel in years. Source: "Shipping Statistics and Economics" [42]. Period: June 1976 to June 1988. The source reports the year during which the vessel was built. We made the assumption that all vessels were built at the end of June of the reported year. AGE is calculated by subtracting the date built from the date the sale occurred.
3.	DWT	Deadweight tonnage in thousand metric tons. Source: "Shipping Statistics and Economics" [42]. Period: June 1976 to June 1988.
4.	PR/DWT	Unit price in US $ per DWT ton. It is calculated by multiplying PR by 1000 and dividing by DWT. Period: June 1976 to June 1988.

VARIABLE		DESCRIPTION
5.	VID	Voyage freight rate index (Jan. 1975 = = 100). Source: "Shipping Statistics and Economics" [42]. Period: June 1976 to June 1988. Its calculation is based on three bulk trades: (i) grain moving from US Gulf Coast to Japan on 20,000 to 40,000 DWT bulk carriers; (ii) coal from Hampton Roads to Japan on 50,000 to 60,000 DWT ships; and (iii) iron ore moving from Brazil to NW Europe on 60,000 to 80,000 DWT bulkers.
6.	VCI	Voyage charter rate index (July 1965 to June 1966 = 100). Source: OECD, "Maritime Transport" [38]. Period: January 1977 to December 1986. It is based on tramp voyage rates on 28 routes, arranged in five bulk commodity groups with approximate weight aimed to give worldwide coverage. It includes tankers employed in the grain trade.
7.	VFR	Single voyage freight rate in US $ per tonne of cargo. Source: "Lloyd's Shipping Economist" [33]. Period: December 1979 to June 1988. For vessels of DWT <= 40,000 tons, the rate quoted is that for grain from US Gulf Coast to Japan on 30,000 DWT ships. For vessels of 40,000 < DWT <= 80,000 tons, the rate used is that for coal from Hampton Roads to Japan on 55,000 DWT carriers. For vessels above 80,000 DWT, VFR is the spot rate for iron ore moving from Brazil to NW Europe on 120,000 tonners.
8.	TCI	Time charter index (1971=100). Source: OECD, "Maritime Transport" [38]. Period: January 1977 to June 1988. It is based on average rates for all time charter fixtures for oil-fired steamers and motor vessels in the 10,000 to 50,000 DWT range. It excludes charters of more than a year in duration.

VARIABLE		DESCRIPTION
9.	S	Ship supply, the world bulk carrier fleet capacity in million DWT tons. Source: "Lloyd's Shipping Economist" [33]. Period: December 1978 to February 1988. Ships below 10,000 tons in DWT are excluded. Combis are excluded.
10.	D	Demand for shipping services in million DWT tons. Source: "Lloyd's Shipping Economist" [33]. Period: December 1978 to February 1988. Demand for ships below 10,000 tons in DWT is excluded. Demand for combis is excluded. It is calculated by subtracting from the world fleet capacity (S) the laid up and idle tonnage, as well as the equivalent tonnage lost due to slow steaming. This calculation of demand precludes the possibility of excess demand.
11.	S/D	Supply over demand ratio. S as described above divided by D as described above. Period: December 1978 to February 1988. Data for the calculation of an S/D ratio which includes combined carriers are also available in "Lloyd's Shipping Economist" [33].
12.	BFI	Baltic Freight Index (January 4th, 1985 = 1000). Source: "Fairplay" [16]. Period: July 1984 to June 1988. It covers voyage (spot) freight rates on thirteen dense trade routes for a variety of bulk commodities. It has been constructed by BIFFEX as an instrument for hedging. It is calculated daily. Monthly estimates are obtained by taking the arithmetic mean of the daily figures over a month.
13.	BIF+n	The closing value of the expected BFI for the nth settlement date. Source: "Fairplay" [16]. Period: May 1985 to November 1987.

VARIABLE	DESCRIPTION
	Settlement dates are separated by three-month intervals. BIF+n is the expected value of BFI for approximately the nth quarter ahead. The maximum value of n is eight. Daily figures of BIF+n are averaged over a month to produce monthly estimates.
14. INT	Yield on medium-term US Government bonds in percent per annum. Source: IMF, "International Financial Statistics" [28]. Period: June 1976 to June 1988.
15. LIB	London Interbank Offer Rate on one-year US dollar deposits, in percent per annum. Source: IMF, "International Financial Statistics" [28]. Period: January 1982 to June 1988.
16. CPI	The US Consumer Price Index (1975 = 100). Source: IMF, "International Financial Statistics" [28]. Period: June 1974 to June 1988.
17. RINT	Real interest rate, in percent per annum. It was calculated by subtracting inflation from INT. An estimate of inflation was obtained by calculating the average change in CPI over the previous two years. Period: June 1976 to June 1988.
18. FUEL	The price of fuel oil (Bunker C) in Rotterdam, in US $ per long tonne. Source: "World Tanker Fleet Review" [46]. Period: June 1976 to June 1988.

Notes

- The symbol "ma" following a variable notifies a moving average of this variable over the three most recent months.
- The symbol "Ln" preceding a variable notifies natural logarithm.

APPENDIX II

BIFFEX: What it is and how it works?

The volatility of the freight markets confront shippers with an unwelcomed degree of uncertainty. The concept of the futures contract (i.e. the commitment to buy or sell a specific quantity of a specific commodity for delivery on a specific future date at a specific price), applied already in many other industries, was desired in the shipping industry for years. But the traditional view was always that such a market was impossible because of the impossibility of delivering a specific freight rate at the maturity of the futures contract (unlike grain, for example, which is easily deliverable).

The solution to this problem was an index of freight rates. The "commodity" which is delivered at the settlement date on the freight futures markets is the cash equivalent of the general freight rate at that time as represented by an index. It is entirely a paper financial transaction, and real ships and cargoes are not involved at all.

On May 1st, 1985 the Baltic International Freight Futures Exchange (BIFFEX) came into being in London, and the Baltic Freight Index (BFI) was established. BFI is an index covering voyage freight rates (expressed in US $ per ton) on thirteen different trade routes for a variety of bulk commodities. It is calculated each day as the weighted average of actual rates on the 13 routes, or if there are no charters, a panel of brokers independently submit their estimates of what the charter rate would have been and these are averaged. The definition of the routes and their weights in the calculation of BFI are presented in Table II.1.

The hedging operation is achieved by selling or buying the BFI[33] for a specified forward date. The price at which ship operators and shippers respectively sell or buy it is set by a process of free and open negotiation between

Table II.1. Routes covered by BFI

Definition of route	Percentage Weighting
1. 1 PORT US GULF/ANTWERP, ROTTERDAM, AMSTERDAM 55,000 5 per cent, **heavy soya sorghum,** free in and out, 11 days Sundays holidays excepted, laydays 10 days forward from date of index, cancelling maximum 30 days forward from date of index 3.75 per cent brokerage	20
2. 1 PORT US GULF/1 PORT SOUTH JAPAN 52,000 5 per cent, **heavy soya sorghum,** free in and out, 11 days Sundays holidays excepted, laydays 10 days forward from date of index, cancelling maximum 30 days forward from date of index 3.75 per cent brokerage	20
3. 1 PORT UNITED STATES NORTH PACIFIC/1 PORT SOUTH JAPAN 52,000 5 per cent, **heavy soya sorghum,** free in and out, 11 days Sundays holiday excepted, laydays 10 days forward from date of index, cancelling maximum 30 days forward from date of index, 3.75 per cent brokerage	15
4. 1 PORT US GULF/VENEZUELA 21,000 5 per cent, **heavy soya sorghum,** 4 days/1,000 free in and out laydays 10 days forward from date of index, cancelling 25 days forward from date of index, 3.75 per cent brokerage	5
5. ANTWERP/1 PORT RED SEA 20,000 5 per cent, **bagged barley,** free in and out 2,500/1,000 laydays 10 days forward from date of index, cancelling 25 days forward from date of index, 5 per cent brokerage	5
6. 1 PORT HAMPTON ROADS AND RICHARDS BAY/1 PORT SOUTH JAPAN 120,000 10 per cent, **coal,** 8 days Sundays holidays included, 15,000 Richards Bay, laydays 10 days forward from date of index, cancelling maximum 30 days forward from date of index, 3.75 per cent brokerage	5
7. 1 PORT HAMPTON ROADS EXCLUDING BALTIMORE/1 PORT ANTWERP ROTTERDAM AMSTERDAM 65,000 10 per cent, **coal,** 5 days Sundays holidays included/Sundays holidays excepted, laydays 10 days forward from date of index, cancelling maximum 30 days forward from date of index, 3.75 per cent brokerage	5
8. QUEENSLAND/ROTTERDAM 110,000/10 per cent, **coal,** free in and out 40,000 Sundays Holidays included/25,000 Sundays Holidays excluded, laydays 15 days forward from date of index, cancelling 25 days forward from date of index, 5 per cent brokerage	5
9. VANCOUVER-SAN DIEGO RANGE/ROTTERDAM 55,000/10 per cent, **petroleum coke,** free in and out 10,000 Sundays Holidays included/10,000 Sundays Holidays excluded, laydays 15 days forward from date of index, cancelling 25 days forward from date of index, 5 per cent brokerage	5
10. MONROVIA/ROTTERDAM 90,000 10 per cent, **iron ore,** 5 days Sundays Holidays included, laydays 15 days forward from date of index, cancelling maximum 30 days forward from date of index, 3.75 per cent brokerage	5
11. RECIFÉ/1 PORT UNITED STATES EAST COAST 20,000 5 per cent, **bulk sugar,** free in and out and trimmed 750 mechanical/1,500, laydays 10 days forward from date of index, cancelling maximum 30 days forward from date of index, 6.25 per cent brokerage	5
12. HAMBURG/WEST COAST INDIA 13/20,000, **muriate of potash,** free in and out 3,500/1,000 laydays 10 days forward from date of index, cancelling 25 days forward from date of index, 5 per cent brokerage	2.5
13. AQABA/1 PORT WEST COAST INDIA 14,000 5 per cent, **phosphate rock,** free in and out 3,500/1,000 laydays 10 days forward from date of index, cancelling 25 days forward from date of index, 5 per cent brokerage	2.5

Source: Fairplay, January 3rd, 1985, p.13

[33]To be more specific the hedger on BIFFEX buys or sells a multiple of "contract units" or "Lots". Each "Lot" is worth the index value multiplied by US $10.

Table II.2. An example on BIFFEX trading

FUTURES TRADING

BIFFEX TRADING-A WORKED EXAMPLE

A Hedging Strategem with freight rates predicted on Baltic Freight Index

1. SCENARIO:— 1st May, 1985. Grain House X comes into the freight market for four cargoes, each 52,000 MT bulk HSS, quarterly over 1986. Japanese shipowners Y have suitable tonnage to take the contract, and would like to do so. The charterers however take the view that the 1986 market will be very flat, and rates much in line with the 1985 levels. The owners take the view that the first and third quarter cargoes will be 5 per cent better than this year, and that the second and final cargoes will be at least 10 per cent better. All other terms and conditions of the proposed contract are quickly agreed, apart from the freight rate.

2. SOLUTION. It is finally agreed that the freight rate for each cargo will be decided on the first business day of January, April, July and October by reference to the Baltic Freight Index for that day. A formula is agreed whereby the spot index divided by 70 will be the applicable rate. So if the index that day stands at 1,000, the rate will be $14.29.

The contract of affreightment can be signed, the charterer is certain that he will pay no more than spot market levels, and the owner is certain that he will receive a fair spot market level.

3. HOWEVER, although both parties are happy that they will respectively pay and receive a fair market freight rate, both may still be concerned that between now and the performance of the contract there may be some occurence which will drive the spot market to either very high or very low levels. (The former, obviously worries the charterer, the latter worries the owner).

To avoid this worry, both parties to the contract could take out total or partial cover on the Baltic International Freight Futures Exchange.

4. FOR EXAMPLE. On the date at which they agree the contract (let us say May 1, 1985), the spot index stands at 1,000. The BIFFEX prices quoted for 1986 are as follows:

January	950
April	1,100
July	1,045
October	1,155

These futures prices mean that BIFFEX is anticipating the Gulf/Japan rate for next year being respectively:—

January	$13.57
April	$15.71
July	$14.92
October	£16.50
Average	$15.17

Since each cargo is 52,000 MT the lump sum freight would therefore be on the basis of these futures prices:—

January	$705,640
April	$816.920
July	$775,840
October	$858,000

The *value* of each futures contract is $10 x Index, or:—

January	$9,500
April	$11,000
July	$10,450
October	$11.550

So to hedge the above lumpsum freights, it would be necessary for the charterer to *buy* or the owner to *sell* the following lots.

	Lumpsum Freight
Jan	$705,640
April	$816,920
July	$775,840
Oct	$858,000

Contract Value	No of Lots
$9,500	74
$11,000	74
$10,450	74
$11,550	74

Let us assume that both parties take out a 100 per cent hedge. Let us further assume that the BIFFEX prices at which they took out their hedge change in the interim before the performance of the contract by the following amounts:—

January	— 5%
April	+ 5%
July	—10%
October	+10%

5. THE OWNERS overall cash position is as shown in the boxed diagram below left.

Physical	Date	Futures
Earns 52,000 x $12.89 (950 less 5% ÷ 70) = $607,280	Jan '86	Sells 74 lots at 902 = $667,480
Earns 52,000 x $16.50 (1,100 plus 5% ÷ 70) = $858,000	April '86	Sells 74 lots at 1155 = $854,700
Earns 52,000 x $13.43 (1,045 less 10% ÷ 70) = $698,360	July '86	Sells 74 lots at 940.5 = $695,970
Earns 52,000 x $18.07 1,155 plus 10% ÷ 70) = $939,640	Oct '86	Sells 74 lots at 1270.5 = $940.170
Total Earnings = $3,166,280 ÷ 208,000 MT Average Rate per Conract = $15.22 PMT		Total Income = $3.158.320

6. RESULT. By using this hedging strategem combined with forward fixing of the freight rate based on the spot index, the owner has achieved two things:—

1. He has secured a contract which he might otherwise have lost owing to the inability to agree freight rates with the charterers.

2. Although the market in the event declines for the January and July quarters, he makes a profit on his futures position for those quarters. Similarly, although he makes a profit on the physical market in April and October, that will be offset by his losses in the futures market. In other word, when he fixes the contract, and takes out his figures position he is effectively writing in a quartered freight rate of $15-$22 over the year.

A similar, but opposite result can be demonstrated from the point of view of the charterer.

The purpose of the exercise is, of course to eradicate the risk of the physical market moving against the hedger. It removes risk and guarantees a pre-fixed return.

James Gray
Manager, GNI Freight Futures

Source: Fairplay, May 23rd, 1985, p. [50]

brokers representing sellers and buyers on the floor of BIFFEX.

Because of the necessity of finding matching sellers and buyers, it is not possible to trade for all future dates. Instead, BIFFEX stipulates certain dates ("settlement dates") for which it is possible to place a hedge. There are four of these settlement dates a year (the last day of January, April, July and October) up to two years ahead. So if today is September 20th, 1988, the futures contract months available are October, 1988 plus January, April, July and October, 1989 plus January, April and July, 1990.

A complete example on BIFFEX trading is presented in Table II.2. For our application it is important to know that BIFFEX not only produces the BFI index, but it also provides estimates of the market expectations of future freight rates for up to eight quarters ahead.

APPENDIX III

Descriptive Statistics for the Regressions of Chapter 5

VARIABLE	MEAN	STANDARD DEVIATION
Equations (63) to (73)		
PR	4.0046	3.1843
PR/DWT	112.9109	76.5687
AGE	11.7710	4.7523
DWT	40.1501	28.3069
DWT^2	2411.2050	4424.9566
Ln(PR)	1.1044	0.7792
Ln(PR/DWT)	4.4933	0.7134
Ln(AGE)	2.3372	0.6383
Ln(DWT)	3.5189	0.5558
Equations (79) to (86)		
Ln(PR)	1.1822	0.8579
AGE	11.1753	5.0794
Ln(DWT)	3.4665	0.5478
Ln(VID)	5.0654	0.3477
Ln[(VID)t/(VID)t-1]	0.0186	0.1049
Ln[(VID)t/(VID)t-2]	0.0349	0.1544
Ln[(VID)t/(VID)t-3]	0.0420	0.1852
Ln[(VID)t/(VID)t-4]	0.0481	0.2017
Ln[(VID)t/(VID)t-5]	0.0513	0.2197
Ln[(VID)t/(VID)t-6]	0.0484	0.2305
Ln(VID)ma	5.0502	0.3410
Equations (88) and(89)		
Ln(PR)	1.1815	0.8802
AGE	11.0969	5.1745
Ln(DWT)	3.4488	0.5321
Ln(VCI)	5.1301	0.1378
Ln(VCI)ma	5.1255	0.1360
Equations (90) and (91)		
Ln(PR)	0.9498	0.8565
AGE	11.8993	5.1205

VARIABLE	MEAN	STANDARD DEVIATION
Ln(DWT)	3.1911	0.2935
Ln(VFR)	2.9201	0.2989
Ln(VFR)ma	2.8956	0.2983
Equations (92) and (93)		
Ln(PR)	1.5545	0.7406
AGE	10.4173	4.9174
Ln(DWT)	4.0502	0.1765
Ln(VFR)	2.5846	0.3546
Ln(VFR)ma	2.5674	0.3463
Equations (94) and (95)		
Ln(PR)	1.9319	0.6955
AGE	11.0330	4.1058
Ln(DWT)	4.7867	0.1691
Ln(VFR)	1.6682	0.2894
Ln(VFR)ma	1.6466	0.2820
Equations (96) and (97)		
Ln(PR)	1.1486	0.8820
AGE	11.5052	5.0539
Ln(DWT)	3.4856	0.5542
Ln(VFR)	2.7671	0.4409
Ln(VFR)ma	2.7445	0.4377
Equations (98) and (99)		
Ln(PR)	1.1827	0.8596
AGE	11.1560	5.0759
Ln(DWT)	3.4707	0.5471
Ln(TCI)	5.3605	0.2954
Ln(TCI)ma	5.3516	0.2929
Equation (105)		
TCI+12	236.9223	83.2120
S/D	1.2439	0.0755
TCI	234.9417	82.2733

VARIABLE	MEAN	STANDARD DEVIATION
Equations (106) and (107)		
TCI+1	240.6389	83.0971
S/D	1.2449	0.0727
TCI	235.2037	78.3539
Equations (109) to (114)		
Ln(PR)	1.1947	0.8795
AGE	11.3668	5.0824
Ln(DWT)	3.4762	0.5496
Ln(TCI)	5.3801	0.3080
Ln(TCI1)	5.4335	0.2881
Ln(TCI)ma	5.3717	0.3055
Ln(TCI1)ma	5.4353	0.2814
Equations (115) to (119)		
Ln(PR)	1.1948	0.8782
AGE	11.3662	5.0819
Ln(DWT)	3.4751	0.5498
Ln(TCI)	5.3797	0.3059
Ln(S/D)	0.2184	0.0584
LnS	5.1333	0.1528
LnD	4.9149	0.1208
Equations (120) to (122)		
Ln(PR)	1.2266	0.8760
AGE	11.1485	5.2360
Ln(DWT)	3.4328	0.5313
Ln(TCI)	5.3843	0.3131
Ln(TCI+1)	5.4005	0.3154
Ln(TCI+2)	5.4223	0.3228
Equations (123) to (125)		
Ln(PR)	1.2261	0.8780
AGE	11.1483	5.2369
Ln(DWT)	3.4361	0.5310
Ln(TCI)ma	5.3865	0.3082
Ln(TCI+1)ma	5.4004	0.3131
Ln(TCI+2)ma	5.4239	0.3160

VARIABLE	MEAN	STANDARD DEVIATION
Equations (126) to (129)		
Ln(PR)	0.8671	0.8160
AGE	11.5091	4.9629
Ln(DWT)	3.5528	0.5603
Ln(TCI)	5.2003	0.1700
Ln(TCI)ma	5.1848	0.1535
Ln(BFI)	6.7812	0.1907
Ln(BFI)ma	6.7632	0.1763
Equations (130) to (138)		
Ln(PR)	0.8667	0.8168
AGE	11.1816	4.9499
Ln(DWT)	3.5648	0.5519
Ln(BFI)	6.7458	0.1863
Ln(BIF+1)	6.7578	0.1848
Ln(BIF+2)	6.7668	0.1815
Ln(BIF+3)	6.7780	0.1748
Ln(BIF+4)	6.7874	0.1490
Ln(BIF+5)	6.7993	0.1485
Ln(BIF+6)	6.8052	0.1572
Ln(BIF+7)	6.8325	0.1496
Ln(BIF+8)	6.8481	0.1192
Equations (139) to (146)		
Ln(BFI)	6.7331	0.1864
Ln(BIF+1)	6.7437	0.1808
Ln(BIF+2)	6.7592	0.1799
Ln(BIF+3)	6.7690	0.1757
Ln(BIF+4)	6.7865	0.1439
Ln(BIF+5)	6.7964	0.1471
Ln(BIF+6)	6.8076	0.1550
Ln(BIF+7)	6.8289	0.1535
Ln(BIF+8)	6.8511	0.1196
Equations (147) to (149)		
Ln(PR)	0.9572	0.8206
AGE	11.5639	4.9532
Ln(DWT)	3.5256	0.5580
Ln(TCI)ma	5.2108	0.1401
Ln(INT)	2.2100	0.2341

VARIABLE	MEAN	STANDARD DEVIATION
Ln(LIB)	2.1915	0.2472
Equations (150) to (153)		
Ln(PR)	1.1827	0.8596
AGE	11.1560	5.0759
Ln(DWT)	3.4707	0.5471
Ln(TCI)ma	5.3516	0.2929
Ln(INT)	2.2481	0.2470
RINT	3.9229	2.6260
Ln(FUEL)	4.8376	0.3533
Equation (154)		
Ln(PR)	1.1837	0.8594
AGE	11.1443	5.0403
Ln(DWT)	3.4706	0.5472
Ln(TCI)ma	5.3517	0.2930
Ln(INT)	2.2482	0.2471

APPENDIX IV

Correlation Matrices

Equations (63) and (65)

	PR	AGE	DWT	DWT^2
PR	1.00000			
AGE	-.77756	1.00000		
DWT	.46476	-.12585	1.00000	
DWT^2	.39391	-.10313	.93972	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .08442
CRITICAL VALUE (2-tail, .05) = +/- .10049

N = 381

Equations (64) and (66)

	PR/DWT	AGE	DWT
PR/DWT	1.00000		
AGE	-.80303	1.00000	
DWT	-.24459	-.12585	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .08442
CRITICAL VALUE (2-tail, .05) = +/- .10049

N = 381

Equations (67), (68) and (69)

	Ln(PR)	AGE	DWT	LnAGE	LnDWT
Ln(PR)	1.00000				
AGE	-.85838	1.00000			
DWT	.42590	-.12585	1.00000		
LnAGE	-.72210	.85014	-.11718	1.00000	
LnDWT	.47001	-.12795	.93474	-.13274	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .08442
CRITICAL VALUE (2-tail, .05) = +/- .10049

N = 381

Equations (70), (71), (72) and (73)

	Ln(P/D)	AGE	DWT	LnAGE	LnDWT
Ln(P/D)	1.00000				
AGE	-.83783	1.00000			
DWT	-.26309	-.12585	1.00000		
LnAGE	-.68526	.85014	-.11718	1.00000	
LnDWT	-.26576	-.12795	.93474	-.13274	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .08442
CRITICAL VALUE (2-tail, .05) = +/- .10049

N = 381

Equations (79), (80), (81), (82), (83), (84) and (85)

	LnPR	AGE	LnDWT	LnVID	LnVID/1	LnVID/2	LnVID/3	LnVID/4
LnPR	1.00000							
AGE	-.70903	1.00000						
LnDWT	.44302	-.19872	1.00000					
LnVID	.38575	.06005	-.06031	1.00000				
LnVID/1	.03124	-.01429	.04651	.16888	1.00000			
LnVID/2	.02827	-.02226	.06558	.18690	.75819	1.00000		
LnVID/3	.05423	-.02801	.05698	.21601	.58571	.85775	1.00000	
LnVID/4	.08020	-.03002	.03621	.26464	.49151	.72809	.87974	1.00000
LnVID/5	.10945	-.02547	.01451	.31890	.44480	.62085	.75630	.90557
LnVID/6	.15020	-.03923	.02385	.33711	.43661	.55389	.65245	.79471

	LnVID/5	LnVID/6
LnVID/5	1.00000	
LnVID/6	.91730	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .03473
CRITICAL VALUE (2-tail, .05) = +/- .04138

N = 2245

Equation (86)

	LnPR	AGE	LnDWT	LnVID	LnVIDma
LnPR	1.00000				
AGE	-.70903	1.00000			
LnDWT	.44302	-.19872	1.00000		
LnVID	.38575	.06005	-.06031	1.00000	
LnVIDma	.38537	.06560	-.07576	.97326	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .03473
CRITICAL VALUE (2-tail, .05) = +/- .04138

N = 2245

Equations (88) and (89)

	LnPR	AGE	LnDWT	LnVCI	LnVCIma
LnPR	1.00000				
AGE	-.71518	1.00000			
LnDWT	.41636	-.22955	1.00000		
LnVCI	.35592	.06473	-.06140	1.00000	
LnVCIma	.35499	.07388	-.06929	.97426	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .03782
CRITICAL VALUE (2-tail, .05) = +/- .04505

N = 1894

Equations (90) and (91)

	LnPR	AGE	LnDWT	LnVFR	LnVFRma
LnPR	1.00000				
AGE	-.69390	1.00000			
LnDWT	.28754	-.17867	1.00000		
LnVFR	.52616	.02207	-.12727	1.00000	
LnVFRma	.46856	.05171	-.13712	.85716	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .04665
CRITICAL VALUE (2-tail, .05) = +/- .05557

N = 1245

Equations (92) and (93)

	LnPR	AGE	LnDWT	LnVFR	LnVFRma
LnPR	1.00000				
AGE	-.73792	1.00000			
LnDWT	.23970	-.14847	1.00000		
LnVFR	.45837	.07642	-.00773	1.00000	
LnVFRma	.44708	.06571	.00353	.94559	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .08187
CRITICAL VALUE (2-tail, .05) = +/- .09747

N = 405

Equations (94) and (95)

	LnPR	AGE	LnDWT	LnVFR	LnVFRma
LnPR	1.00000				
AGE	-.78528	1.00000			
LnDWT	.25093	-.23277	1.00000		
LnVFR	.54359	-.17050	-.07417	1.00000	
LnVFRma	.50225	-.15583	-.08669	.94608	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .16070
CRITICAL VALUE (2-tail, .05) = +/- .19080

N = 106

Equations (96) and (97)

	LnPR	AGE	LnDWT	LnVFR	LnVFRma
LnPR	1.00000				
AGE	-.69278	1.00000			
LnDWT	.44205	-.17516	1.00000		
LnVFR	.10042	.07286	-.61498	1.00000	
LnVFRma	.07072	.08537	-.61653	.94388	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .03927
CRITICAL VALUE (2-tail, .05) = +/- .04679

N = 1756

Equations (98) and (99)

	LnPR	AGE	LnDWT	LnTCI	LnTCIma
LnPR	1.00000				
AGE	-.70708	1.00000			
LnDWT	.44160	-.19363	1.00000		
LnTCI	.46210	.00329	-.09962	1.00000	
LnTCIma	.46517	.00664	-.11204	.98264	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .03498
CRITICAL VALUE (2-tail, .05) = +/- .04168

N = 2213

Equation (105)

	TCI+12	S/D	TCI
TCI+12	1.00000		
S/D	-.80036	1.00000	
TCI	.53321	-.68916	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .16305
CRITICAL VALUE (2-tail, .05) = +/- .19357

N = 103

Equations (106) and (107)

	TCI+1	S/D	TCI
TCI+1	1.00000		
S/D	-.85409	1.00000	
TCI	.55456	-.78170	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .58607
CRITICAL VALUE (2-tail, .05) = +/- .66422

N = 9

Equations (109), (110), (111), (112), (113) and (114)

	LnPR	AGE	LnDWT	LnTCI	LnTCI1	LnTCIma	LnTCI1ma
LnPR	1.00000						
AGE	-.70295	1.00000					
LnDWT	.43684	-.17822	1.00000				
LnTCI	.48615	-.01844	-.12153	1.00000			
LnTCI1	.28836	-.08017	-.05947	.60931	1.00000		
LnTCIma	.48821	-.01516	-.13412	.98232	.59771	1.00000	
LnTCI1ma	.30361	-.07765	-.07183	.63500	.97328	.62745	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .03738
CRITICAL VALUE (2-tail, .05) = +/- .04454

N = 1938

Equations (115), (116), (117), (118) and (119)

	LnPR	AGE	LnDWT	LnTCI	LnS/D	LnS	LnD
LnPR	1.00000						
AGE	-.70431	1.00000					
LnDWT	.44082	-.18137	1.00000				
LnTCI	.48345	-.01829	-.12042	1.00000			
LnS/D	-.32286	.08759	.07567	-.67336	1.00000		
LnS	-.41341	.05189	.15228	-.76970	.68076	1.00000	
LnD	-.36657	.02325	.15595	-.64757	.37717	.93517	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .03713
CRITICAL VALUE (2-tail, .05) = +/- .04423

N = 1965

Equations (120), (121) and (122)

	LnPR	AGE	LnDWT	LnTCI	LnTCI+1	LnTCI+2
LnPR	1.00000					
AGE	-.72960	1.00000				
LnDWT	.41720	-.23658	1.00000			
LnTCI	.47308	-.01246	-.09524	1.00000		
LnTCI+1	.32954	-.12098	-.04258	.63268	1.00000	
LnTCI+2	-.07904	-.14497	.00130	-.12044	.49241	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .03936
CRITICAL VALUE (2-tail, .05) = +/- .04690

N = 1748

Equations (123), (124) and (125)

	LnPR	AGE	LnDWT	LnTCIma	LnTCI+1m	LnTCI+2m
LnPR	1.00000					
AGE	-.72822	1.00000				
LnDWT	.41690	-.23564	1.00000			
LnTCIma	.47793	-.00670	-.10962	1.00000		
LnTCI+1m	.36191	-.11841	-.06236	.65056	1.00000	
LnTCI+2m	-.04058	-.15640	.00005	-.10151	.50618	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .03959
CRITICAL VALUE (2-tail, .05) = +/- .04717

N = 1728

Equations (126) and (127)

	LnPR	AGE	LnDWT	LnTCI	LnTCIma
LnPR	1.00000				
AGE	-.69906	1.00000			
LnDWT	.63257	-.15439	1.00000		
LnTCI	.30113	.07729	.02332	1.00000	
LnTCIma	.28885	.09227	.00831	.96154	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .05540
CRITICAL VALUE (2-tail, .05) = +/- .06599

N = 883

Equations (128) and (129)

	LnPR	AGE	LnDWT	LnBFI	LnBFIma
LnPR	1.00000				
AGE	-.69906	1.00000			
LnDWT	.63257	-.15439	1.00000		
LnBFI	.23981	.13296	-.00152	1.00000	
LnBFIma	.22287	.14058	-.01347	.93001	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .05540
CRITICAL VALUE (2-tail, .05) = +/- .06599

N = 883

Equations (130) to (138)

	LnPR	AGE	LnDWT	LnBFI	LnBIF+1	LnBIF+2	LnBIF+3	LnBIF+4
LnPR	1.00000							
AGE	-.70060	1.00000						
LnDWT	.62942	-.15390	1.00000					
LnBFI	.28316	.08187	.02452	1.00000				
LnBIF+1	.28234	.07349	.03038	.94422	1.00000			
LnBIF+2	.27772	.06418	.02399	.87138	.90271	1.00000		
LnBIF+3	.28839	.06037	.04690	.81242	.88813	.89003	1.00000	
LnBIF+4	.28941	.06676	.02678	.88037	.87731	.92303	.88004	1.00000
LnBIF+5	.26705	.06254	.03864	.83489	.93062	.88803	.90166	.85868
LnBIF+6	.22828	.04691	.01994	.68685	.73758	.92412	.77505	.81392
LnBIF+7	.24904	.04071	.04440	.64740	.74749	.81009	.93430	.74967
LnBIF+8	.26384	.05088	.01153	.80257	.77887	.89308	.84747	.95380

	LnBIF+5	LnBIF+6	LnBIF+7	LnBIF+8
LnBIF+5	1.00000			
LnBIF+6	.83637	1.00000		
LnBIF+7	.85981	.81408	1.00000	
LnBIF+8	.80888	.85835	.79135	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .06061
CRITICAL VALUE (2-tail, .05) = +/- .07218

N = 738

Equations (139) to (146)

	LnBFI	LnBIF+1	LnBIF+2	LnBIF+3	LnBIF+4	LnBIF+5	LnBIF+6	LnBIF+7
LnBFI	1.00000							
LnBIF+1	.93309	1.00000						
LnBIF+2	.86783	.90377	1.00000					
LnBIF+3	.77969	.87136	.87555	1.00000				
LnBIF+4	.87828	.87759	.91964	.88133	1.00000			
LnBIF+5	.79777	.92398	.86361	.89310	.84731	1.00000		
LnBIF+6	.69296	.75773	.92726	.78334	.82332	.83290	1.00000	
LnBIF+7	.62170	.73899	.79253	.94138	.76768	.85702	.81130	1.00000
LnBIF+8	.79072	.76515	.87324	.84710	.95350	.77806	.84391	.79941

	LnBIF+8
LnBIF+8	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .30127
CRITICAL VALUE (2-tail, .05) = +/- .35441

N = 31

Equations (147) to (149)

	LnPR	AGE	LnDWT	LnTCIma	LnINT	LnLIB
LnPR	1.00000					
AGE	-.74853	1.00000				
LnDWT	.54404	-.15469	1.00000			
LnTCIma	.27077	.05795	-.00966	1.00000		
LnINT	.12175	.09593	-.05641	.42431	1.00000	
LnLIB	.13173	.09093	-.05364	.45379	.98842	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .04397
CRITICAL VALUE (2-tail, .05) = +/- .05238

N = 1401

Equations (150) to (153)

	LnPR	AGE	LnDWT	LnTCIma	LnINT	RINT	LnFUEL
LnPR	1.00000						
AGE	-.70708	1.00000					
LnDWT	.44160	-.19363	1.00000				
LnTCIma	.46517	.00664	-.11204	1.00000			
LnINT	.26868	.08104	-.08928	.56450	1.00000		
RINT	-.24551	.10854	.10824	-.51053	.20435	1.00000	
LnFUEL	.18306	.11782	-.08543	.45501	.82810	.25181	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .03498
CRITICAL VALUE (2-tail, .05) = +/- .04168

N = 2213

Equation (154)

	LnPR	AGE	LnDWT	LnTCIma	LnINT
LnPR	1.00000				
AGE	-.71028	1.00000			
LnDWT	.44219	-.19345	1.00000		
LnTCIma	.46507	.00844	-.11218	1.00000	
LnINT	.26850	.08183	-.08915	.56451	1.00000

CRITICAL VALUE (1-TAIL, .05) = + Or - .03500
CRITICAL VALUE (2-tail, .05) = +/- .04170

N = 2211

VITA

George P. Panagakos was born in Greece in 1958. In addition to the presently seeking degree in Economics, he has received an M.S. in Ocean Systems Management from M.I.T., Cambridge, Massachusetts, and a diploma in Naval Architecture and Marine Engineering from the National Technical University of Athens.

Presently he is an associate consultant with the DAS-International Development Consultants Ltd. in Athens, Greece. He has worked for three years with the World Bank as a consultant for sectoral, research and policy projects in shipping and ports. He has worked on topics such as estimation of capital and operating ship costs, coastal shipping, shipping investments in developing countries, international trade in shipping services, effects of shipping regulations, port equipment costs, and industrial port planning. He has co-authored several articles on shipping.

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