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"Qualitative analysis tells the ironmaster that there is some sulphur in his ore, but it does not enable him to decide whether it is worthwhile to smelt the ore at all; and if it is, then by what process. For that purpose he needs quantitative analysis, which will tell him how much sulphur there is in the ores." Alfred Marshall (1897)

"If you want to acquire knowledge you must take part in the practice of changing reality. If we have a correct theory, but merely talk about it, lay it aside, and fail to put it into practice then that theory, however good, has no importance. Knowledge begins with practice, reaches the theoretical level through practice, and then returns to practice."

Mao Tse-Tung (1937)

OPEN REGISTRY SHIPPING: AN ECONOMETRIC STUDY OF THE COST STRUCTURE OF OPEN REGISTRY SHIPPING AND ITS IMPACT ON FREIGHT RATES

by

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A DOCTORAL THESIS

Submitted in partial fulfilment of the requirements for
the award of the degree of Ph.D. of the
Loughborough University of Technology

March, 1986

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TO MY MOTHER

UNCLE JONATHAN TOLOFARI

AND

MONICA

ABSTRACT

Whilst the issue of open registry shipping has constituted one of the greatest controversies in the shipping industry over the last thirty years, no detailed quantitative work has been carried out on the issue. In this thesis transcendental logarithmic cost functions are estimated for the production functions of open registry bulk ships and those operating under traditional maritime nations. In this way an appropriately unrestricted cost function for the flag dichotomy is estimated and the parameters of the cost functions provide the basis for determining the structure of the production technology of tankers and bulk carriers under the two flag groupings. Evidence of scale economies and the extent to which they have been exploited by each flag group is provided along with factor substitution patterns, own-price and cross-price factor demand elasticities.

It is found that the costs of bulk carriers operating under open registries are lower for all vessel sizes than for those operating under traditional registries. For tankers, open registry costs are found to be higher for product tanker services and lower otherwise. The translog estimates reveal that the manning cost element is the greatest contributor to the cost differential between the two groups. Open registry operations are also found to be subject to greater factor substitution flexibility.

Statistical analysis of tanker and bulk carrier time charter freight rates over a ten-year period provides empirical evidence for the hypothesis that lower open registry costs are passed on to consumers of shipping services by way of lower freight rates. For this reason, a methodology for measuring this benefit is suggested.

It is concluded that whilst this study provides evidence of the possible cost to international trade of phasing out open registries, such cost of itself does not provide an argument for retaining the system. The social and economic rationality of retaining the system will be determined by a wider cost-benefit analysis to which this study has contributed.

ACKNOWLEDGEMENTS

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CHAPTER 1

INTRODUCTION

"Flags of convenience are a most menacing ... and the most disturbing maritime phenomenon of the post war years."

Lord Winster, 1958, House of Lords

1.1 The Need for Research

For nearly thirty years, the phenomenon of open registry shipping has remained one of the greatest controversies in the shipping industry. In this period the share of the World's Fleet registered under this system has grown from a mere 4% of world tonnage in 1948 to nearly one-third of the total tonnage in 1980 by gross registered tonnage (g.r.t.), making Liberia, the principal open registry country, the world's largest fleet since 1967. Despite very strong national, international and trade union opposition to the system of open registry shipping, the unremitting problems of operating cost differentials, mainly in wage rates, between operators of open registry ships and those who operate under the flags of industrialised economies coupled with the need for operational and financial flexibility have ensured the continued registration of ships under those registries.

In parallel with the growth of open registry fleets is the decline in the share of world tonnage under the traditional maritime nations from 82% in 1948 to less than 50% in 1982. The fact that this development is taking place amidst very generous financial and fiscal regimes in the traditional shipping nations, aimed at bridging the differentials in shipbuilding and operating costs between the domestic and foreign flags,underscores the cost attractions of open registry shipping, in spite of its notoreity in respect of marine casualties and poor working conditions.

In 1979, the United Nations Conference on Trade and Development (UNCTAD)

at its fifth session held in Manilla adopted a resolution to study the possibility of 'phasing out' open registries. By resolution 120 of that session it was agreed that UNCTAD should:

> "undertake further studies in respect of the repercussions of phasing out open registries, its economic and social impact on the economies of developing countries, its effect on world shipping, and how the phasing out of open registries would ensure simultaneous development of the merchant fleets of developing countries, with a view to taking a decision on the desirability of phasing out."

Accordingly, UNCTAD has produced reports dealing with this mandate (UNCTAD, 1977, 1979a, b, c, 1981). These reports have prompted studies on the open registry issue which have consistently asked for a quantitative study of the implications of phasing out. (The Economist Intelligence Unit, 1979, Sturmey, S.G., 1984, for example).

The need for this study was born out of the fact that whilst it is generally believed in the industry that open registry operators experience lower operating costs than their counterparts in traditional maritime nations, "there is no evidence to suggest that savings which owners of high-cost countries achieve by operating under open registry flags have ever been passed on to users." (UNCTAD, 1979a). Conversely, the view is strongly held that"the thesis that the use of open registries has not lowered average shipping costs flies in the face of all logic (and) the thesis that lower shipping costs have not reduced freight rates . . . is antithesis." (Sturmey ibid).

The need for research was born against this background and motivated by the fact that there has not been any quantified assessment of the cost structure of open registry shipping and its implications for freight rates. Existing works on the open registry issue are mainly consultancy reports, much of which has tended to present the case of a particular interest group (for example, Maritime Associates, 1979; Economist Intelligence Unit, 1979; National Union of Seamen, 1981). Only one of these studies (Metaxas and Doganis, 1976) tried to quantify the differences in costs between the two flag groupings by the use of a simplistic regression model based on a very limited sample and subject to all the limitations of a Cobb-Douglas formulation.

Hence the necessity to contribute a quantitative dimension to the open registry issue by a detailed study of the cost structures for producing shipping services under open and regulated registries and their relationships to the freight rates charged by these groups, with a view to providing evidence for a more detailed cost benefit study on the implications of abolishing or 'phasing out' the open registry system.

1.2 Objectives and scope of the study

Detailed and rigorous econometric analysis of international shipping costs are comparatively sparse and virtually non-existent for the cost structures of open and traditional maritime registries. The primary objective of this study, therefore, is to employ a transcendental logarithmic framework for a detailed and statistically rigorous examination of the cost structures of the bulk shipping industry generally, and more specifically, to establish the cost variations which exist between ships operating under open registries and those of traditional maritime nations. The examination is aimed at highlighting the plausible economic effects emanating from the differences in registration conditions between the flag dichotomy such as factor substitution possibilities, factor demand elasticities, scale economies and the general structure of the production technology.

Having identified these secondary causal factors for the variations in costs and the structure of the production functions, a second objective of the study is to identify the relationship between the different cost structures of the two flag groups and their freight rates since, theoretically, it is generally believed that in a competitive market, such as those of bulk carrier and tanker services, cost is the "bedrock" of freight rates. From a cost-benefit standpoint, this analysis is intended to throw light on the social implications of abolishing or phasing out the open registry phenomenon, particularly in the light of the apparently different views given above. For this reason, a methodology for measuring the impact of costs on freight rates is suggested for further research.

The scope of the thesis covers only bulk carriers and tankers which constitute 80% of the open registry fleet by gross registered tonnage (g.r.t.). It is also only concerned with the traditional shipping nations, which, by strict definition, are those countries which owned over a million grt before World War II, thus the group covers U.S.A., U.K., U.S.S.R., Japan, Norway, Germany, Italy, Netherlands, France, Greece, Sweden and Denmark. These countries are OECD countries except the U.S.S.R. which is also not included in the econometric analyses. For the purpose of this study, therefore, the term traditional shipping nation is interchangeable with OECD countries. The reason for studying the costs of open registries vis a vis those of traditional shipping nations is justified by the fact that these countries as a group, own well over 85% of the fleets operating under open registries and thus suffer more than any other group of countries from the effects of national fleet erosion caused by flag transfers. It is also noteworthy that the cost reference year is 1982, and all costs are in U.S. dollars.

The thesis is set out in nine chapters. In the next chapter the historical background of the evolution of open registry shipping is discussed, after which detailed analyses of the historical and present development of the fleet, its general characteristics in terms of its composition by vessel type, its age profile, size distribution and beneficial ownership are undertaken in comparison with those of traditional maritime registries. In view of the opprobium attached to open registry shipping, due to poor marine casualty records, an overview of the possible social costs of the system is undertaken in chapter 3, with a view to providing an insight into the most controversial negative factor of open registry shipping.

Since the study is concerned only with open registry operations in the bulk shipping sector, chapter 4 provides an overview of the bulk industry; covering the structure and mechanics of bulk carrier and tanker freight markets, the determinants of freight rates in the different markets and the different charter arrangements obtainable in them.

This chapter, having identified the demand and supply of tonnage and the cost structure of the world fleet as the main determinants of freight rates both in the short and long runs, goes on to define the main components of shipping costs. Both chapters 5 and 6 use these definitions in the analyses of operating and capital costs undertaken therein. These two chapters deal with the cost differentials between open and traditional shipping operations for all the cost centres by using regression analyses based on cost survey data to show variations in costs between the two flag groups for ships of varying sizes and age.

In chapter 7 a more rigorous statistical model is applied to the cost survey data to analyse not only the cost variations between the two groups but more importantly to identify the causal economic effects underlying the variations by way of using a transcendental logarithmic cost function (translog) to examine partial elasticities of factor substitution, price elasticities of factor demand, scale economies and the general structure of the production function of open and traditional shipping operations for bulk carriers and tankers. In chapter 8 an empirical analysis of the relationships between the costs of providing bulk shipping services as analysed in the preceding chapters under the two registry groups and the prices charged by the two groups over a ten-year period (1972-1982) are explored with the aim of ascertaining whether or not lower costs are passed on to consumers by way of lower freight rates.

The final chapter attempts to suggest a methodology which can be profitably employed in measuring, in a cost-benefit context, the benefit of lower shipping costs, if and when, such costs are evident in lower freight rates; and additionally, brings together all the strands of the preceding chapters in the form of summaries, concluding remarks and the contributions of the study to the open registry controversy with suggestions for further quantitative work on the issue in order to highlight further the wider implications of the open registry system.

CHAPTER 2

THE NATURE AND DEVELOPMENT OF OPEN REGISTRIES

"An open registry flag is undoubtedly convenient, but not all convenient registries are open."

Sturmey (1984)

2.1 Definition of an open registry

For the purpose of this thesis the terms "flag of convenience" and "open registry" are interchangeable as the former is now more commonly referred to as "open registry".

The origin of the term "flag of convenience" is not clear, but it is believed that its general usage started in the 1950's because it was used in 1954 in a report of the Organisation of European Economic Co-operation (OEEC, now Organisation of European Economic Co-operation and Development - OECD) in relation to the flags of Panama, Honduras and Liberia (Boczek, 1962). This does not mean that the system of flag of convenience does not pre-date the 1950's, as the next section reveals.

In 1958 the Maritime Transport Committee of the OEEC defined flags of convenience as:

> "The flags of such countries as Panama, Liberia, Honduras, and Costa Rica whose laws allow - and indeed make it easy for - ships owned by foreign nationals or companies to fly these flags. This is in contrast to the practice in the maritime countries (and in many others) where the right to fly the national flag is subject to stringent conditions and involves far-reaching obligations." (OEEC, 1958)

In 1962, Sturmey defined an open registry as, "the flag of any country which permits persons or companies, other than those with a genuine link with the country, to register their ships in its ports". He

however, remarked that what constituted a genuine link was a matter of definition because there was "a lot of casuistry employed in determining the genuineness of existing links in individual cases" (Sturmey, 1962).

Acknowledging the difficulty of providing a simple definition of flags of convenience, the Rochdale Committee in 1970, identified six features as being common to such flags. The features are:

"i) the country of registry allows ownership and/or control of its merchant vessels by non-citizens;

ii) Access to the registry is easy. A ship may usually be registered at a consul's office abroad. Equally important, transfer from the registry at the owner's option is not restricted;

iii) Taxes on the income from the ships are not levied locally or are low. A registry fee and an annual fee, based on tonnage, are normally the only charges made. A guarantee or acceptable understanding regarding future freedom from taxation may also be given;

iv) The country of registry is a small power with no national requirement under any foreseeable circumstances for all the shipping registered, but receipts from very small charges on a large tonnage may produce a substantial effect on its national income and balance of payments;

v) Manning of ships by non-nationals is freely permitted; and

vi) The country of registry has neither the power nor the administrative machinery effectively to impose any government or international regulations; nor has the country the wish or the power to control the companies themselves."

The report notes that one or more of these features may be found in the policies or circumstances of many maritime countries; but "it is only for flags of convenience that <u>all</u> apply and it is only they which effectively have no possibility of imposing taxation on shipping in future" (Committee of Inquiry into Shipping Report, 1970).

In view of some policy changes made by some open registry countries such as Liberia and Panama in the mid 1970's, it would be inappropriate to characterise open registries as having all the features given by the Rochdale report. In 1971 the Liberian Government established a ship inspection programme under the Liberian Bureau of Maritime Affairs in New York. The scheme which started effectively in 1976 is charged with ensuring that all vessels on the Liberian register undergo annual inspections and that all matters relating to safety and crew qualification are given special attention. Vessels coming out of lay-up, changing ownership or attaining the age of fifteen years are required to undergo automatic inspection. Also since 1975, vessels over twenty years old cannot be allowed a first-time registration. Panama also started an inspection service in 1977.

Therefore, the second and sixth features should not apply in their entirety to all open registries. However, in relation to regulated registries, access to open registries is easy and the very nature of open registry shipping which is discussed in this chapter makes it almost impossible for the country of registry to exercise any effective control and jurisdiction over ships registered under its flag because of the total absence of a genuine link with the ship.

There are other definitions (for example, see Metaxas and Doganis, 1976; and Grundey, 1978) which are not as all-embracing as the Rochdale definition in laying down criteria common to open registries. They are narrow in their implications and in some respects loose in their meaning and, therefore, less exacting. Because the Rochdale criteria cover all the salient features of an open registry, no attempt is made in this thesis to redefine the system and, as such, the Rochdale definition is the accepted one for this study.

Sturmey, commenting on the Rochdale definition notes that there are conceptual and practical problems in defining categories and setting limits because some registers not classed as open registries are, nevertheless, quite convenient (Sturmey, 1984). This line of thought

had, in the past, led to some flags being called "quasi-flags of convenience", ie. Greek and British flags, because of the presence of some features of convenience shipping in their maritime policies, (Metaxas and Doganis, ibid). In this regard it is worth noting that whilst an open registry is undoubtedly convenient, not all convenient registries are open. Thus this study is concerned with those countries with a declared policy of open registration. Whatever the difficulty in interpretation, the Rochdale report clearly notes that it is only for the flags of convenience that all the features apply. Also, as will be seen in section 2.3, the conditions for registering ships in all the non-open registry countries are far stricter than those of open registries as regards the involvement of nationals in the ownership, management and manning of ships. These conditions, at least, ensure the effective control of ships so registered.

The list of open registries has always been a shifting one because of new entrants and normalisation of registration conditions by existing members. Under the Rochdale criteria and for the purpose of this study the following countries have in the recent past offered, or are still offering, open registry facilities (OECD, 1971): Liberia, Panama, Cyprus, Singapore, Somalia, Honduras, Costa Rica, Morocco, Lebanon, Malta, San Marino, Sierra Leone, Haiti, Bermuda, Bahamas, Gibraltar, Netherlands Antilles, Maldives and Cayman Islands. Currently, five major countries are listed by UNCTAD (UNCTAD, 1985) as still offering open registry services: Liberia, Panama, Cyprus, Bahamas and Bermuda. There are smaller open registries such as Vanuatu (former New Hebrides), Netherland Antilles, Cayman Islands, Virgin Islands, etc, but they are of little significance.

2.2 The Evolution of Open Registry Shipping

The history of the practice of open registry dates back to the Roman Empire, when Roman shipowners registered their ships under the Greek flag. Maritime history contains a wealth of evidence of the early existence of the phenomenon of open registry shipping. It is recorded that in the 16th and 17th centuries English shipowners transferred their vessels to the French and Spanish flags in order to circumvent

restrictions barring non-Spanish flag vessels from the lucrative trade of the West Indies, and restrictions limiting their fishing rights, (Williamson, 1941, cited in Boczek, 1962). Similarly, English shipowners during the Napoleonic wars registered their ships under small German principalities for the purpose of obviating the Continental blockade. In much the same manner, American shipowners in Massachussetts in the War of 1812 between the U.S. and Great Britain flew the Portuguese flag in order to avoid capture by the British. These historical precedents of the phenomenon of open registry shipping are well catalogued by Boczek (ibid), Metaxas and Doganis (1976) and Metaxas (1981).

Not surprisingly, Boczek notes that well before the emergence of Panama and Honduras as acclaimed flag of convenience states, the practice was well-rooted in the maritime practice of the early 20th century. Because, for instance, the registration of the "Dhows" under the French flag by the subjects of the Sultan of Muscat, which was a British protectorate in the late 19th century, was motivated by the desire to evade the regulations and inspection of Muscat. This case, which went to the Permanent Court of Arbitration in 1905, created one of the nuclei on which the principle of the nationality of a ship rests in International Law, as the next section reveals. Therefore, the registration or re-registration of vessels with the ulterior motive of evading strict maritime regulations in the home country is not a new historical phenomenon. Thus, the fact that the open registry phenomenon became a controversial and topical issue in the 1950's, early 1960's and recently is not a demonstration by the maritime community against a novel shipping practice, but rather a natural reaction against the enormous magnitude of the problems posed by the institution since ~~after~~ World War II, particularly on the competitiveness of shipping, and its unprecedented impact on world tonnage distribution. For instance, Liberia which joined the open registry league in 1949, became the world's largest fleet, eighteen years later, in 1967.

The maritime unions were naturally afraid of losing their control over the maritime labour market, and shipowners in traditional shipping nations were apprehensive of losing their age-long monopoly of international

maritime transport because of the competition posed by open registry shipping, (see Naess, 1972).

The history of the origin and evolution of the present-day open registries can be traced to five antecedents in the inter-war years and after, (see Boczek, ibid, and Carlisle, 1981), namely:

i) the 1922 Prohibition laws in the U.S.;
ii) rising American labour costs for U.S. flagships and their consequent high operating costs;
iii) the imminence of World War II in the inter-war years;
iv) the U.S. Neutrality Laws of 1939; and
v) competition in the world shipping markets after World War II.

The 1922 Prohibition laws in the U.S. forbade the sale or carriage of alcoholic beverages aboard American-owned vessels. As a result, an American shipping company, United America Line, in 1922, transferred two of its U.S.-flag passenger ships, 'SS Resolute' and 'SS Reliance', to the Panamanian registry in order to circumvent this law. This transfer provided the 'first experiment' with modern day open registry shipping.

This maiden transfer was followed by other shipowners, particularly oil companies, because of soaring American labour costs, caused by the requirement under U.S. maritime law that a large majority of the crew complement of a U.S.-flagship be Americans. In order to avoid being obliged by this condition, and to escape from the rising operating costs due to union pressure, the flags of Panama and Honduras became more or less 'flags of necessity'.

Whilst rising operating costs of U.S.-flag ships was the primary motivation towards a recourse to open registries, the circumstances of European shipowners were somewhat different in the sense that their flagging out was brought about mainly by political instability in Europe caused by the imminence of World War II. Thus the fear of requisitioning of their vessels (and for the Greeks the fear of nationalisation in the immediate post-war years) combined with heavy tax burdens led European

shipowners to resort to flags of convenience.

The U.S. Neutrality Act of 1939, which sought to prevent American-owned and crewed vessels from trading in the European war theatre, in an attempt to keep U.S.-flag ships from entangling the U.S. in the war, is an important antecedent in the history of open registry shipping. Despite the Neutrality laws, the U.S. government wanted to supply essential war materials, such as petroleum, to the U.K. without breaching the laws. The Panamanian flag, which was a netural flag, provided the solution. As a result, a large number of U.S.-owned vessels, mainly tankers, were transferred to the Panamanian flag, under the auspices of the U.S. government, and voyaged to Britain in 1939-42.

The turning point in the evolution of open registries occurred in the post-war years. In the aftermath of war, there was a tremendous increase in the volume of seaborne world trade, but there was a shortage of shipping tonnage to match this growth. Consequently, after the boom years up to the Korean war (1953) through the first closure of the Suez Canal (1956), shipping experienced a slump coupled with overcapacity of tanker tonnage built up in the boom years. The competition which ensued in this period made operating costs an important element in shipping operations. The American Committee of Flags of Necessity was formed in 1958 (now Federation of American Controlled Shipping, FACS) to promote the transfer of ships to open registries. The result was that while in 1948, U.S.-flag ships carried 53% of U.S. foreign trade, only 12% was carried by these vessels by 1960, a share lower than any in the previous forty years, (Boczek, ibid).

As high operating costs necessitated American shipowners to reflag under open registries, so did the tax burden in most European countries drive European owners to these registries. The very liberal corporation and shipping laws, and, most importantly, the virtual tax immunity which operators of open registry ships enjoyed, gave them an immense competitive advantage over their rivals.

It was this desire and necessity to be competitive in the world shipping

markets in the post-war years, which gave rise to the spectacular growth of the fleets of open registries. The league of open registers was thus joined by Liberia in 1949, Costa Rica in 1953, Lebanon in 1959, Cyprus in 1966, Somalia in 1968, Singapore in 1968, Bahamas in 1976, and Vanuatu in 1981.

It is noteworthy that in the past, the reasons for registering a ship under the flag of a country other than that of the owner varied between one owner and another. Historically, these reasons have varied from the need to have military protection under a stronger naval power, the need to circumvent political sanctions on trade, to a desire for laissez-faire. Today, while the practice still retains some of those earlier motivations, the primary reason for open registry operations is deep-rooted in the need to obtain cost economies in order to remain competitive in the industry.

2.3 Conditions for ship registration

The difference in the conditions for registering ships under different countries provide the demarcation line between an open and a regulated registry. Acording to Article 5 of the 1958 Geneva Convention on the High Seas, (United Nations, 1958):

> "Each State shall fix the conditions for the grant of its nationality to ships, for the registration of ships in its territory, and for the right to fly its flag. Ships have the nationality of the State whose flag they are entitled to fly. There must exist a genuine link between the State and the ship; in particular, the State must effectively exercise its jurisdiction and control in administrative, technical and social matters over ships flying its flag."

This Convention is the only treaty provision which lays down international rules on ship registration. The provisions of Article 5 have, however, been variously interpreted (see Boczek) especially with respect to the concept of genuine link between vessel and flag of registry. The controversy over the meaning and practical interpretation of the genuine link concept still remains the central issue in the debate on open registries.

2.3.1 The concept of genuine link

The misunderstanding about the meaning of a genuine link between the ship and its flag of registry is created by the fact that neither the International Law Commission (ILC) which did the preparatory groundwork for the Geneva Conference of 1958 nor the Conference itself defined what the concept of genuine link means, or set criteria of how it can be tested. Not surprisingly, there is a disagreement amongst legal commentators on what a genuine link means as thoroughly dealt with in Boczek's legal study of the open registry issue. To UNCTAD, the chief exponent of the principle of genuine link, the absence of such a link means that a registry is an open one. This position raises the curious question of what constitutes a genuine link?

Sturmey commenting earlier (Sturmey, 1962) on the notion of a genuine link heroically defined it in terms of the location of effective management. He notes that the criterion for a genuine link is the location of the immediate effective control over the ships, not the location of the ultimate control. Where there is control through a nationally registered company with the ability to exercise that control through resident directors, the link is genuine, but where the immediate owning company is a name-plate and both immediate control and ultimate control lie elsewhere, the link, he argues, is not genuine. The latter is characteristic of open registries.

UNCTAD believes that the purpose of the genuine link clause in Article 5 is to provide a means with which states can ensure the exercise of effective jurisdiction and control over vessels under their registry and as such the interpretation of a 'genuine link' should be made within the context of the material requirements for the registration of ships to reflect economic ties between vessel and flag State, and hence administrative control by the State. To this end it thinks that such interpretation should include the following elements of genuine link (UNCTAD, 1977) which are not dissimilar to the criteria given by Sturmey above:

i) the vessel or the company owning the vessel should be beneficially owned for a substantial part by nationals or the flag State;

ii) the principal place of business and effective management of the legal entity should be located in the flag state;

iii) the principal officers of the shipping company should be nationals;

iv) the flag state should exercise financial control by subjecting the profits of the shipping company to taxation;

v) the State of registry should exercise full and regular control over the standards of the vessels and, qualifications and conditions of crew employment.

The point must be made that whilst these five elements clearly constitute genuine link between ship and registry, it is not intended that a country's registration requirements should encompass all the elements, but rather a combination of them.

In the light of the discussions of this section and in view of the fact that it is the conditions of ship regisration that make a registry open or regulated, the next section undertakes an international comparison of ship registration conditions with a view to highlighting the possible existence and non-existence of the elements of genuine link as a basis for differentiating open registries from others.

2.3.2 International comparison of the conditions for ship registration

The conditions laid down by countries for accepting ships under their registers vary a great deal according to their national interests. But as can be seen in table 2.1, which summarises in an abbreviated form some of the material conditions for registration, there are some elements of commonality within the five groups of that table. The groups show different degrees of rigidity in their requirements for national equity participation and management of the shipping company, and the crewing of the ships so owned.

For the first group, it is absolutely essential that substantial national involvement in the ownership, management and manning of prospective national flag vessels must be met in order to qualify for registration.

It is important to note at this outset that whilst there can be several forms of ownership (ie. State, individuals, partnerships and corporations), we are concerned here with ownership by companies as it is the most common form of ownership. It is also notable that national equity or ownership may refer to either nationally incorporated companies or to ownership of the shares of a company by nationals. Whilst some countries' maritime laws stipulate that ownership of vessels must be by national companies in the sense of national citizens owning the shares of the company, others do not. This makes it difficult to give a uniform definition to what is meant by "equity participation". But as UNCTAD rightly points out the national character of a national company is not only determined by specific equity requirements, but also by requirements relating to management (UNCTAD, 1982). However, national equity as given in table 2.1 refers to national ownership of shares of a locally incorporated company.

The countries in the second group do not apply any specific equity requirements but have stringent conditions with regard to management and crew nationality. Amongst this group is the United States whose 100% officers and 75% national manning requirements led to the phenomenon of open registration. Whilst the laws of some of these countries require shipowning companies to be incorporated under national laws, the share capital of such companies is not legally required to be owned by nationals. For instance, American company laws allow the capital of a locally incorporated company to be beneficially owned outside the United States.

Countries in both groups 3 and 4 have better flexibility than those in the second group. The U.K., Greece, and Saudi Arabia have been called quasi-open registries because of some features in their conditions of ship registration. But as was noted in section 1.3, the difference between a quasi-open registry and an open registry is in their requirements for national ownership, management or manning of their flagships. On this score, therefore, the difference is clear. It is doubtful, however, in the case of the U.K. according to UNCTAD (ibid) whether the mere requirement for locally based management is sufficient to ensure a de

facto national participation both in equity and management. Greece requires over 50% national equity participation but the laws permit ownership of vessels by companies incorporated outside Greece provided there is conclusive evidence that the majority of the company's equity is owned by Greeks.

The five countries listed in group 5 appear to apply no material conditions at all. The little there is (ie. Cyprus and Panama) leaves room for manipulation by prospective shipowners. Escape clauses such as 'if available' almost certainly create a loophole in the legislation and makes its provisions more illusory. These are the open registry countries. Boczek commenting on the 10% manning requirements for Panama remarked that this prerequisite is not for the granting of nationality, but only the consequence thereof because the crew's nationality does not govern the ship's nationality (Boczek, ibid, p. 53). Indeed, the Cypriot registry appears to be slackening its conditions of registration. A new policy which took effect from March, 1983, now permits ships of any age to register under the Cypriot flag, on the condition that manning is with 50% Cypriot crew subject to availability. This manning requirement has been described as hypothetical because it is admitted that Cypriot seafarers could not provide even 15% of the crew requirement of its fleet (Lloyds List, 1983).

Table 2.1 provides evidence to the fact that the main difference between normal and open registries derives from their conditions for ship registration. For normal registries it is essential to ensure that vessels flying their flags are operated in the national interest and as such can be identifiable and made accountable to the jurisdiction and control of national maritime authorities. To the extent that the conditions of national equity participation, management and manning are non-existent in the requirements for registering ships in open registry countries, identification of ownership of vessels and hence accountability to the flag state will be very difficult.

Accountability is made almost impossible by the nature of open registration which apparently guarantees anonymity as one of the advantages of open registry operations. This is evidenced by the requirements for the incorporation of companies in Liberia:

"Anonymity is easily preserved since:

i) all or part of the stock issue may be in the form of registered or bearer shares;

ii) after incorporation, any change of officers and directors need not be recorded in a public register;

iii) the resident business agent is not required to file any reports with the Government regarding corporate activities."

(Tax Havens Encyclopaedia, cited by UNCTAD,1981)

In the light of the above, despite the flexibility and discretion inherent in some of the conditions enumerated in table 2.1, it can be safely said that the countries of groups 1 to 4 taken together, have ensured the national character of their fleets and can effectively exercise jurisdiction over them due to their requirements for national equity, national management and national key shipboard personnel. The same cannot be said for the open registry countries; and in a genuine link context it can ~~only~~ be said that only countries in the first four groups possess such elements.

It must be borne in mind that the legal conditions given in table 2.1 may overstate or understate the extent to which nationals are involved, for instance, in the manning of their flag vessels due to trade union activities and practical considerations such as shortage of skilled seafarers. For instance, whilst the Greek law requires that no more than 25% of the crew of a Greek vessel should be foreigners, in practice over 30% of Greek flag crews are non-Greeks, (OECD, 1984). Also even though Australian law provides for 100% national manning of Australian flag vessels, in actual fact 3,436 foreigners including 184 Masters were employed on Australian flag ships in 1979. In countries where key-posts are reserved for nationals, there are also cases where foreigners

Table 2.1 CONDITIONS FOR SHIP REGISTRATION WITH RESPECT TO NATIONAL OWNERSHIP, MANAGEMENT AND MANNING

Country	Equity %	Conditions applicable to management		National manning requirements
		National personnel	National offices	
USSR	100	Implied	Implied	100%
China	100	Implied	Implied	100%
GDR	100	Implied	Implied	No information
Ethiopia	100	Directors	Principal place of business	100%
Iraq	100	Implied	Implied	100%
Mexico	100	All directors & managers	Company domicile	100%
Ghana	100	According to company law	Principal place of business	No information
Finland	80	Managing director and 2/3 board members resident nationals	Implied	Master
Austria	75	All management	Company base	Discretionary
Switzerland	75	Majority of managers - domiciled nationals	Real centre of activity	Nil
India (1)	75	Implied	Principal place of business	100%
or (2)	75	3/4 board including chairman and managing director	Principal place of business	100%
Netherlands (1)	67	Majority of directors resident nationals	Actual management of ship	Master
or (2)	Nil	All directors (3/4 residents) & 3/4 supervisors (2/3 residents)	Actual management of ship	Master
Brazil	60	Management by native-born nationals	Implied	Master + 67%
Norway	60	Majority of board including chairman resident nationals	Head office & board	Master + 67%
Australia	50+	According to national company law	Company law	100%
Belgium	50+	Not stated	Head office	100%
Sweden	50+	National company law	Company law	Master + 67%
France	50	Chairman & majority of board	Headquarters	100%
Poland	50	Not stated	Head or branch office	100%

Table 2.1 continued

Country	Equity %	Conditions applicable to management		National manning requirements
		National personnel	National offices	
Group 2				
Denmark	Nil	2/3 board resident nationals	Implied	Master
W. Germany	Nil	Maj. of board or management	Local representative	Master
Italy	Nil	Maj. of board and management	Local representative	100%
Egypt	Nil	Majority of board	Administrative office	95%
Japan	Nil	All directors & all representatives	Principal office	Nil
Syria	Nil	Majority of board incl. chairman	Not stated	67%
U.S.A.	Nil	Maj. of board needed for quorum	Principal office	Officers + 75%
Group 3				
U.K.	Nil	Nil	Principal place of business	Key officers
Group 4				
Greece	50+	Nil	Local representative	Master + 70%
Saudi Arabia	51	Nil	Nil	Nil
Group 5				
Liberia	Nil	Nil	Nil	Nil
Panama	Nil	Nil	Nil	10% if available
Cyprus (1)	Nil	For ships up to 17 years: nil	Nil	15%
(2)	Nil	For ships 17-20: national ship's husband	Establlished office + bank a/c	51%
Honduras	Nil	Nil	Nil	Nil
Bahamas	Nil	Nil	Nil	Nil

SOURCE: UNCTAD (1982), Conditions for registration of ships

are used (International Labour Organisation (ILO), 1980a). Whereas in all OECD countries the number of nationals employed on national ships is relatively larger than foreigners, the reverse is the case on open registry ships. Of the 95,448 seamen of 107 nationalities sailing on Liberian-flag ships in 1984, only 6 were Liberians, (Wiswall, 1984); and out of a total of 17,500 seamen who served on Cypriot vessels in 1979 only about 2,500 were Cypriots (ILO, 1980b).

2.4 Development of the open registry fleets

Even though registration of ships under open registries started with Panama in 1922, it was the inauguration of the Liberian registry in 1949 as an open register which started the rapid expansion of open registry fleets. As table 2.2 in Appendix A shows, Panama was the leading open registry country between 1949 and 1954, but by 1955, Liberia had overtaken Panama as the leading nation. Comparing tables 2.2 and 2.3 it can be seen that in 1957 Liberia became the third largest fleet in the world behind only the United States and the United Kingdom. Ten years later in 1967, Liberia became the world's largest fleet with 1,513 vessels totalling 22.6 million gross tonnage, giving the open registry countries a share of 16% of world fleet by g.r.t.

The growth of the fleet of open registries was steady up to 1959, but became punctuated from 1960 to 1962, when the share of the fleet fell from 14% in 1959 to less than 11% of the world tonnage in 1962. This temporary lull has been attributed to transfers to the Greek flag by Greek owners of open registry vessels in response to a campaign by the Greek authorities to attract Greek-owned ships back to the Greek register. Also, the uncertainties caused by American trade union activities which led to the 18-day strike of 1961 in the U.S. was contributory to the lull in the development of the fleet. But from 1963 the growth resumed until 1979 when open registry fleets represented over 28% of world gross tonnage and over one-third by dwt.

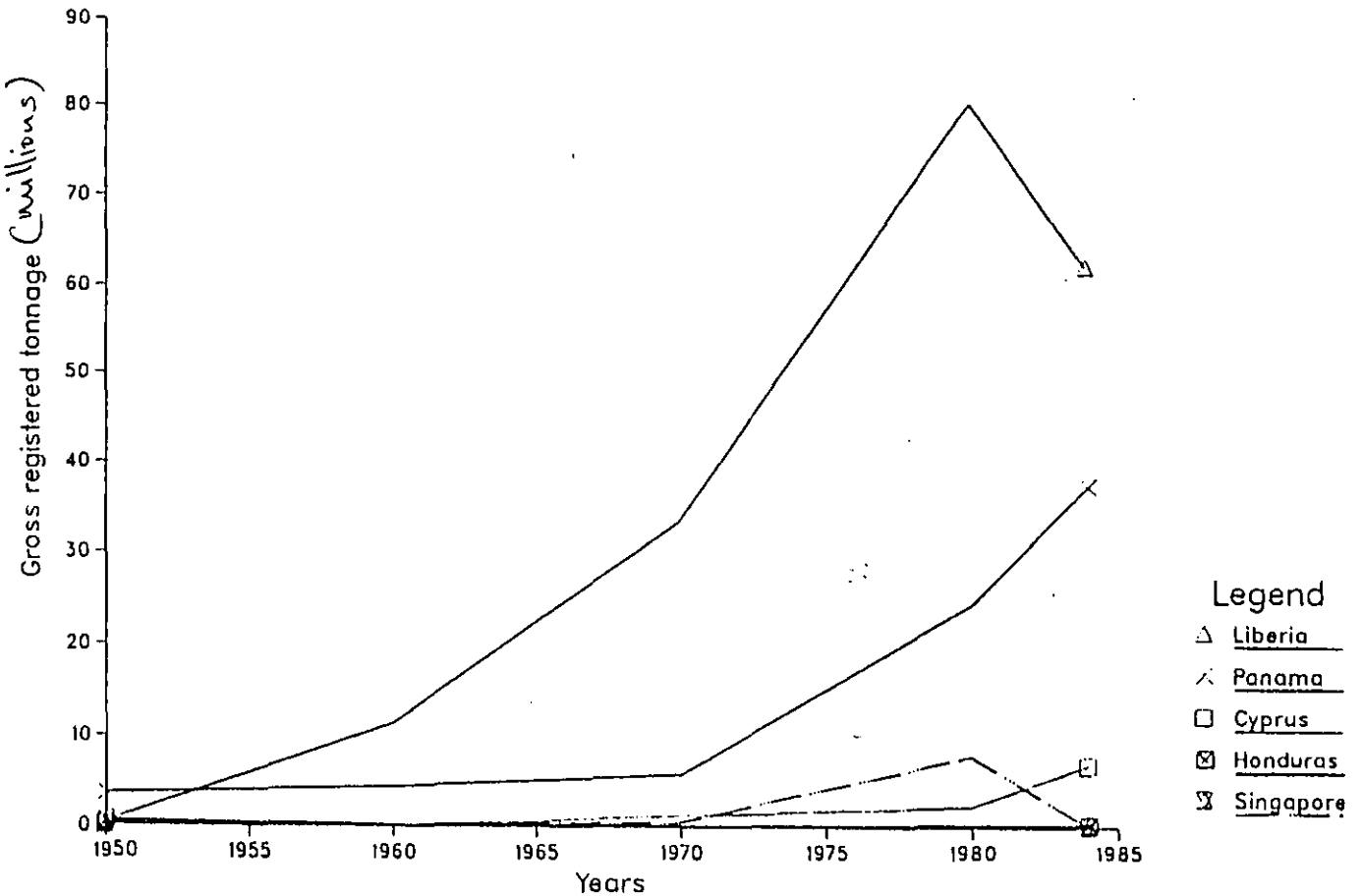
Between 1980 and 1981, the fleets experienced a decline but have been virtually stationary since 1982 at one-quarter of the world tonnage.

In 1979, the open registries had 8,549 vessels of 117 million grt, with Liberia having 82 million of that total - more than twice the tonnage under the Japanese flag which was the second largest fleet in the world. Almost one-fifth of the world tonnage was under the Liberian flag in 1979. The coup d'etat in Liberia in 1980 contributed to the decline in the Liberian tonnage in particular and that of the fleets of the open registries. In addition to this development ~~was~~ were tonnage fee increases which started from January, 1981. Since 1949, Liberia has not increased its original tonnage tax of $0.10 per ton. Therefore, the coup, the recent tonnage fee increases, and the age limit of 20 years for vessels seeking new registration have contributed to the decline in the Liberian fleet.

The development of individual open registry fleets is demonstrated by figure 2.1. The Panamanian fleet had developed in much the same manner as that of Liberia, but at a much slower rate of growth up to 1970. But as table 2.4 shows the average annual growth rates of the Panamanian fleet have been ahead of those of Liberia since 1970. It seems that Liberia's loss in the 1980's became Panama's gain. Out of a total of 3.6 million grt which left the Liberian registry in 1980, 494,000 grt went directly to the Panamanian registry, while 2.47 million went to Greece. In the same year Panama received some 2.6 million grt from traditional maritime countries, mainly Greece and Japan, which accounted for 60% of the total transfers. Early in 1981 Panama overtook the U.K. to become the fourth largest fleet in the world. In 1981/82 the fleet recorded an increase of 18% and in 1982/83 whilst Liberia continued its steady decline (due mainly to the scrapping of 13 million dwt of tankers), the Panamanian registry increased by over 2 million grt. It will be noticed in table 2.4 that Panama never experienced any negative growth rates in the periods shown in the table and recorded an average annual growth rate of 11.39% between 1980 and 1984. As the statistics of table 2.2 and 2.3 show, Panama became the world's third largest fleet in 1984 superseding Greece.

Whilst the Liberian fleet decline continued due to high tanker scrappings, the smaller open registries, particularly Cyprus and Bahamas have been

Figure 2.1
Development of in dividual open registry fleets
1950–1984



making spectacular progress. From table 2.2 it can be seen that Cyprus after a period of decline which started in the later 1970's up to 1981, has ~~made an~~ experienced unprecedented growth between 1983 and 1984, taking its total fleet to almost 7 million grt. The Cypriot fleet increased by 63% in 1983 and 9% in 1984 according to table 2.4. It is notable that none of the ships added to the registry in 1983 was less than five years old. It would therefore seem as though this upsurge in the fleet may be a response to the age limit removal by the Cypriot authorities as noted in section 2.3. Its average annual growth rate of 34% for the four years of 1980-1984 is the second highest rate of growth amongst the open registries.

The Bahamas, which began a campaign in 1982 to attract shipowners particularly from the U.S., has ~~made~~ experienced a meteoric rise from a fleet capaicty of less than 100,000 grt in 1980 to over 3 million in 1984. Its competitive registration conditions, its historical links with the U.S. combined with its political stability and traditional tax haven role make it very attractive not only to U.S. beneficial owners but also to European shipowners. A recently completed agreement with the U.S. regarding the 'effective control' of U.S. owned ships under its flag during an emergency (a feature of all open registry facilities) is an added competitive advantage. It is noted that following this agreement, several major oil companies and independent tanker owners have transferred tankers to the flag (OECD, 1984; Seatrade, 1982(a); Seatrade, 1983). It is therefore not surprising that whilst, between its inception in 1977, as an open register, and 1980, it made no progress by way of attracting shipping tonnage, the 1980's have seen it develop at an average annual growth rate of 144%, by far more than any other growth rate shown in table 2.4.

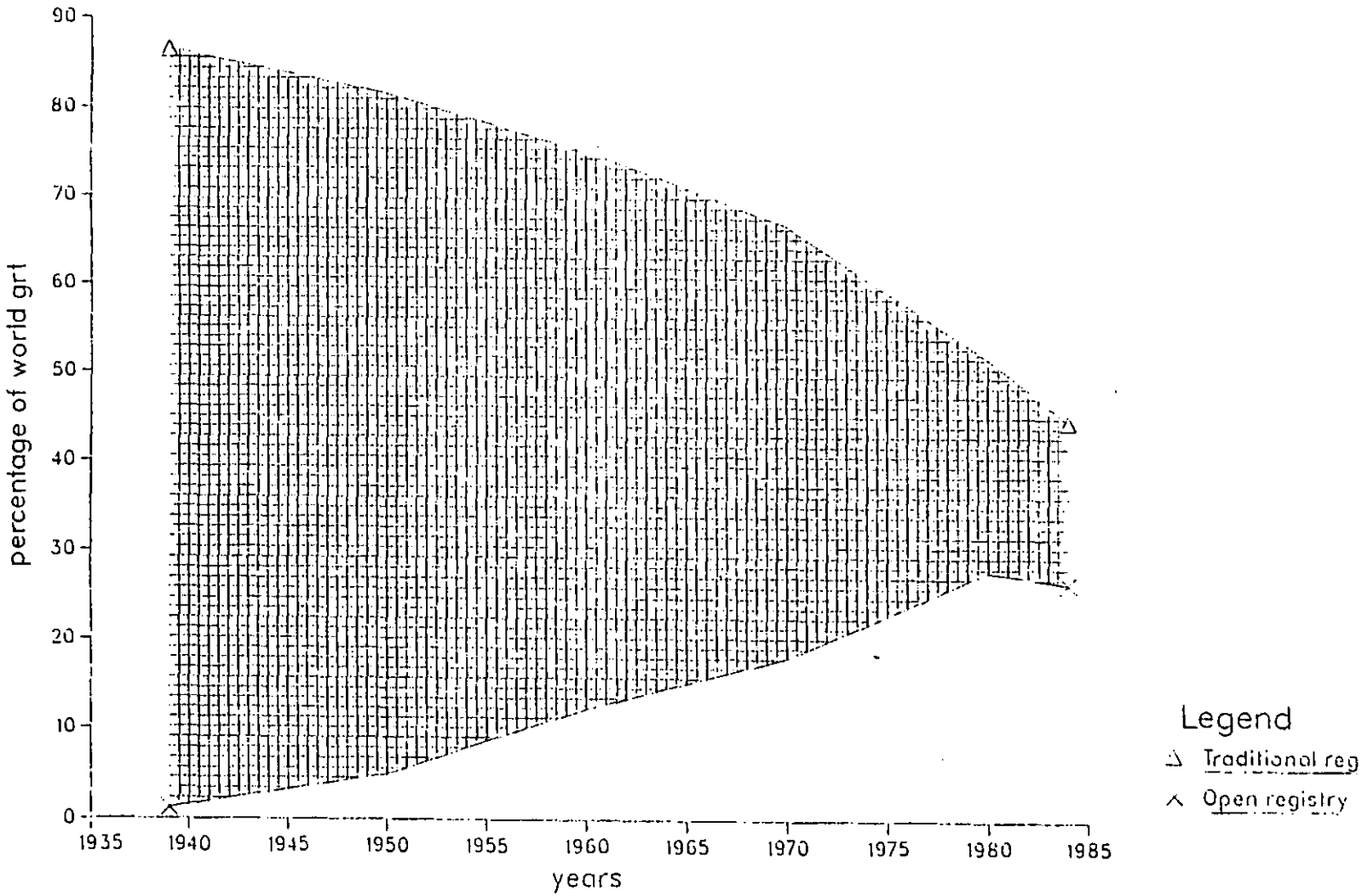
As table 2.2 demonstrates, the minor open registries such as Costa Rica and Somalia withered away with the passage of time. Honduras, one of the originators of open registry shipping, has not been as successful as Liberia and Panama in attracting shipowners to its registry. In 1980 an effort was made to market the flag by introducing low registration

and annual fees of U.S. $0.25 per nrt (net registered tonnage) and $0.50 per grt respectively, with the possibility of completing registration formalities within 24 hours, (Fairplay, 1980). In late 1982, arrangements were being made to introduce new conditions including a vessel inspection scheme, (Seatrade, 1982(b)). But as can be seen from its relatively modest fleet development in table 2.2, the plan to revamp the Honduran registry seems to have failed. The Bermudan fleet also has not taken off yet.

Table 2.3 shows the development of the fleets of the traditional shipping nations. Their share of the world fleet has been steadily declining since 1939 when they constituted 87% of the world fleet. This decline and the development of the open registry tonnage as a percentage of the world fleet is illustrated by figure 2.2. As shown by this figure, the traditional maritime nations now represent less than 45% of the world's grt. This decline is a result of the shrinking fleets of the individual countries. In the 1950-60 decade, the German, Japanese and the Greek fleets grew at very high annual rates (table 2.4). These were followed by those of Norway, Italy, Sweden and Denmark. The fleets of these countries also continued the same trend in the 1960's and 1970's, except for the Swedish fleet which actually showed a negative rate of change for the 1970's; and the German and Norwegian fleets which barely grew. For the U.K., the growth rate since 1950 to 1980 has been modest. The American fleet in that same period has been declining.

The 1980's have been a period of great decline for all traditional shipping fleets with ~~only~~ the U.S. showing a 1% growth rate for the 1980-1984 period. The U.K. seems to be the worst hit nation; losing 6% in 1981, 12% in 1982, 15% in 1983 and less than 1% in 1984, with an overall annual average of 12.5%. Whereas in 1939 the U.K. flag represented 26% of world fleet, it now (1984) represents only less than 4%. Both the German and French flags have also been experiencing substantial tonnage decline. Since 1982, the traditional countries have been losing a substantial amount of their tonnage. Conversely, aside from the Liberian situation, the open registry countries have been recording substantial tonnage increases in the 1980's.

Figure 2.2
The growth of the fleets of traditional and open registries
1939–1984



Taken together, the 1980's have not been as bad for the open registries compared with the traditional shipping nations, as table 2.5 explains. The 1980's generally have been bad for international shipping because of the very prolonged shipping recession resulting from the global recession particularly in the oil trade. The world tonnage declined for the first time since 1935 as a result of high levels of tanker scrappings. But comparing open registry developments with those of traditional countries it can be seen in table 2.5 that the latter's fleets have been declining at an average annual rate three times worse than the former. Since 1950, the open registries' fleets have been developing at an average annual rate more than three times faster than the average growth rate of the fleets of their traditional counterparts for the period 1950 - 1984.

2.5 Structure of the fleet by vessel type and flag

An examination of the structural composition of the open registry fleets is important to the purpose of this study as it will highlight the sectors of the shipping industry in which open registry operations are more prevalent. These sectors are in the ~~wet~~ liquid and dry bulk areas as tables 2.6 and 2.7 reveal. From table 2.6 it will be seen that the open registry fleets are made up mainly of bulk vessels - tankers, bulk carriers and combination carriers, an area in which the fleets have a much greater share than the world fleet as a whole, as the former has 80% of its vessels made up of bulk vessels compared with the latter's 66.8%. The bulk vessel composition of the fleets of the main maritime countries is also far less than that of the open registries at 63.4%. This means that 88 million gross tons of the total 110 grt under open registries are bulk vessels.

The table shows that within this aggregate there are differences in composition according to vessel types. Oil tankers are by far the largest group in the open registry fleets, accounting for 43% of total open registry fleet or 48.3 million grt which represents 33% of the world's tanker fleet. This is followed by dry bulk carriers at 27%, and combination carriers at 8%, whilst product tankers (chemical tankers) account for less than 2% of the fleet.

The spread of the bulk fleet according to individual open registry countries is also diverse. Liberia's fleet is mainly composed of oil tankers which out of a total of 91% of bulk tonnage account for 54%. This same distribution is characteristic of the fleets of Cyprus and the Bahamas, which respectively are composed of 47% and 81% of oil tankers. The Panamanian fleet and that of Bermuda are made up more of dry bulk tonnage both having 35% and 40% of their fleets under this category respectively. The bulk sector taken together represents the largest tonnage area for all the five countries shown in table 2.6. The Panamanian fleet is 62% bulk, the Cypriot 74%, the Bahamanian 91%, and the Bermudan 66%. One of the reasons for the high proportion of bulk vessels in the open registry fleets is that a majority (two-thirds) of the fleet is engaged in cross-trades between developing and developed countries rather than in home trades, because some of the main beneficial owners, ie. Greece, Hong Kong, Monaco and Singapore, do not have sufficient foreign trade in which to employ all their beneficially owned tonnage, neither do the open registry countries have any requirement for all tonnage registered under their flags (UNCTAD, 1979).

The general cargo sector is the third largest single vessel category (table 2.6) at 13.3% of the fleet or 14.6 million gross tons. The open registries constitute 19% of the world's tonnage of general cargo ships. Even though the bulk of the open registry fleet is employed in the transportation of bulk raw materials and oil, the fleets of Panama, Cyprus and Bermuda have a substantial general cargo tonnage. With 2,509 vessels of over 10 million grt, Panama is the world's largest general cargo fleet followed by the Soviet Union and Greece with 8 million and 7 million grt respectively. A quarter of the Cypriot fleet is composed of general cargo vessels and nearly the same proportion is made up of these vessels in the Bermudan fleet.

The share of containerships in the open registry fleet structure is relatively small; at less than 2%, it represents only 1.8 million grt of the total fleet. The individual fleet shares are also small with most of the tonnage - 68% and vessels (111 out of a total of 164) operating under the Panamanian flag. The reason for the small tonnage of container-

ships under open registries is not far-fetched. Containerisation was primarily motivated by high stevedoring and cargo-handling costs in the developed economies. Its development since the early 1970's has therefore tended to serve the high value trades of the developed countries which generate such commodities. In consequence the bulk of the containerised trades is concentrated on specific trade routes such as the North Atlantic, Australia and the Far East. In addition to this established structure of containerised trades is the fact that the organisation of containerised operations is in the hands of long-established maritime concerns organised into a limited number of international consortia which control the main trade routes (see Gilman, 1980; Pearson, 1981). Since the open registry countries have comparatively little demand for high value commodities and export none of the commodities for which containerisation is economical, it is not surprising that these countries constitute only 10% of the world's container tonnage and the traditional maritime nations 67%.

Table 2.6 also shows that the structure of the open registry fleets is similar to those of the regulated fleets of the traditional shipping nations. The most common feature is the large proportion of bulk tonnage represented in individual fleets. Of the major world fleets in this category, the following have the highest share of bulk tonnage in their fleets: Norway, 82%; Greece, 77.8%; Italy, 76.1%; France, 72.2%; and the U.K., 64.2%. In most of the fleets, tankers feature prominently and in much the same way as in the open registry fleets, each fleet has its own characteristics of vessel composition.

For example, the Greek registry has more dry bulk carriers than any other type of vessel; whilst the Soviet, Dutch, and German fleets contain more general cargo tonnage. The bulk of the container tonnage is under the fleets of five countries: Denmark, Germany, Japan, the U.K., and the U.S. Together they account for 78.2% (8.8m grt) of the total container gross tonnage of 11.2 million. Structurally, it can be seen in table 2.6 that both the open registry and traditional fleets provide a broad reflection of the composition of the world fleet as a whole.

Table 2.7 provides the percentage flag composition of the open registry fleets. The predominance of the Liberian fleet in the bulk sector is clearly shown: 71% of tankers, 56% of dry bulk carriers and 78% of combined carriers are under this fleet. Whilst a large number of tankers and dry bulk vessels are under the Panamanian fleet, they represent tonnage proportions far less than their numbers. This fact demonstrates the large average vessel sizes under the Liberian flag as can be seen in the next section. The three major open registries constitute 96% of all open registry tonnage with Liberia and Panama accounting for over 90%. In terms of number of vessels, Panama is by far the largest fleet with 5,499 vessels of a total of 8,409.

2.6 Age and size distribution of the fleet

The age and size distribution of the world fleet classified into two main groups of open and traditional maritime registries is given in tables 2.8-2.11. Table 2.8 deals with the percentage age profiles of all the vessels under the two groups and the world fleet. At mid-1984, of the 76,068 vessels in the world fleet, 36% were under 10 years old, 56% under 15 and 73.7% under 20. In terms of gross tonnage, 48% were under 10 years, whilst 75.6% and 89% were under 15 and 20 years respectively. Both the open and traditional registries have similar vessel age profile with some differences in terms of number of ships and tonnage.

In terms of tonnage, the tonnage over 20 years in the fleets of the major maritime nations is almost three times more than that of the open registries in the same age group. The position is more or less the same in terms of number of vessels: 24.2% of open registry ships are over 20, whilst 27.8% of the fleet of the traditional shipping nations is over 20. In absolute terms it means that the latter group has five times more vessels in the over 20 class than the former: 10,874 vessels against 2,017. Whereas there are 633 vessels of less than a million grt in the open registry fleet that are 30 years old and above, there are over 5,000 vessels of over 24 million grt in the same age group in the traditional fleets.

Whilst the above analysis presents the general profile of the aggregate

fleet in the two flag groupings, individual vessel age characteristics are bound to be masked by such aggregation. An analysis of individual fleet characteristics is therefore necessary. Within the open registry group, the historical position of the Liberian fleet as the newest has been taken over by the Bahamanian fleet which as at mid-1984 had 68.7% of its fleet under the age of 10 and nearly all its fleet in tonnage terms under 15. In fact, as can be seen in table 2.9, all its tankers are under 15 years old tonnage-wise. As regards number of vessels, about a quarter of the Bahamanian fleet is above twenty years of age. These vessels are mainly non-bulk vessels. In contrast, only 4.3% of the Liberian fleet is over 20. The Liberian fleet is still new with half its number and tonnage under 10 years. The Panamanian and Cypriot fleets have a mix of new and old ships. A third of their ships are over 20. These ships are mainly in the conventional general cargo sector. Both Cyprus and Panama have had a reputation of acting as dumping grounds for older tonnage.

Of the other major fleets, the Swedish fleet is the newest in tonnage terms with 71.4% of tonnage under 10 years, followed by Denmark (69.3%), Norway (64.4%), Germany (62.9%), France (59.5%), Netherlands (58.2%) and Japan (58%). These seven countries have substantial new tonnage under their fleets and in relative terms are newer than the tonnage under any one open registry country excepting the Bahamas. In terms of number of ships, however, only the Japanese and Dutch fleets have half their numbers under the age of 10. In contrast with the Liberian fleet it will be observed in table 2.8 that nearly all the countries of the traditional shipping group, with the exception of Japan, the Netherlands and the U.S.S.R., have between one-quarter and one-third of their ships in the 20-30+ age range, with Greece, Italy, Sweden, Norway, West Germany, the U.K. and the U.S. having over 10% of their numbers in the over 30 age range. The U.S. fleet, however, has by far, the oldest vessels and tonnage: 1,201 out of 7,455 vessels in the world fleet over 30 years old and 3 million (or 31%) of the 10.5 million world grt in that category. The reason is that U.S. operators reserve their older tonnage for the U.S. cabotage trades, which is by law reserved

for American flag ships, and register their new tonnage in open registry countries.

2.6.1 Tankers

The distributions are shown in table 2.9. The open registries as a group have relatively newer tanker tonnage than the traditional shipping group, with 53% of tonnage less than 10 years old and 10.1% more than 14 as compared with the latter's 50.2% and 19.1% correspondingly. Their spread of vessels is about the same: 43.2% of open registry tankers is under 10 years old and barely a third (31.2%) older than 14 ; similar to 44.4% and 36.6% for the traditional shipping group. The traditional group, however, exceed the open registries by 17% in the over 14 age bracket in terms of number of vessels.

The age structure of the individual countries is demonstrated by figure 2.3. It can be seen that the Bahamanian fleet with 67.6% of tonnage under 10 and none over 14 is the newest open registry tanker fleet, followed by Liberia. Even though over half the Panamanian tonnage is under 10 years of age over one-quarter of the fleet is over 14 years. In terms of number of ships, Panama has the largest number of old tankers at 51.6% with barely one-third of its tankers in the under 10 years range. Tonnagewise, the Cypriot fleet is the oldest with 28.7% over 14 years and a little over one-third under 10 years. The point must be made that Panama appears to be the largest repository of the world's old tankers over the age of 14 in absolute number of ships' terms. Of the 367 tankers over the age of 14 in the open registry fleet, 74% or 271 tankers are under the fleet of Panama. This figure surpasses those of Greece, the U.S.A., the U.S.S.R. and Italy all of which have substantial numbers of tankers (over 60% of the fleet) in the over 15 range. Therefore, Panama in absolute terms represented (at mid-1984) the highest contributor to the world tanker fleet over the age of 14. It should thus not be surprising to see a large proportion of Panamanian tankers involved in marine casualties; as will be seen in chapter 3 appendix B.

Most of the traditional tanker fleets is comprised of new tonnage under 10 years old, ranging from proportions of 51% to 86% of fleet. The

Figure 2.3
Tanker % age structure of open and traditional registries
a{% of grt less than 10 years old

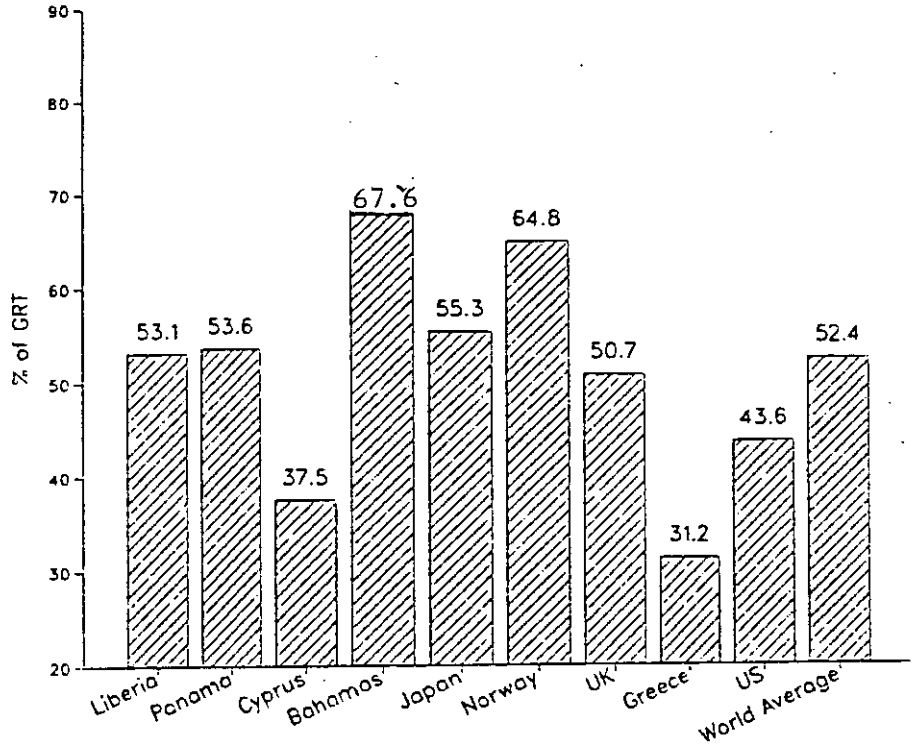
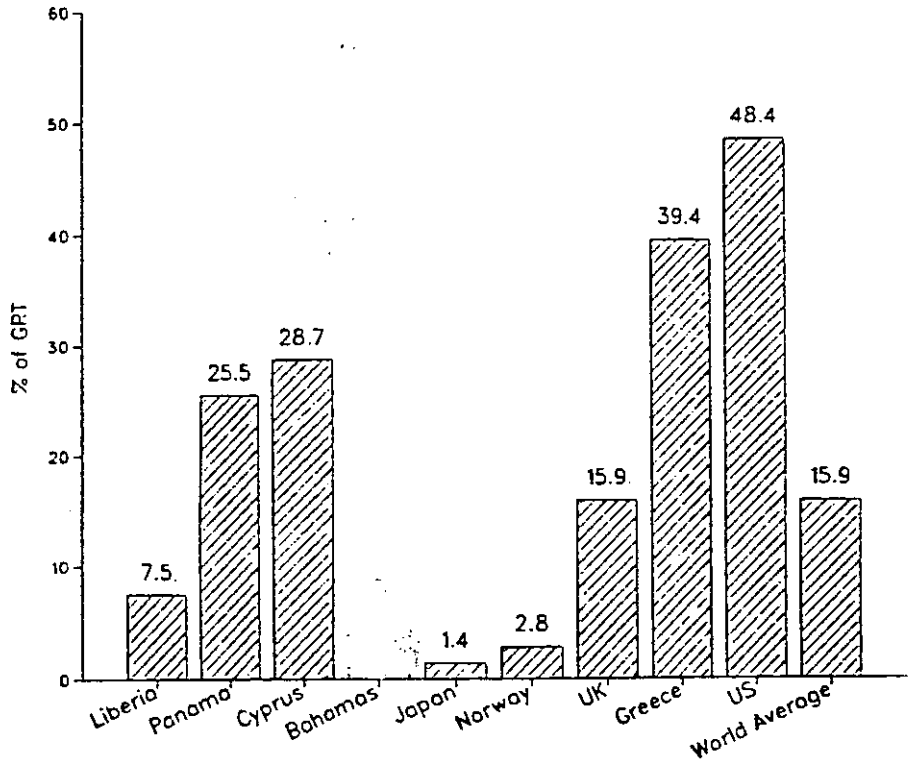


Figure 2.3b
Tanker % age structure of open and traditional registry fleets; 1984
b{% of grt older than 14 years



Swedish fleet is the most modern in this group with 86% of its fleet under 10, followed by the Danish and Norwegian fleets. The exceptions are Greece, Italy, the Netherlands, the U.S. and the U.S.S.R. These countries have substantial over 15 year old tonnage and less tonnage in the under 10 category (except Italy with 51% in this category). The Soviet tanker fleet is the oldest with 55.5% of tonnage older than 15 years. But in terms of absolute tonnage and the world fleet, the Greek fleet is by far the oldest with 4.3 million grt of the world total of 23.4 million grt above the age of 15. It is also likely that, on this score, the Greek tanker fleet could be more susceptible to marine accidents. With only 17% of its tankers under 10 years it has an enormous 65% of its 362 tankers over the age of 15, including 14.4% over 30 years old.

Both the American and Italian fleets are also very old with 31% and 22% of their respective ships over 30 years old. The Dutch fleet is also growing old both in number of ships and tonnage. With the exception of these cases the traditional tanker fleets compare favourably with the modern fleets (Liberian and Bahamanian) of the open registry countries.

2.6.2 Dry Bulk Carriers

Table 2.10 and figure 2.4 show the age structure of the dry bulk fleet. Clearly the traditional bulk carrier fleet is more modern and newer than that of the open registries. The statistics of table 2.10 and figure 2.4 show that 50% of the dry bulk tonnage under traditional shipping registers is under 10 years old with a corresponding 19% over 15 years. This contrasts rather unfavourably with 44.2% and 24.1% in the open registry fleet for the two age groups. The traditional dry bulk fleet has the same age profile as its tanker fleet, whereas the open registry fleet in the dry bulk sector is older than its tanker fleet. With respect to number of vessels, the open registries have slightly more vessels (47.6%) in the less than 10 category against 45.8% for the traditional fleet. For the over 15 range, the structure is the same: 27.6% for open registries and 28.9% for the traditional shipping nations.

If the American fleet which has 65% of its ships over 30 years old and

Figure 2.4
Dry bulk % age structure of open and traditional registry fleets
1984
a{% of grt less than 10 years old

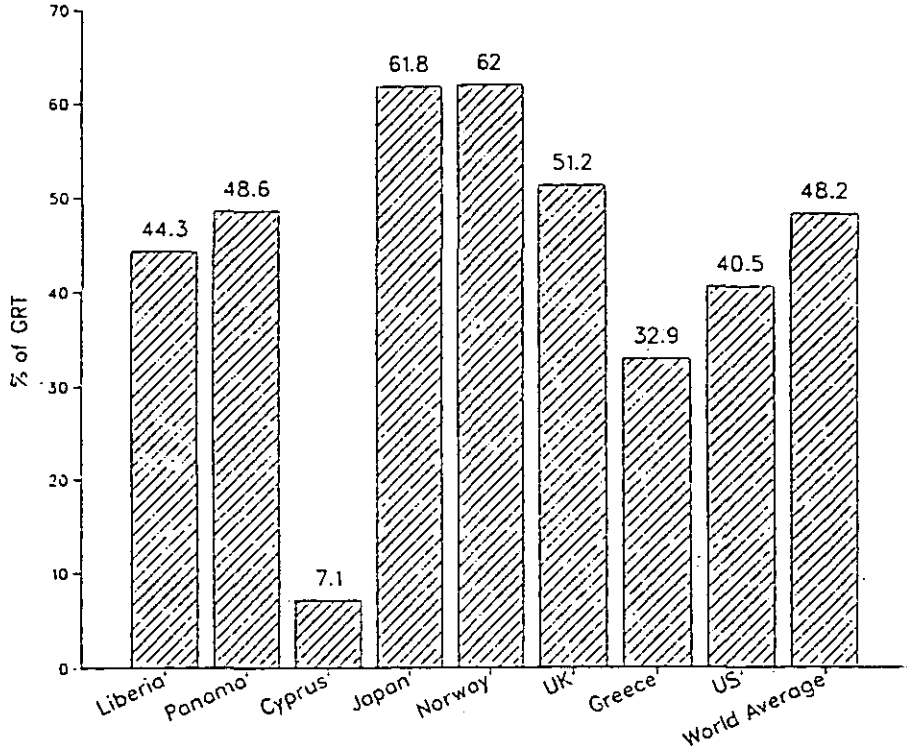
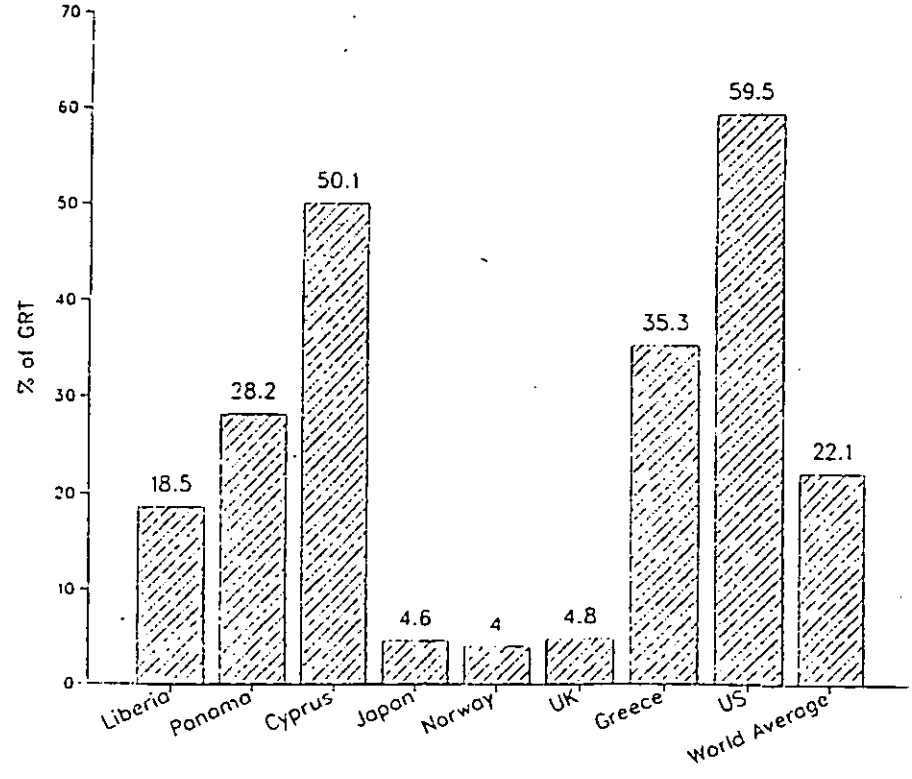


Figure 2.4
Dry bulk % age structure of open and traditional registry fleets
1984
b{% of grt older than 14 years



43% of tonnage in the same category is excluded, then the traditional fleets will by far have a much more modern age composition. It is shown in both table 2.10 and figure 2.4 that the French, German, Dutch and Norwegian fleets are composed only of vessels under 20 years of age. Both the U.K. and Japan also have very minimal proportions of their fleet in the 20-24 year age bracket. The Italian, Greek, and American registries are also the custodians of old dry bulk tonnage. The Greek fleet has more or less the same age profile as its tankers, but both the Italian and American dry bulk fleets are older than their tanker fleets.

The Cypriot fleet is the oldest in the open registry group with over 50% of ships and tonnage over 15 years of age and only 9.5% of ships and 7.1% of tonnage in the same range. The Liberian dry bulk fleet is relatively older than its tanker fleet whilst the Panamanian fleet is newer with over half less than 10 years old. It is noteworthy that the proportion of all vessels in the open registry fleet over the age of 15 is below the world average both in vessel numbers and in tonnage. The proportion of tankers over 15 years is well below the world average in all respects whilst the bulk carrier tonnage is slightly above the world average but below it in vessel numbers.

2.7 Size structure of the fleet

Table 2.11 shows the size structure of the bulk fleet; first the tankers. The world tanker tonnage appears to be concentrated in two size ranges: 20-under 80,000 and over 100,000 grt, peaking in the 120-under 140,000 grt range. This same trend is also reflected in the fleets of the open registries. Whilst for Liberia, Cyprus and Bahamas their greatest concentration of vessels is in the over 100,000 grt range; the Panamanian tonnage is concentrated more in the 20-under 80,000 grt class. This situation is reflected in the relatively smaller average tanker size of the Panamanian fleet, which is also smaller than the world average. The large size of ships in the Bahamanian fleet is shown by its large average size; bigger than that of Liberia, because well over 50% of its tanker fleet is over 140,000 grt. Generally, open registry tankers tend to be large as the average tanker size is almost twice that of the

world average. This is a result of well over half the fleet being in the over 100,000 grt (approx. 187,000 dwt) size class.

The bulk carriers, on the other hand, show quite a different pattern of distribution: 76% of the world fleet and 82% of the open registry fleet are in the 10,000 - under 60,000 grt size range (ie. approx. 15,385 - 96,000 dwt). The heaviest vessel concentration is in the 10,000 - under 20,000 grt range (approx. 15,385 - 30,769 dwt), where there is 65% of the world fleet and 72% of the open registry fleet. This picture is mirrored by the open registries: Liberia has 64% in this range (15-30,000 dwt), Panama 82% and Cyprus 84%. Cyprus and Panama with higher than the open registry average concentration in this popular category have average sizes smaller than the world average; denoting that their bulk carrier tonnage is principally made up of relatively smaller vessels. The Bahamanian bulk carrier fleet is less than a quarter of a million grt and represents less than 1% of the open registry bulk carrier fleet (table 2.7), ~~and~~ therefore is of little consequence.

2.8 Beneficial ownership of the fleet

The ownership and management structures of the fleet are given in table 2.12. The table shows that 73% and 67% of the open registry fleet were respectively owned and managed as at 1982 by four countries: the U.S., Hong Kong, Greece and Japan. Also, the table shows that 62.3% and 56.1% of the fleet were respectively owned and managed by shipowners in traditional nations. The view has been expressed that the increase in the share of Hong Kong ownership of open registry tonnage between 1976 (607,000 dwt) and 1982 (4.9 million dwt) must have been brought about by "factors other than natural growth". It is thus believed that since Hong Kong is a British Colony it may well be serving as a haven for British shipowners to channel their ships to open registries via Hong Kong companies (Sturmey, 1984, p. 14). If the effective ownership and management were to be considered, then adding the Hong Kong figures makes the traditional countries owners and managers of 80% of the open registry fleet.

CHAPTER 3

AN OVERVIEW OF THE SOCIAL COSTS OF OPEN REGISTRY OPERATIONS

"It is unreal to talk of sub-standard ships without considering the underlying causes of sub-standard managements and sub-standard administrations."

UNCTAD (1981)

3.1 Introduction

For years the fleets of open registries have been seen by their critics, famous amongst whom is the International Transport Workers Federation (ITF), as being synonymous with sub-standard shipping; both in the sense of their vessels not meeting the international legal requirements for the technical seaworthiness of ships and in the sense of employing poorly qualified crew which contributes to the fleet's poor accident records. It must be noted at the outset that the association of open registry shipping with sub-standard operations can be misleading because not only do a number of highly reputable shipowners operate ships under these registries, but also poor safety records tend to be found in other flags, as it is probable that sub-standard vessels operate in all fleets to a varying degree.

However, in Appendix B, marine casualty statistics dealing with total losses (a total loss according to Lloyd's "Casualty Returns" is defined as a merchant ship which has ceased to exist as a direct result of being a marine casualty) are presented. The statistics therein provide sufficient evidence of the higher rate of involvement of open registry ships in accidents leading to total vessel loss. Since total losses, apart from the loss of vessel, also involve loss of life and limb, pollution and hence damage to the marine environment, natural ecosystem and other externalities, the purpose of this chapter is to reflect the possible social costs of open registry shipping, particularly the costs resulting from marine accidents, or rather sub-standard operations.

Quantitative analysis of the social costs of open registry shipping is outside the ambit of this study. Therefore, the intention of this chapter is to give an overview of the magnitude of the economic and social costs of marine accidents, as well as other social costs, with the view to comparing these costs with the likely benefits of open registry shipping. The possible costs and benefits of the system to different communities are set out in Table 3.7. It is clear from this table that the potential costs and benefits of the system are widespread. Of all the costs, the most important is the cost of marine accidents; it is also the most amenable to estimation.

3.2 The social costs of marine accidents.

The cost of a marine accident can be broadly divided into internal and external costs. The first category covers the cost of the ship (hull cost), the cost of cargo lost, the cost of loss of life and limb, and the cost of salvage operations. The second covers all externalities caused by the accident such as, the cost of pollution, the cost of prevention of further pollution and control, the cost of clean-up and the cost of damage to the general marine environment, habitat and natural ecosystem. The latter covers the costs of the effects of oil pollution on fisheries, the effects on tourism and the effects on coastal agriculture (eg. seaweed farming and sheep grazing on seaweed on coastal foreshores; see report of the Royal Commission on the effects of oil pollution on the marine environment, H.M.S.O. (1981), for a good treatment of these costs).

Giziakis (1981), Rathaile and Wiedemann (1980), Goss and Vanags (1982) and Gardner and Goss (1982), have all done work on the evaluation of the costs of marine accidents involving total vessel loss. Giziakis in arriving at the costs of hulls of vessels totally lost used insurance claims paid out on the vessels lost as a measure of the market values of such ships. Goss and Vanags (ibid. p.220) also agree that the insured value of a ship is a better indicator of the value of the ship to the

shipowner than its book value which may never have been adjusted for inflation. Giziakis also used secondhand values to estimate hull values for part of his data for which insurance values were not available. Secondhand values are good indicators of the market values of assets - see chapter 6.

It is, therefore, possible in any year or period of years, using the statistics of total loss given in appendix B to estimate the private cost of vessels lost under open and traditional registries. The cost of cargo can also be estimated by using market values of the lost cargoes - a methodology applied by Giziakis. It is clear that these methods of estimation are based on internal (private) cost considerations, what matters, however, from a social cost point of view is not so much the loss of property (vessel and cargo), but the loss to society of the use of that resource; for example, the cost to society of not delivering the cargo at the right time (ie. effects on factories at the receiving end).

Casualty data are provided by the Liverpool Underwriters' Association and other sources provide information on the number of lives lost in accidents. These statistics are, however, not always complete as deaths occurring some time after the accident are often not reported. The valuation of human life is a thorny problem because of the objection that the value of life cannot be measured in monetary terms. However, two methods are today generally accepted for the valuation of life: the economic and the non-economic (the subjective) costs of life.

The economic cost can be measured from the loss of output which the community suffers from the death of a person or alternatively in terms of a person's expected lifetime earnings, or in terms of industry's expenditure on safety measures per life saved. Gardner and Goss (ibid.) employ both of these methods in valuing the life of a seaman in their cost-benefit study of lifeboats and inflatable liferafts. Rathaile and Wiedemann (ibid.) using the values provided by Gardner and Goss,

estimated the life of a seaman to be between £10,000 and £120,000 (using 1977 prices). Using the same approach, Giziakis estimated the life of a seaman at £118,000 at 1978 prices (average for 1975-1978). The fundamental shortcoming of these studies (except Gardner and Goss) is that their valuations of human life are commercially-based evaluations without consideration for the non-economic aspects of loss of life, such as the subjective elements of pain, grief and suffering of the families affected. To the extent that pain, grief and suffering exist, the community is thus worse off. Therefore, the absence of social considerations makes estimates of economic costs only an under-estimate of the real cost of loss of life and property - ship and cargo.

Pollution is the most important external cost of a marine accident. In table 3.5 (appendix B) it is shown that open registry tankers, over the nine year period, have accident ratios far above the world average. Since the tankers covered by that table are oil tankers, there is little doubt that most of the tankers might have polluted the marine environment. Therefore, it is also possible, given the appropriate data, to estimate the cost of pollution by open and traditional registry vessels.

The transportation of oil by sea causes pollution in two main ways - by tanker operations (operational pollution - that is, pollution caused by tank cleaning operations) and tanker accidents. The latter is the best known cause of oil pollution due to the transportation of oil. It has been argued that there are grounds to believe that open registry tankers are also far more involved in operational pollution than their regulated counterparts, Metaxas and Doganis (op. cit.).

Oil pollution damage from accidents can be caused either by oil spilt or by the subsequent clean-up efforts - the latter being known on some occasions to have caused more damage than the former. The costs are

obviously difficult to measure because of the wide variety of externalities involved. More commonly, estimates of the cost of pollution are attempted on the damage on the tourist and fishing industries, and on the natural environment - see Rathaille and Weidemann and the Royal Commission on Oil Pollution (ibid.). In most evaluations the known costs of pollution incidents, ie. the cost of clean-up and oil dispersal operations are used to provide a quick estimate of the cost - see, for example, Burrows et. al. (1974). Rathaille and Wiedmann using a selection of ships involved in some of the largest accidental spillages of oil due to marine accidents, (including the Torrey Canyon (1967) and Amoco Cadiz (1978) between 1967 and 1978, estimated the mean cost of pollution caused per collision as between £385,000 and £460,000 at 1977 prices. The mean cost per grounding was found to range from £10.0m to £50.0m at 1977 prices. They admit that these selected incidents underestimate the cost of pollution since many other costs are not estimated. The figures serve, however, to indicate the magnitude of the cost; especially when the largest spillages were caused by open registry tankers - Torrey Canyon and Amoco Cadiz.

There is no doubt using the historical statistics given in appendix B that open registry ships, as Grundey also found, have a higher probability of marine accidents than traditional registry ships, but the problem of marine accidents is not only determined by the flag of the ship per se but also by the ownership and hence management of the ships; a fact demonstrated by figure 3:1. In assessing the cost of phasing out open registries, therefore, it will be necessary to set the marine accident cost of open registry ships under a beneficial owner against the likely benefit derived by such an owner in order to have a balanced cost-benefit balance sheet of the beneficial country from the open registry system.

3.3 Other social costs

Other social costs include the general lowering of international safety standards due to competition amongst classification societies, loss of

Figure 3.1a:Marine casualties by ownership & control;1979–% world grt

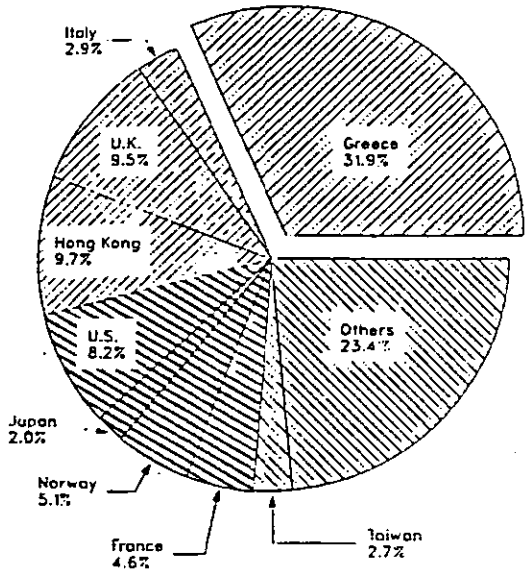


Figure 3.1b:Marine casualties by ownership & control:1980–% world grt

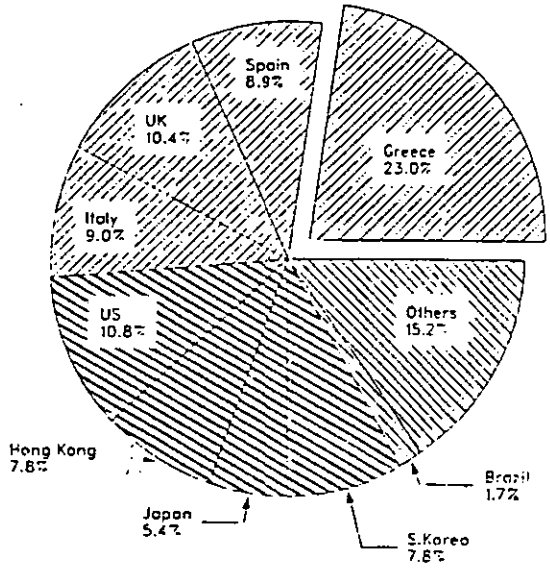
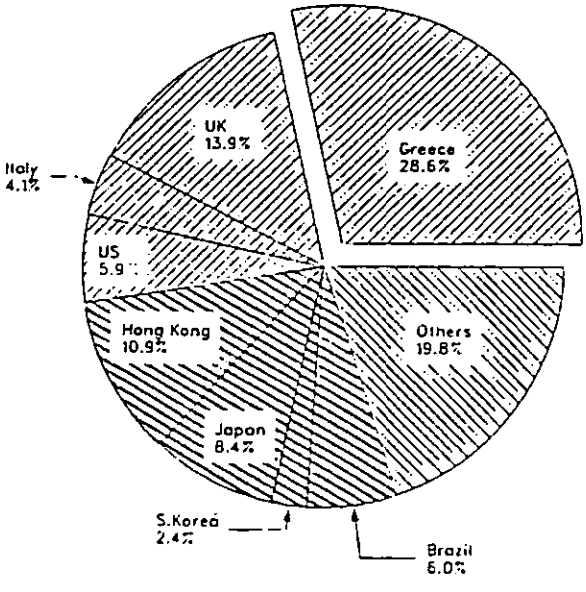


Figure 3.1c:Marine casualties by ownership & control;1981–% world grt



trade by traditional shipping nations and hence lower direct earnings from shipping and lower foreign exchange earnings; and an additional loss of foreign exchange as a result of payments for national trade carried in open registry ships which might have been carried in national vessels. The general social effect due to loss of trade results in a smaller shipping industry and hence limited employment opportunities for national seafarers. The social implications of the open registry system are well treated in Metaxas and Doganis and Sturmey (1984).

One of the issues at the centre of the open registry phasing out debate has been UNCTAD's claim that the existence of the system has a stifling effect on the growth of the fleets of developing countries. In this regard, it must be mentioned that whilst it can be established using published statistics of vessels sold in traditional shipping nations and their intended registries that the traditional registries experience loss of tonnage to open registries due to vessel transfers, the same cannot be established for the developing countries - see Sturmey (ibid.).

In the final cost-benefit analysis, a global balance sheet, including the cost of marine accidents in all its ramifications and other social costs, must be considered along with the likely benefits of lower freight rates - which is the primary subject matter of this thesis. It is very probable that the latter are outweighed by the former.

Table 3.7 Potential Costs and Benefits of Open Registry Shipping

Costs -	Benefits +
A. Open Registry Countries	
1. The bad reputation of the institution because of its very poor safety records and sub-standard vessel operation.	1. Foreign exchange earnings.
2. Loss of tax revenue that would have been earned if vessels were economically linked to their flags of registry.	2. Employment opportunities for nationals in nominal companies established in open registry states by beneficial owners.
B. Countries of Beneficial Ownership/Traditional Maritime Countries	
1. Loss of tonnage to open registry ships: Hence: a) loss of trade; b) loss of foreign exchange earnings and therefore a reduction in the contribution of shipping to the balance of payment.	1. Enhanced employment opportunities (over 30% of open registry crew come from developed countries)
2. Loss of tax revenue: Resulting from: a) loss of tax revenues on vessels transferred or registered under open registries; b) loss of tax revenues on shipping revenues because of liberal fiscal policies on shipping; c) loss of revenues on personnel working on open registry ships.	2. Savings on the cost of subsidising the construction and operation of ships under high cost countries.
3. Cost of government subsidies and other financial packages aimed at making national flag ships as competitive as those of flags of convenience.	3. Availability of vessel for requisitioning during times of war and national emergencies.
4. Manpower drain.	4. Increased shipbuilding activity. Profits from open registry operations are reinvested in shipping.
5. Higher social security costs.	5. Lower freight rates.
C. Developing Countries	
1. Possibly stifling the growth of the fleets of developing countries.	1. Lower freight rates. 2. Increased employment and training opportunities. 3. Foreign exchange earnings.

Table 3.7 continued

D. World Community

1. Higher capital and human resources costs in real terms due to: a) higher rates of vessels totally lost and loss of life and limb; b) higher accident rates involving loss of life and limb; c) loss of earning for seamen and their families in the event of accidents and/or labour disputes arising from trade union opposition of the institution.	1. Lower freight rates as a result of: a) lower operating costs; b) reinvestment of shipping revenue to provide more capacity.
2. Higher externalities of operation as a result of: higher environmental pollution involving oil spillage from tankers; damage to marine resources and habitat.	2. As a result of (1b): increased foreign exchange earning for ship exporting countries and job creation.
3. As a result of poor safety records, higher insurance premiums and club calls.	3. Possibility of reducing global unemployment level.
4. Institution earns a bad reputation for the shipping industry.	4. Providing shipping capacity at a lower cost to developing countries which c annot, as yet, afford to own their own national fleets; or cannot afford to carry all their foreign trade.
5. Negative effects on normal registry leading to: a) excessive tax concessions; b) shipping subsidies aimed at establishing competitive parity.	

Note: The framework of this table is drawn from Metaxas (1981) with substantial additions by this author e.g. section C.

CHAPTER 4

AN OVERVIEW OF THE BULK SHIPPING INDUSTRY

> *"Cost is the bedrock of freight rates. In a competitive market, freight rates will be driven down to the level of costs. The tramp market is substantially competitive, and the rates probably are explained almost entirely by the cost of operation."*
>
> Bennathan and Walters (1969)

Bearing in mind that this study is concerned with the bulk (tramp) shipping sector of the shipping industry, this chapter surveys the economic characteristics and mechanics of the bulk freight markets with a view to providing the background for the analyses of the following chapters, particularly chapter 8. The shipping industry is broadly divided into two main divisions - the general cargo and bulk cargo sectors. The main difference between the two sectors lies not so much in the type of cargo carried as in the ~~type of~~ structure of the sectors ~~shipping services offered~~, and hence the markets in which they operate. The general cargo sector is characterised by scheduled liner services. In other words, the liner service operates like a bus service with a fixed route and plies in accordance with a pre-determined time-table, whilst the bulk trade is akin to a car-hire service, where a ship like a car is hired or chartered for a single voyage or period of time. Whereas the freight rate charged for liner services is determined by a cartel - called conference - that of the bulk freight market is determined by the interaction of demand and supply in a competitive market setting.

4.1 Demand and supply of bulk shipping capacity

The demand for shipping, like the demand for all transport services, is a derived demand; derived from the demand for the commodities for which shipping space is required. This demand is represented by the volume of commodities carried and the distance over which they are carried. Hence the unit of measurement of the demand for shipping is the ton-mile. On the other hand, the total supply of shipping capacity is represented by the world fleet inclduing ships in lay-up; but the effective supply at any point in time is composed of the total of

unfixed tonnage plus laid-up vessels available for chartering - available supply.

The supply of bulk carriers and tankers comes mainly from vessels owned by the shippers of commodities, privately owned tonnage by independent shipping companies and national fleets of the exporting countries. The ownership and operation of the tanker fleet can be divided into four groups:

a) tonnage owned and operated by oil companies, which amounts to some 30 to 40% of the total tanker fleet;
b) tonnage owned by independent shipping firms but on long-term charters to the oil companies;
c) privately-owned tonnage operating in the spot market;
d) national fleets owned and operated by oil producing countries, ie. developing countries and countries in the communist bloc.

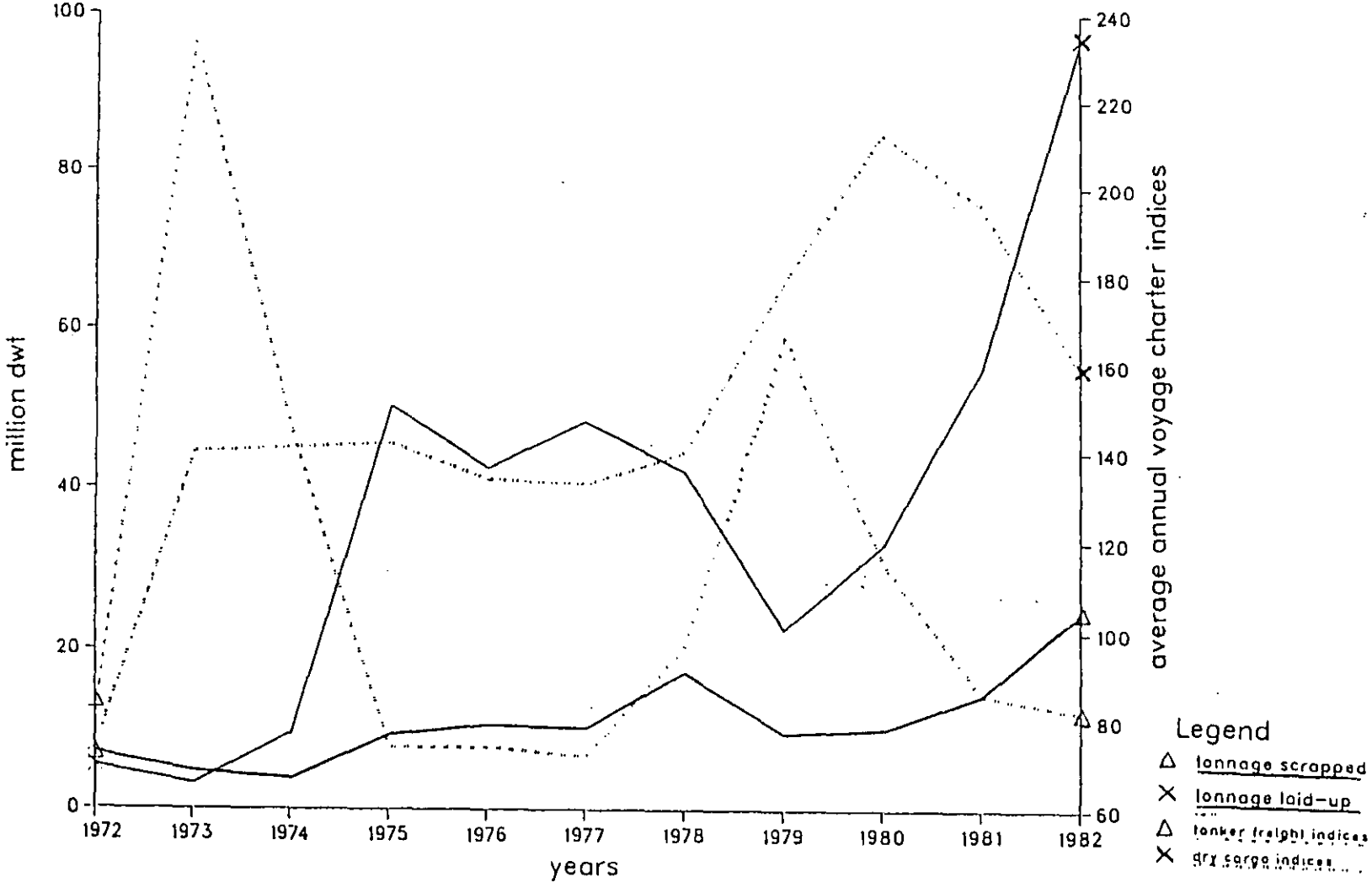
The bulk carrier vessel supply also comes from independent shipping companies and tonnage privately-owned by large industrial companies engaged in integrated operations including the transportation of their raw materials, ie. the steel-making industry (for the extent of involvement of cargo interests in the shipping sector see UNCTAD, 1978, 1980). In both the tanker and bulk carrier sectors, the independently-owned tonnage forms a major part of the fleet.

In theory, the total supply of shipping, in the short term, is inelastic at all rates down to the lay-up rate of the ship with the highest unit operating cost (ie. the marginal ship), but at rates below this highest lay-up rate, supply is more elastic (Sturmey, 1965). This region of elasticity provides a kind of floor, such that rates cannot fall below the lowest lay-up rate (that of the ship with the lowest unit operating cost), even in the deepest of slumps. Rates cannot fall below this floor as they cannot fall to zero at which level no trade will be possible. The dynamics of the freight market are such that as shipping capacity is constantly withdrawn from the market due to a prolonged slump the level of rates gradually readjusts itself upwards.

In the elastic region, supply is determined by the changes in freight rates. When rates fall, the volume of laid-up tonnage will begin to rise. The first to be affected are usually ships which are expensive to operate. If the fall in rates continues for a prolonged period of time and rates fall to very low levels, a movement to scrap or sell old and expensive tonnage in the secondhand markets begins. When rates begin to rise again, both the tonnage in lay-up and the rate of scrapping decline. The movement of the level of freight rates, therefore, is inversely related to the volume of tonnage laid-up and scrapped. This relationship can be seen in figure 4.1. It must be borne in mind that the adjustments in supply due to lay-ups and scrappings are not automatic by virtue of the fact that when rates fall existing charters have to be completed before a decision to withdraw from the particular market by laying up, selling or scrapping the vessel can be taken. Contrariwise, in the event of rising rates, time is also needed to recommission laid-up vessels or acquire additional tonnage.

It follows from the above that at any point in time, both in times of rising and falling freight rates, the supply of tankers and bulk carriers is inelastic. The reasons are that first, during periods of rising freight rates, additional tonnage cannot be secured in the short run except through the marginal re-entry of vessels from lay-ups; subject to fulfilling their charter terms or by substitution amongst vessels (ie. crude tankers cleaned for clean products and vice versa or grain tankers used for carrying oil) or further by operational strategies such as increased voyage speeds and faster port turn-round times, postponed dry-docking and scrapping of older units. Conversely, when rates are depressed the rate of scrappings and conversions tends to be on the increase, but may not be sufficient enough to limit supply. For instance, despite large tanker scrappings, and (relatively to a lesser extent) scrappings in the dry bulk sector in 1983(which in effect led to a 2% fall in world fleet in that year), tanker surplus was still about two-thirds of demand for 1983 (including laid-up tankers and the effect of slow steaming) and that of the dry bulk sector 200% of the fleet.

Figure 4.1
Relationship between freight rates,vessel scrappings and lay-ups



Even though operatonal practices - ie. slow steaming, advance dry-docking, part-cargo trading and the use of tankers for storage are aimed at restricting supply in the short-run, they do not lead to a permanent variation in supply because these vessels and those laid up are effectively part of the available tonnage. However, it is noted that the seasonal variations in demand and the effects on supply of low freight rates are such that in practice it is difficult to find rates ever remaining at a level at which supply is completely inelastic (UNCTAD, 1969).

The demand for bulk shipping services is derived from the world demand for dry and liquid bulk commodities like iron ore, coal, grain, bauxite and alumina, phosphate,oil, petroleum products and other bulk commodities. To the extent that the demand for these commodities is dependent on the state of the world economy and the structure of world trade, sea transport demand is primarily determined by this factor and other objective factors such as poor or boom harvest, wars, political factors and natural disasters, rather than by endogenous factors in the shipping industry.

In the competitive market setting of the bulk freight markets, the main effect of changing demand is seen in its effects on freight rates, through which it percolates to supply. This is so because at any given level of demand, there is a certain elasticity with respect to freight rates. This elasticity is influenced by three factors: first, the elasticity of demand for the final product; second, the proportion of the price of the commodity represented by transport costs and finally, the availability of substitution possibilities both in terms of sources of substitution for the bulk cargo (the primary commodity) and alternative means of transport.

The influence of the first factor derives from the derived nature of the demand for transport since a rise in rates leads to a rise in the price of the bulk commodities and consequently to their final products causing, in the course of time, a fall in the demand for the final products, - such a fall depending on the elasticity of demand for the final products. This fall in the demand for the final product leads

to a fall in the demand for the bulk commodities for which sea transport is demanded and hence to a fall in the demand for bulk tonnage. Given these inter-relationships, it can be said that the elasticity of demand for bulk shipping services will positively move in the same direction as the elasticity of demand for the final product.

Sturmey has noted that the main cause of short term elasticity of demand for shipping services is the effect of rates on the prices of the commodities carried. This effect depends on the relation between rates and the price of the commodities. The smaller the proportion of the cost of bulk transport in relation to the price of the commodity, the more inelastic will be the demand for the carriage of the primary bulk commodity. Thus so long as rates are less than the value of the goods carried, the elasticity of demand for carriage will be lower than that for the goods carried. It follows from this point that given the relatively low price elasticities of bulk raw materials transported by bulk carriers and tankers, that the elasticity of demand for ton-miles will tend to be low in the short run. Thus elasticity will be affected by the existence of substitutes in the importing country or supplies from nearby territories which may reduce the distance component of demand or by the availability of alternative modes of transport. These factors, however, are more relevant to the long-run than the short-run.

At this point let us use the tanker sector to illustrate the reasons for the inelasticity of demand for bulk tonnage in the short-run. In this sector the demand for shipping comes mainly from the major oil companies and a number of small independent oil companies. Demand for tanker transport is inelastic in the short run because first, the oil companies have contractual obligations to supply oil to their various customers. Most of the trade is carried by their own vessels (owned or chartered-in) and the remainder complemented by tonnage from the spot market. For any unforeseen reason, should there be any shortage of tonnage due to bad forward planning or any other contingency, they will be forced to pay the going rate in order to meet their contractual obligations. The specialised nature of tankers makes substitution by alternative means of transport difficult. Secondly, since the demand

for tankers is derived mainly from the demand for fuel which itself is inelastic in the short run due to the lead time required to provide alternative sources of energy, substitution possibilities are limited; (it must be noted, however, that modern electricity generating plants have in-built flexibility which allows conversion between sources of energy, ie. from oil to coal). Also because the cost of transport represents only a small fraction of the total cost of output, many industries are not likely to change their demand for oil and its by-products in the short run because of an increase in freight rates. These features also apply to a large degree to the bulk carrier trades.

In the long-run, it is generally agreed that the freight markets exhibit a general tendency towards an equilibrium, ie. a tendency for supply to adjust itself to demand for tonnage. This is possible due to the fact that in the long run there is ample time for supply to react appropriately to demand. In periods of rising freight rates supply can be increased by vessel re-entry into service from lay-ups, new buildings and purchases from the secondhand market or conversion of redundant or unremunerative units in other trades; on the contrary, during falling rates, supply can adjust accordingly by vessel scrappage, laying-up and conversions. This adjustment to an equilibrium price which derives from the normal price theory of a competitive market is not an automatic process as static economic theory states (Kojima, 1926).

The theory postulates that in the long-run the market price fluctuates around the cost of production. Even though sometimes it rises above it and at other times falls below it, it has a natural tendency to find its proper level at the cost of production in a competitive market. This is due to the fact that although the market price, as we have earlier discussed, is determined by the relation between demand and supply, when freight rates are higher than the cost of shipping services, more capital is attracted to the industry from within and from outside; this apparent increase in supply causes prices to fall. Conversely, when rates are lower than the cost of shipping services, owners will contract supplies of tonnage by scrapping, conversions and lay-ups and thereby cause a rise in price again.

Whilst there is a consensus amongst shipping economists that cost is the bedrock of freight rates in the long-run in the bulk shipping market, as we shall see in chapter 8, it is also recognised that the long run equilibrium level, when it occurs, is not stable except for very short periods of time because the quantities demanded and supplied are a function of both current and expected prices (Zannetos, 1966). The process of adjustment is not instantaneous because there is a time-lag between shipowners decisions to expand their fleet during rising freight rates, for example, and the actual time of delivery of vessels ordered. Both shipper and shipowner expectations of future freight rate levels can also affect the extent of an adjustment towards an equilibrium, particularly as shipowners are generally reluctant to dispose of old vessels in depressed market periods in favour of a 'wait and see' attitude in the hope that conditions might improve. It has been noted, however, that "the absence of stable equilibria situations in the main maritime markets and particularly in the quasi-competitive ones such as the tramp freight market and the tanker spot-market, and the fact that in these markets freight rates tend to fluctuate sharply, should not be taken to indicate that their functioning is not characterised by an inevitable tendency towards long-run equilibrium a tendency of the industry to adjust itself to demand requirements." (Metaxas and Parker, 1979)

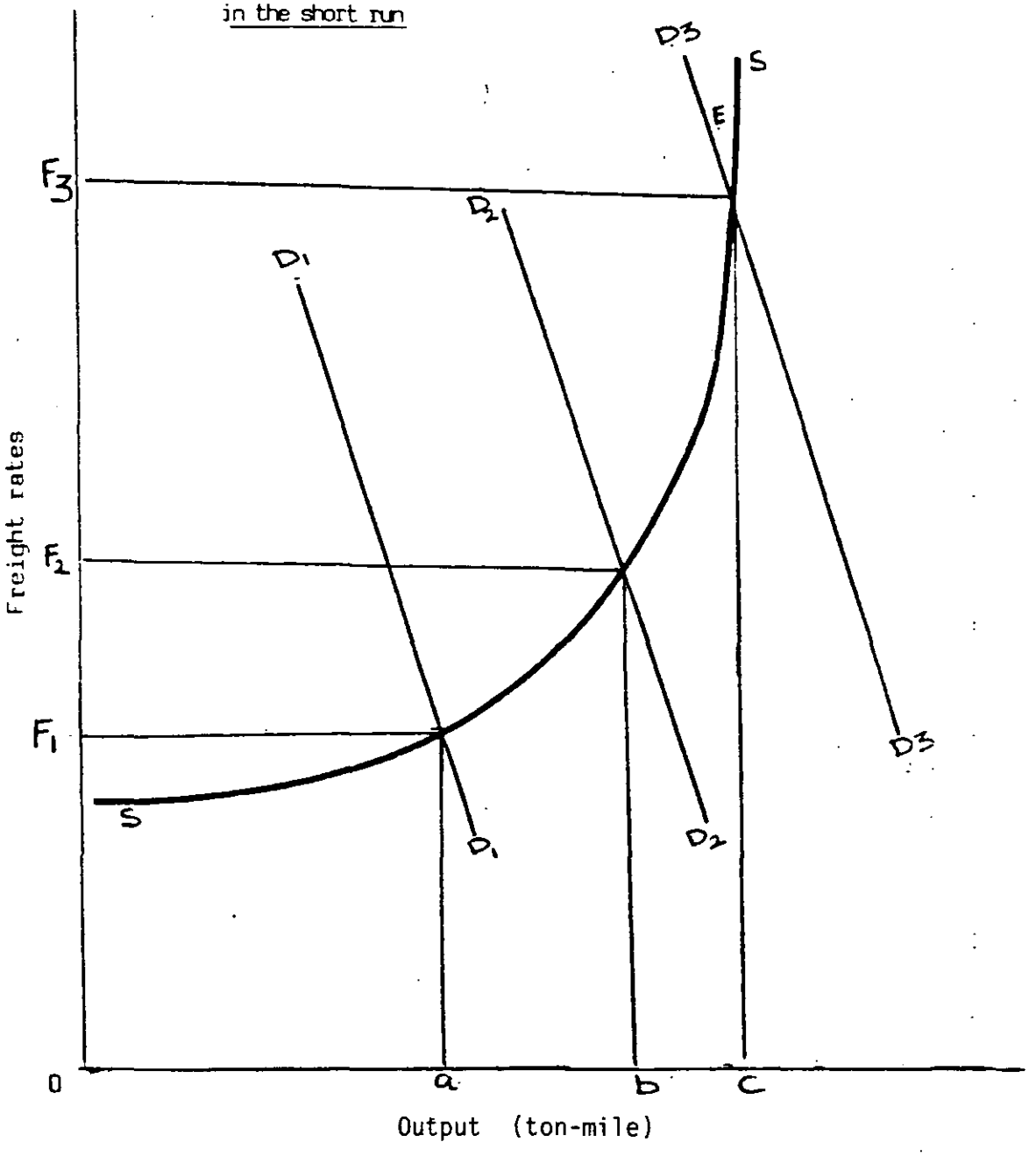
Figure 4.2 summarises the discussions so far, ignoring shifts in supply. At D_3D_3 demand is high and the demand curve intersects the supply curve in its inelastic range at E where tonnage supplied is Q_c at a price level of F_3. In this range supply is inflexible in the short term in view of the points raised earlier. This means that sudden changes in demand cannot be met by proportionate changes in supply and therefore are borne completely by changes in freight rates. If demand falls to D_2D_2 and crosses the supply curve at a point where it is becoming elastic such that it contracts to Q_b at a new equilibrium freight rate of F_2, then the effect of changing demand will become smaller on freight rates and affect supply more. As demand continues to fall at D_1D_1, a point will be reached (the lay-

up point) where supply becomes completely elastic. At this stage, freight rates will fall no further and, therefore, all subsequent falls in demand will affect only the supply of tonnage still operating in the trade (Sturmey, ibid).

On the other hand, figure 4.2 can be interpreted as representing a scenario of rising demand. If D_1D_1 is taken as the initial demand level and O_a the equilibrium ton-mileage equating supply to demand at the rate of F_1, then an increase in demand to D_2D_2 will raise freight rates from their initial level to F_2, and consequently quantity supplied to O_b; and in similar manner D_3D_3 will raise rates to F_3 and equilibrium tonnage to O_c. It is noticeable that the change in the quantity supplied at O_b (ie. O_a-O_b) is larger than that of O_c (ie. O_b-O_c). This is because the response of supply to changing demand is becoming fairly inelastic and to meet D_3D_3 all available tonnage will have to be supplied. The effect of this slow response is reflected in higher freight rates as shown by the difference between F_2 and F_3. After all available supply is exhausted, supply becomes completely inelastic at point E only to increase in the long-run when ships ordered will have arrived to meet further increases in demand.

The process of adjustment of O_c to D_3D_3 can also be delayed not only by the time-lag problem of recommissioning laid-up vessels and converting ships in other trades, but also by delays in the arrival on the market of ships ordered during periods of rising rates (D_1D_1 and D_2D_2). Delays of this sort are normally caused by shipyards taking on too many orders than their productive capacities can reasonably cope with. In the boom years of 1973-74, for example, most of the tanker tonnage ordered then started arriving in 1975-76 long after the initial momentum which brought about the orders in the first place had disappeared. Delayed reactions due to speculative actions and expectations on the part of shipowners can all contribute to a slow response in supply during periods of rising and falling prices. Therefore, the slowness in response of supply will cause freight rates to rise significantly, and, conversely, at the new equilibrium level of O_c where supply is inelastic any fall in demand will leave the market heavily over-tonnaged

Figure 4.2 The effects of changes in demand and supply on freight rates in the short run



Note: An alternative presentation of the supply curve can be seen in Lorange and Norman (eds.) (1973).

and consequently result in a big drop in rates in the short term.

It is important to state at this juncture that whilst at any point in time supply of shipping tonnage tends to be inelastic, demand, on the other hand, is capable of varying in either direction at any time due to the exogenous nature of its determining factors. Equally notable is the fact that the spread of the effects of variations in the demand/supply balance is rarely uniform over all types and sizes of ships, and all sectors of the shipping freight markets.

4.2 The charter markets: their morphology

For the purpose of this study it is important to discuss the nature of the markets in which bulk tonnage is bought and sold. (See Appendix C.1 for definitions of types of charter.) This requires answering the question as to whether the bulk carrier and tanker freight markets are competitive markets. In doing this it may be necessary first to state what perfect competition is. Perfect competition is generally taken to mean a market structure in which there is a large number of firms in the industry selling identical products; and into which entry by new firms and exit by existing ones are unhindered with consumers having a perfect knowledge of the entire market structure and firms being only price takers.

Judging by the criteria laid down by the theory of competition, the dry bulk and tanker freight markets approximate well to the theory of perfect competition. Koopmans (1939) in his classical work on the tanker industry confirms this statement by noting that: "The study of the causation of the fluctuations in tanker rates of freight may be considered largely as a special case of the study of price formation in a market where pure competition prevails on both sides."

It is not, however, apparent that the demand side of the tanker market in which the oil companies constitute a large majority is in accord with the theory of perfect competition; as the situation on the demand side could be regarded as oligopsonistic even though in practice it appears to be as competitive as the dry cargo market. Agreeing with

this observation Koopmans makes the point that this situation notwithstanding, the concept of a demand curve as expounded under the theory of competition is still applicable providing that these large charterers cannot or do not make use of such power as they might exercise over the market rates by withdrawing from the market. As mentioned in section 4.1 above, the oil companies are under contract obligations to supply oil and to meet this commitments they must depend to a degree on the charter market to augment their tonnage. A withdrawal therefore is a remote possibility especially as they own only 35-40% of the tanker fleet and no one oil company owns more than 5% of the fleet - the seven majors (BP, EXXON, Mobil, Shell, SOCAL, Gulf and Texaco) own only 16.11% of the fleet (July, 1985); individually owning between 1.4-4.8% of the total fleet.

Furthermore, the demand for oil and its products is outside the control of the oil companies and is influenced, apart from the price, by such 'demand factors' as cyclical factors, such as general business activity and the way it influences the oil requirements of various industries; seasonal factors (ie. winter and summer in the northern hemisphere) and incidental factors such as the Yom Kipur War of 1973 and the British coal strikes of 1984/85. Therefore, it is thought that: "the aggregate activity of charterers, considered in its aspects relevant to the mechanism of the formation of freight rates, hardly differs from what it would be if they acted under conditions of perfect competition." (Koopmans, ibid).

Moreover, recent advances in economic theory in the field of contestable markets (Baumol et. al. 1982), suggest that traditional fears of inherent market instability or monopoly exploitation in conditions where economies of scale are predominant are unfounded if appropriate policies regarding market entry exist.

Zannetos (op. cit.) in his theoretical expose of the tanker industry was also faced with the question of whether or not the tanker industry can be described as competitive. In his extensive treatment of this question, he concluded that although logic and the ownership composition of the tanker tonnage may imply oligopolistic powers, "the tankship markets operate more like perfectly competitive markets." One of the pertinent reasons for this conclusion is the fact that he agrees that the major oil companies cannot be feasibly self-sufficient in transportation because of the imbalance in oil producing and refining capacities and hence their dependence on the spot market. It is further noted

that because the ship is the firm in most cases, capital is mobile and this mobility makes for a more competitive international market as it tends to equalise rates by balancing supply and demand.

The dry bulk industry also operates under conditions similar to the theoretical perfect competition. Here there is a large number of small firms owning vessels which produce more or less homogenous services. Since there is virtually no monopolisation of ownership by established firms, access to the industry is easy. Exit is also unhindered as the shipowner can always decide when to leave the market by either selling his ship, laying it up or transferring to another trade; barring any long-term commitments. Thus there is no doubt that the "tramp industry is an industry that has a market which functions under conditions that are not dissimilar to the theoretical model of perfect competition." (Metaxas, 1971); a fact shared by the shipping industry, for example Gripois (1956), Thorburn (1960), Sturmey (1965) and Bennathan and Walters (1969). The fact must be noted that even though in practice, the dry bulk freight market really does operate under conditions of perfect competition, it is also characterised, albeit to a lesser extent than the tanker sector, by cargo interest involvement in shipping, particularly by the steel industry - see for example, Drewry (1978a and 1978b), and UNCTAD (1980).

Having made this point, the fact can not be denied that the open market is indispensable. This is so, as we shall see soon, because occasions arise when it becomes absolutely necessary to have recourse to the spot market to possibly charter-in additional tonnage to cope with an upturn in demand or, conversely, to seek employment for surplus tonnage in times of low demand.

4.2.1 The short-term charter market

The two most important classifications of the bulk freight markets are the short-term and long-term markets. The short-term market which is very often referred to as the 'spot' or 'open market' serves as the interface between vessel supply by shipowners and vessel demand by charterers. It can be appropriately described as the barometer

or main indicator of changing conditions in the bulk shipping industry and thus the world economy.

The main services of this market are two-fold: first, the provision of shipping space at short notice to carry specified cargo from one or more ports to named destinations and second, to offer for hire vessels for single voyages on short-term ranging from a voyage, trip, voyage to a series of voyages - see appendix C.1 for the definition of types of charter. By so doing it performs three important functions viz: to cater for charterers who are unable to own ships or to hire them on long-term charters and whose needs cannot be effectively served by the liner sector; secondly, it provides tonnage both for cargoes not suited to long-term freighting arrangements and for the marginal needs of the oil companies and those integrated industries (ie. the steel industry) that handle their own transportation. Thirdly, the market provides a reserve of ships which the liner companies draw on from time to time to augment their needs.

It is obvious from what has just been said that the short-term market embraces all short-term charters from single voyage charters, trip charters to consecutive voyage charters. What is not so obvious is the fact that since short term chartering is usually a response to ad hoc requirements for tonnage or the result of sudden needs to meet short-term peaks or conversely, an outlet for redundant tonnage (for example, in times of recession, oil companies let in the spot market tankers that are surplus to their needs; when times are good they enter the market to charter tonnage to meet their marginal requirements or unexpected short falls in capacity), it represents only a small proportion of total world seaborne trade in both the tanker and dry bulk sectors - in the mid-1970's the respective proportions were 16-17% and 6-9% (Drewry, 1978b, 1980).

The mechanics of rate-fixing is done by a process of bargaining by brokers representing shipowners and prospective charterers. At any moment of time the open market is comprised of the aggregate of tramp shipowners looking for employment for their ships and charterers requiring

dry bulk services for a limited period of time. The groups are brought together by brokers through the medium of shipping exchanges all over the world (ie. the Baltic Exchange of London which is the most important - see Maugham (1931) and Davenport (1954)).

The primary function of the brokers is to marry the right ship to the right cargo. This they achieve by seeking out the appropriate tonnage suitable for the carriage of the type of cargo on offer for transportation. The interest of a broker in this exercise would lie in securing a better deal for his client, depending on whether he is working for the shipowner or the charterer. When the appropriate vessel has been identified for the intended charter, a freight rate is agreed upon after a process of bargaining.

The rate fixing process in the tanker market is the same as that which obtains in the dry bulk market, except that instead of trading oil tanker services in a shipping exchange, charters are usually conducted through the offices of brokers mainly in London and New York. Tanker chartering for grain cargoes is, however, conducted in the customary manner at the shipping exchanges. Tanker owners normally register their current and future availability of tonnage with brokers, and on the demand side the oil companies and others involved in the oil trade also register their needs with brokers. In much the same manner as for the shipping exchanges, the brokers by means of telephone try to match the right vessel to the appropriate demand. For their services a brokerage, which is usually a percentage based on the freight rate, is paid.

Naturally, the shipowner or his broker would try to obtain a rate sufficient ~~enough~~ to cover his costs of operation and the charterer or his broker would tend to bargain for rates cheap enough for his purposes. In the final analysis, the agreed rate would tend to depend on the state of the freight market and the particularities of the individual charter. During excess demand for tonnage the shipowner expects to obtain a rate above his full costs, but in times of surplus tonnage and hence depressed rates he may decide to take a charter at rates below his

unit operating cost if he is able to cover his marginal or voyage costs. His refusal rate will be determined by his cost of operation since an owner will not charter out any ship at less than its lay-up rate, except in exceptional cases. These circumstances would decide in whose favour the agreed freight rate is tilted. The charter is 'fixed' once a compromise is reached by the two sides. The rate so fixed will be determined not only by the state of the market but also by other factors as the next section shows.

4.2.1(1) Factors determining freight rates in the short-term

Short-term charter rates are subject to great fluctuations. The reason for these fluctuations is primarily caused by the fact that the level of the freight rate ruling in the market at any one time is given by the intersection of the short term demand and supply curves. Since demand is subject to sharp and often unpredictable fluctuations, the bulk freight market is often out of balance, and hence subject to incessant fluctuations. For reasons which will be discussed in the next section, the long-term rate tends to fluctuate less violently than the short-term rates.

The most important determinants of short-term demand and thus of short-term rates are seasonal factors (ie. the seasonality of certain trades, eg. grain and other agricultural trades, the yield of harvests/crop failures and climatic conditions), industrial expansion or contraction, the development of new export or import commodities, political events such as wars (ie. the Korean War, the Suez crisis and the Yom Kipur War which brought about the 1973 boom, the present Iran-Iraq war), threats of war and international and regional sanctions, and natural disasters. In addition to these external factors, each charter rate is also determined by its own particularities such as the type and volume of cargo to be shipped, the distance of haul, the trade route, and the terms of the charter-party.

This means that a charter fixed for the same type of commodity and the same vessel size may vary because of the idiosyncracies of individual

charters. As an example, the rate per ton for a vessel of 20,000 dwt on a voyage charter will be higher if only half its capacity is to be utilised than if its entire capacity is to be loaded, since the shipowner will naturally be interested in covering the full cost of the voyage in other words he is interested in the overall return on his vessel. Since the owner also bears the cost of the voyage, particularly fuel costs, the charter rate will also be distance-related. The trade route also plays a role to the extent of how well-equipped designated ports of loading and discharge are in terms of catering for the type of vessel in question. Also the security of the trade route is important, the more hazardous the risk of trading into certain ports, the higher the rates for such routes will tend to be, ie. the recent danger to shipping posed by fighting in the Strait of Hormuz between Iran and Iraq. Under normal conditions, everything remaining equal, it is normal for spot rates in the tanker sector to rise in winter months in the northern hemisphere, when demand for fuel rises by about 10% over consumption in the summer, and fall in summer (UNCTAD, op.cit). Also the demand for coal tends to rise in the winter months.

In the tanker market the type of commodity to be carried also determines the individual freight rates. Here tankers carrying 'clean' petroleum products (product tankers) usually enjoy higher freight rates than vessels of similar specifications carrying 'dirty' (crude oil) cargo, as we shall see in chapter 8. This feature of the market suggests that there are sub-markets within the tanker freight market. While this is true, the divisions are not watertight because vessels of different sizes are substitutable (for example see Strandenes, 1981), and hence there is substitution between trades.

There are five reasons why petroleum products command a freight premium over comparable vessels in the crude trade (UNCTAD, op. cit). First, clean petroleum products are heterogenous in nature, and therefore, require separation into different tanks and the use of different pumps to avoid mixing, entailing additional costs in terms of crew time, ship's equipment and considerable delays in loading and discharging.

Secondly, clean oils are generally more corrosive than crude oil and therefore require expensive tank coatings in respect of certain products. Thus the method of carrying, handling and managing the distribution of petroleum products is much more complex than that of crude oil. Thirdly, all this means that the surveys for tankers carrying clean products are more costly. Fourthly, because of their high value, clean oils must be carried in clean tanks free of traces of crude oil or water in order to avoid contamination, especially if the previous cargo was crude oil. This cleaning exercise entails more cost to the shipowner. Finally, because of the restructuring of the oil trade in which refineries are located close to consumption areas, demand for clean product tonnage comes mainly from where consumption is insufficient to justify the installation of a refinery. For this reason and that of storage problems, clean products are transported in handy-sized tankers (20-35,000 dwt ships) which have relatively higher costs per ton of cargo carried.

One further factor which was touched upon previously but needs some further treatment here because of its importance as a determinant, is buyer and seller expectations about the future movement of current prices. Expectation is a psychological factor which underlines the degree of optimism or pessimism exhibited by the people who operate in the spot market - charterers, shipowners and brokers. In a period of gently rising rates, charterers, through expectations, may become uneasy about securing suitable tonnage to safeguard their future transportation needs. This feeling may induce them to undertake consecutive charters or increase the number of short-term charters and thence long-term charters. Such a trend once started tends to snowball as more and more charterers, especially the big charterers who require a large and regular tonnage, enter the market fearful that the actions of others might affect their chances of securing tonnage to meet their own requirements. This panic chartering will have the effect of pushing up rates higher than should have been reached in the first place. Conversely, when some shipowners sense that the period of high rates is over, they may also get worried about their ability to obtain a remunerative rate in future, and on this score, may decide to fix their ships for rates

below the current rate. They are able to gauge the market rightly in most cases because they know from experience that periods of boom in shipping are more short-lived than periods of slump. For example, Hawdon (1978) in his study of tanker rates found that the average length of a peak period over a study period of 24 years, 1950-1973, was 1.8 years and that of a trough period 3.75 years. Other owners uncertain about their own future employment may hasten the fall in rates by undercutting their predecessors. Once a downward trend is noticeable, the big charterers like the oil companies and the big grain charterers (ie. Cargill/Tradax, Bunge, Continental, Louis Drefus and Garnac who account for over 50% of grain charters each year) tend to delay their chartering temporarily with a view to further weakening the rates and thereby demoralising shipowners. However, the rate in the market will not fall below the lay-up rate of the lowest cost vessel since theoretically the minimum freight rate in the short-term is that at which the lowest-cost vessel will lay-up instead of operating.

In summary, it is notable that the short-term freight rate in a period of high demand is determined by demand which in turn is determined and influenced by extraneous and other factors internal to the working of the spot market. In periods of surplus tonnage, it is the elasticity of supply which determines the ruling and minimum rates. This elasticity of supply is dependent on the range of voyage and operating costs of the world fleet because charter rates in times of excess capacity are determined by the costs (voyage and operating) of marginal vessels (most expensive vessels) and the minimum rate determined by the costs of the cheapest vessels.

4.2.2 The long-term charter market

In appendix C.1, we defined the short-term market in the context of charters having a timespan ranging from a single voyage or trip to a series of voyages. For the purpose of this study, any charter exceeding this duration is hereby described as a long-term charter. By this definition, time-charters, contracts of affreightment and bareboat charters defined in appendix C.1 are long-term charters. From the

nature of these charters it should be borne in mind that the period market covers charters of different timespan covering short, medium and long-term charters. Long-term charters are, in the main, concluded privately and do not pass through shipping exchanges. Nevertheless, prospective charterers and shipowners are free to use the expertise of members of the shipping exchange in concluding contracts.

It may be asked: why may a time charter be preferred to a short-term charter? There is no one answer to this question because there are a number of reasons that may confront a prospective charterer or shipowner in deciding whether to have a short-term or long-term contract. These reasons will depend on the circumstances of both parties, ie. their expectations vis a vis the state of the freight market in future, their commitments by way of contracts and the type of commodity for which tonnage is sought since certain commodities, eg. gas, iron ore, etc. - are more suited to long-term arrangements because of their dependence on specialised vessels.

Whatever may be the reasons for choosing a long-term charter, there are certain advantages to be gained by both charterer and shipowner in long-term charters; the foremost of which is the security and stability which they offer to both parties. The shipowner by accepting a time-charter, builds a hedge against fluctuations of rates and thus of income, whilst the charterer is assured of meeting his long-term shipping requirements. By so doing, the shipowner foregoes the opportunity of making high profits if and when a boom occurs and equally insulates himself from losses if and when a slump occurs. Whilst, on the other hand, the charterer enjoys stable rates throughout the duration of the charter by foregoing the possibility of acquiring cheap tonnage in times of depressed rates in order to obviate paying higher rates in times of boom.

Generally, the average shipowner tends to be interested in long-term charters when freight rates are high, for the simple reason that a long-term charter contracted at a sufficiently high rate provides the

owner security for the 'rainy days', as it were. This was the case in 1973 when almost 50% of tonnage was engaged for periods longer than twelve months. A situation which is in contrast with the present situation in which the bulk of tonnage is fixed for less than one year because of low freight rates which make long-term commitments progressively less economical for owners.

In addition to the security of employment for vessels, a long-term contract is administratively more simple and cheaper for both the charterer and the owner. It saves time and money spent on frequent decision making regarding short-term charters. It not only saves both the owner and the charterer the cost of brokerage fees which would have had to be paid under a spot market charter, but also saves the owner the managerial cost of bearing the voyage costs. As will be seen in the next chapter, there are administrative economies relating to fleet operations, so that any given management structure can effectively manage a fleet of ships operating under a time-charter in a relatively less costly manner. A further advantage to the shipowner is the loan value of a long-term contract, in the sense that it is mortgageable. Many independent owners follow this method of financing because it saves them the cost of interest. It is known that banks are not only more willing to accept long-term contracts as a form of collateral security for granting loans to shipowners, but also make concessions in the interest rates commensurate with the reduction in risks. Because of these advantages, the shipowner is usually prepared, under normal conditions, to accept a long-term rate that is lower than a spot rate in times of high demand for tonnage.

Despite the fact that long-term charters are privately negotiated rather than fixed through the open market, the spot and long-term markets are intimately related as expectations about the movement of spot market rates influence the long-term rate. For example, when spot market rates are rising, charterers fearing further rises will, under normal circumstances, often try to enter into longer duration charters than a single voyage. Shipowners in such a situation may do the opposite

by favouring single voyage charters in the hope that rates will continue to rise, except if they are less optimistic about the future. Whereas when rates are falling charterers may tend to postpone commiting themselves to long-term contracts in the expectation of securing more favourable terms in the future; whilst the shipowner will try to secure such charters before rates fall further. Therefore, the prevailing rate in the spot market influences the bargaining positions of the parties to a long-term contract. Expectations aside, there are other objective factors which influence the long-term rate, hence the next section.

4.2.2(1) Determinants of the long-term rate

Above it was pointed out that a long-term charter has differing life-span ranging from short, medium to long-duration charters. This characterisation is relevant here because according to Zannetos (op. cit) there are ten most important determinants of the long-term rate in the short run; namely: 1) the short term rate prevalent in the spot market at the moment of charter; 2) future expectations engendered by short term rates; 3) the volume of laid-up tonnage at time of charter; 4) the level of outstanding orders for new buildings; 5) the size of the vessel to be chartered; 6) the type of propulsion system (whether diesel or steam turbine); 7) the duration of the charter; 8) the lead time between the charter agreement and the actual delivery of the vessel; 9) the type of commodity, ie. clean (petroleum products) or 'dirty' (crude oil); and 10) the type of currency in which payment is to be made.

The influence of the short-term rate on the long-term rate has already been mentioned above, it is necessary to add to what has so far been said in this respect that under normal conditions (that is everything being equal), the long-term rate is expected to move in the same direction as the underlying short-term rate, but will not be subject to the same erratic fluctuations of the short-term rate. Generally, the long-term rate may be expected to be lower than the short-term rate in times of high freight rates and higher during periods of depressed market conditions.

One of the reasons why the long-term rate is expected to be lower than the spot market rate in addition to the advantages of long-term charter discussed earlier, is that the spot rate is expected to be sufficiently higher than long-term rates in order to compensate speculators in the market for the risk of unemployment inherent in the spot market. The premium of the spot rate over the long-term rate must also be sufficient ~~enough~~ to attract marginal speculators and high-cost vessels to stay in the market and to induce those in lay-up to join the market. Buyer and seller expectations also determine the long-term rate, since logically if a charterer expects current short-term rates to rise further in future, he will expect long-term rates to follow suit. Therefore, his reaction towards a long-term charter will be conditioned by expectations induced by current short-term rates.

The volume of laid-up tonnage at any given time is part of the available supply of tonnage and thus the greater this volume of reserve, the lower the long-term rates since any improvement in demand is dampened by the existence of large inactive tonnage which can re-enter the market at relative short notice. Orders for new buildings are mainly determined by spot rates but because of the lead time between ordering and delivery, most orders arrive in the market after their initial momentum had worn out. The effect of this seeming lack of synchronisation is that outstanding orders are compatible with or are a feature of times of high and depressed rates. The impact of outstanding orders in periods of rising and falling rates is not uniform. When rates are rising, orders rise too, with outstanding orders at the given time having no adverse influence on the going long-term rate because of expectations prevailing in the market at the time. But in times of falling rates, with all the surpluses brought about by ordering in the preceding period, outstanding orders through expectations exert influence on long-term charters since prospective charterers' bargaining positions are strengthened. They can decide to buy or charter new tonnage not already fixed as cancellations could make some vessels redundant, therefore the charterers are in a better position to judge whether to charter or buy.

The economies of ship size will undoubtedly have an impact on long-term rates and so also will the duration of the charter. The lag between the signing of a charter agreement and when the ship is actually delivered can sometimes cover the period it takes to order and build a new vessel and some agreements may require prompt delivery, so the time it takes to actually make the vessel available to the charterer will also account for the variations in rates. The system of propulsion will also cause variations in rates since, as will be seen in the next chapter, turbine engines consume far more fuel than diesel engines. The prospective charterer, since he will be responsible for fuel costs, will therefore reflect his choice through the rate he is prepared to pay. Variables 5-9 form the basis of the empirical freight rate analysis of chapter 8. The dollar is the unit of account in international shipping and its fluctuation vis a vis any other currency in which a charter agreement is reached will have an impact on the shipowner's revenue and therefore on his choice of an acceptable rate.

In general, the long-term rates tend to be cost-based. This is so because the owner-operators such as the oil companies and the other dry bulk cargo-interest shippers, as owners of tonnage, are able to calculate with fair accuracy the operating costs and profits which can accrue to independent operators at any particular rate. Since these owner/operators have the option of building their own tonnage instead of hiring tonnage on long-term basis (excepting requirements for prompt delivery), they would not offer terms that make time-chartering more expensive than owning the ship, especially, as mentioned above, in view of the fact that the lag between an agreement and the delivery of vessel can be enough to order and build a new vessel.

It follows from this reasoning that although in the short-term the idiosyncracies of the market make it difficult to relate freight rates to real trading costs; it is possible for the shipowner to continue to operate in the market if he is only covering his marginal or voyage costs or in the medium term operating and voyage costs - since capital cost will be incurred whether or not the ship is operating - this

situation cannot be tolerated over an extended period of time, therefore, in the long-term the owner will aim to cover his total costs (capital and operating) if he is to remain competitive.

In section 4.1 it was stated that there is a general consensus amongst shipping economists of the relationship between cost and freight rates in the bulk shipping market. In this regard Zannetos (op. cit) notes that there is sufficient "evidence that only cost can serve as a guidepost in the long-term markets, as we have been claiming all along for several other reasons." To summarise what has been discussed up to this point it is pertinent to quote Sturmey (1965) who states that "the level of freight rates at any one time depends on three factors, namely, the volume of cargo to be carried, the volume of tonnage and the cost structure of the world's tramp fleet." Since the level of rates at any given time, both in the short and long-terms, is a function of demand, supply and the cost structure of the world fleet, it is important to define and analyse the different components of shipping costs, thus the definitions of the main elements of shipping costs in appendix C.2 as a prelude to the next chapter.

CHAPTER 5

OPERATING COST ANALYSES

"Economic considerations (primarily operating costs) explain why American ... shipowners have had to resort to these registries (open registries) in order to remain internationally competitive."
Federation of American Controlled Shipping (1976)

The purpose of this chapter, having defined the different components of operating costs above, is to statistically estimate the operating costs of ships of varying sizes operating under open and traditional maritime registries; with the primary aim of analysing the cost differentials associated with ships of the two registries and to, thereby, provide evidence of their respective operating cost structures as a prelude to the more detailed and rigorous cost analyses of Chapter 7.

The methodology employed in this chapter is similar to that used by Metaxas and Doganis (op. cit.) in their pioneering study of the cost differentials between open and regulated registries. Their data however, was very limited and did not allow them to distinguish tankers and bulk carriers. For the same reason, the calibration of the model for individual operating cost components could not be done and different cost components such as stores and provisions and administration costs were aggregated and the bulk carrier data used to simulate tanker costs. Their study also did not consider the likely influence of age on operating cost elements. Neither were the levels of reliability of the parameters of their regression equations reported - ie. t-ratios or standard errors.

In this chapter, the model tests the effect of vessel age on all the main component elements of ship operating costs with each specification specifying a stochastic disturbance term.* The chapter covers a review

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* unspecified by Metaxas and Doganis

of cost estimation methods; the data and its treatment; the results and their statistical validation plus the empirical implications for the cost differences between open (OR) and traditional (TC) registries.

5.1 Review of Operating Cost Estimating Methods

Many of the limited cost studies in shipping have centred around the fundamental relationship of ship size and unit costs, in other words 'economies of ship size', meaning that ship costs per unit of carrying capacity decline with increases in the size of a given ship. This relationship holds for all types of ships and both for capital and operating costs. Whilst the dominance of capital cost in a ship's total cost may tend to suggest that size economies due to capital costs are higher than for operating costs, the reverse is true. Jansson and Shneerson (1978) in their analysis of scale economies for general cargo ships found that the size elasticity of capital cost for all vessel types lies between 0.6 and 0.7, and that of operating costs between 0.3 and 0.6. A result confirmed by every ship cost study they examined.

Studies have also found that the manning component is the single most important source of size economies of operating costs (see for

example, Erichsen, 1971; Zannetos, p. 236). Manning economies derive from the simple fact that no matter how big a car may be, it does not require more than one driver, hence the number of crew required to man a 200,000 dwt very large crude carrier (VLCC) will be approximately the same required for a tanker twice its size. Cost studies on the bulk sector by Thorburn (1960), Heaver (1968), Goss and Jones (1971), Kendal (1972) and Benford (1967) were all based on this principle of economies of size.

An essential criticism of these studies is that they were all focused on the issue of ship size and costs without attempting to relate variations in cost to some causal factors. For instance, it can be argued that operating costs tend to exhibit a linear relationship with age, ie. insurance cost for a new vessel will tend to be higher than for an older one, everything being equal, and so will repair and maintenance costs be expected to be affected by vessel age. They therefore fail to explain sufficiently the reasons for cost variations aside from the differences in size. This shortcoming might have been due to the difficulty of obtaining cost data at the time the studies were undertaken, a fact acknowledged by all the studies. Generally, this data problem still persists today as published cost information do not carry enough detail as to the characteristics of reported cost data.

The other shortcoming is that these studies do not show the influence of a ship's registry on its costs. As we have seen in appendix C-2, this can have a considerable direct and indirect impact on operating costs. Cost data were generally drawn from one or two European countries. With the redistribution of the structure of the world ship ownership caused primarily by cost pressures against a background of poor freight markets since the 1970's, it is of utmost significance not only to show the economies of scale but to relate such economies to the cost structure of the world fleet according to flag of registry, in order to identify the cause-and-effect relationships underlying the changing pattern of world fleet ownership.

Even though published cost data by shipping consultants such as Drewry

of London, provide cost information covering different flag groupings, ie. open and traditional registries, the data are average cost estimates of the different cost components relating to a wide range of vessel sizes lumped into a class of, say, ±25,000 dwt, for example. The technical and operating characteristics of the vessels are not usually given, ie. type of engine, age, number of crew and type of employment. Neither do they nor the studies mentioned earlier treat factor substitution possibilities and factor demand elasticiites as likely causes of variations in costs. These factors are all taken into account in this thesis.

In general, there are three commonly used methods of calculating shipping costs: the daily cost per ton, cost per ton-mile and voyage cost.

(a) Daily cost per ton

This is the simplest approach and one that is most commonly used in marine studies. By this method, the capital cost, or purchase price, of the ship is converted into an annual capital repayment charge, annualised at a chosen discount rate reflecting the opportunity cost of capital over the ship's economic life. To this annual capital charge is added annual total operating cost and the sum divided by the number of days per year a ship is in operation after allowing for 'off-hire' periods of usually 15 days in the year. The daily costs so derived are then reduced to unit costs by relating them to ship sizes and can then be used to compare a range of ships. The procedure is summarised in equation 5.1.

$$D_c = \frac{\left[\dfrac{C_o}{\dfrac{1-(1+r)^{-n}}{r}}\right] + C_p}{O_d} \qquad (5.1)$$

where: D_c = daily costs per ton

C_o = ship's initial capital cost

C_p = ship's total operating cost

r = discount rate

n = life of the ship

O_d = assumed effective trading period (days) per year. 365 - off hire days.

Equation 5.1 represents the opportunity cost of ship's time as propounded by Goss et al. (1972). Unit cost derived from this method is called a 'shadow price' and defined as "that level of 'price' (in our case freight rate) at which the discounted revenue, for a given level of output, is exactly equal to the discounted cash operating costs plus the capital costs". It is in other words known as the long-term equilibrium revenue level which yields an internal rate of return (irr) equal to the opportunity cost of capital. This concept of shadow price is different from that of the 'required freight rate' proposed by Benford (ibid.) which is merely an average cost. Goss (1968a) contends that unit costs derived on the basis of equation 5.1 is not an average cost in the ordinary sense of the expression because whilst average total costs assume that output and cost levels are capable of being static over the life of the ship, a shadow price can account for variations in cost levels of output over the life of the ship, ie. cost levels rising and output levels falling as the ship gets older.

Such variations can be incorporated in equation 5.1 as:

$$\frac{W_i \left[\dfrac{1-\left(\frac{1+g}{1+r}\right)^n}{r-g}\right]}{\dfrac{1-(1+r)^{-n}}{r}} = \frac{W_i \left[r-r\left(\frac{1+g}{1+r}\right)^n\right]}{(r-g)\left[1-(1+r)^{-n}\right]} \qquad (5.2)$$

Equation (5.1) will then read:

$$\frac{\dfrac{W_i \left[r-r\left(\frac{1+g}{1+r}\right)^n\right]}{(r-g)\left[1-(1+r)^{-n}\right]} + C_{P-i} + \left[\dfrac{C_o}{\dfrac{1-(1+r)^{-n}}{r}}\right]}{O_d} \qquad (5.3)$$

where: W_i = the ith component of operating costs

C_{P-i} = operating costs less the ith component

g = the rate at which W_i grows over the life of the vessel in real terms

r = the same rate of discount as for capital

Values so derived either from equation (5.1 or 5.3) can be used in deciding the profitability of a long-term time charter since it represents the long-run opportunity cost of capital and hence the required revenue per ton of vessel size covering all the expenditures borne by the shipowner plus interest on equity. The emphasis is on the economies of ship size as the main determinant of unit costs.

(b) The cost per-ton mile

Total costs per ton are made up of two separate parts, costs per ton at sea and cost per ton in port. The former takes account of differences in fuel costs associated with different speeds and so compares transport costs over a given distance, in contrast to costs over a given time as per the cost per ton method. Basically, the estimation procedures are the same except that the latter includes the cost of fuel at sea and instead of spreading total costs over the ship's size or its cargo carryings, they are spread over the product of vessel size or cargo-carrying capacity and the distance covered by the voyage. This method provides a basis for comparing the different combinations of size and speed and finding the pair with the least marine sector costs (for example, see Gilman, 1980).

The usefulness of this formulation lies in the importance the fuel cost element has assumed in vessel operating costs in recent years making greater emphasis on the variations of cost with speed and fuel consumption more desirable. On this score, the approach is more relevant to the general cargo sector where there is a wide range of speed (eg. 15-33 knots) amongst vessels of different sizes even though speed does not necessarily increase pro rata with ship size. In the bulk trades there is very little speed variation with size, therefore this method will tend to give the same result as the cost per ton approach. For example, in the bulk trades whilst ship speed maintains a narrow range of variation of between 14 and 16 knots, ship sizes vary widely from, say, 5,000 to well over 400,000 dwt, therefore its usefulness in this sector is limited. Whilst this method may be useful to an owner considering a voyage charter, distance related costs as noted above are not relevant in time charters.

Cost comparison in terms of ton-miles have not been as widely used in marine transport as in other sectors of transport, ie. air and land, because it does not incorporate time spent in port into its calculations. Prior to the emergence of unitised transport, ship's time in port constituted a large proportion of round voyage time with attendant high cargo-handling costs. This factor reduced the importance of distance and diminished the meaningfulness of the concept in shipping. Flott et al. (1976) in a detailed critique of the concept argue that perhaps its greatest shortcoming as a tool for general analytical purposes is that "it is not a homogenous unit"; a view supported by Jansson and Shneerson (ibid.). It also does not take account of increases in transport capacity brought about by increases in speed (Ryder and Chappell, 1979).

(c) Total cost per voyage/ton

Whereas the above methods are concerned solely with marine transport costs (ie. the cost of actually transporting the cargo by sea), the voyage cost approach aggregates sea transport and port costs for a given ship size and over a given voyage distance and expresses them per unit of carrying capacity. It can be estimated as an economic cost based on any desired capital and operating characteristics plus port characteristics for a round voyage or on some other basis. Three alternative approaches are considered here:

(i) The cost of ship's time at sea is calculated according to equation 5.1 and to this is added the cost of fuel at sea and in port for auxiliaries, etc. and expressed per unit of cargo capacity.

(ii) Adding port costs incurred both by the ship and cargo to (i) and expressing total costs per unit of effective cargo carrying capacity.

(iii) Adding other cargo costs such as storage and inventory costs to (i) and (ii).

The first is the most commonly used and the second sometimes assumed to be constant because of the differences in port charges between countries, for example see Goss (1971). In bulk trades because of the trading

pattern it is necessary to allow for one leg of a voyage in ballast; and multilateral trading, which will tend to increase ballast journeys, can also be incorporated in this method by taking such ballast legs into account as demonstrated by Goss (ibid.). The third alternative is more suitable to liner trades. Generally, estimation of voyage costs on a round voyage basis is simpler for the liner sector with fixed itineraries than the bulk sector. But the voyage costing method is very appropriate for estimating the profitability of a voyage charter and less so for time charters. See Packard (1979) for practical methods in voyage cost estimation.

It is noted that port time or cost does not necessarily affect the relative economics of the various combinations of size and speed (Ryder and Chappell, ibid.). In the bulk sector therefore owing to the relatively lesser importance of speed, port time may be assumed constant for all vessel sizes because economies of size in capital and operating costs are the dominant factors in determining optimum vessel output and therefore a better basis for ship cost comparisons.

Heaver (1985, op. cit.) has argued that there is no 'true cost' in the sense of a single cost and that the relevant cost is always dependent on the purpose of the costing and therefore, in costing, the end justifies the means. He went on to elucidate the point by adding that it follows that costing cannot be undertaken without an explicit purpose, hence "since there are many purposes for which it may be desirable to know the cost of a shipping service, various methods of costing and levels of cost can and should co-exist." Therefore, although the cost per ton method (and that of the cost per ton-mile) implicitly assumes two important factors - unrestricted cargo availability and the unimportance of port time in deciding the relative competitive advantages of different ship sizes - it is the method used for the purpose of this chapter which is addressed to shipowner's cost under a time-charter arrangement. The question of cargo availability is thus irrelevant since no prudent charterer will consider a long-term charter without adequate cargo commitments and so are port costs.

5.2 The Data and Estimation Procedures

The data

The basic operating cost data for this study was obtained from an operating cost survey carried out between September 1983 and March 1984. The survey took the form of a questionnaire (see Appendix D.1) which covered ship characteristics, trading characteristics, manning characteristics, and annual operating costs. Questionnaires were sent to 232 shipowners and ship management companies in Western Europe, the U.S. and the Far East - Hong Kong and Japan. Because of the secrecy surrounding shipping costs and the apprehension of shipping companies about being identified, we did not receive as much data as would have been possible under normal circumstances.

However, sufficient data was realised from the survey to enable the study to be carried out. Total data from the survey covered 87 bulk carriers and 37 tankers, giving a total of 124 ships. To augment these figures, published data was derived mainly from Drewry publications (1982, 1983a and 1984). Data from these sources brought the total to 147 vessels - 100 bulk carriers and 47 tankers. The breakdown of the total in each vessel category according to the two main flag groupings and their characteristics are given in table 5.1 below.

It is noteworthy that the traditional maritime countries' (TC) data set contains 5 Greek ships in the bulk carrier set and 3 U.S. ships in the tanker set. Although some studies (ie. Metaxas and Doganis, op. cit.) have preferred to treat Greek ships as flag of convenience ships, this approach is not pursued here. The total bulk carrier set also contained 4 ships from developing countries; these were excluded from the analysis.

The data was classified into six operating cost components - manning, repairs and maintenance, stores and provisions (including lubricating oils), insurance, administration and total operating costs as defined in Appendix C. For insurance costs only H & M and P & I costs are covered. The firstproblem encountered with the data was the problem of dealing with

Table 5.1 Data Characteristics

	Bulk Carriers		Tankers	
	Open registries	Traditional registries	Open registries	Traditional registries
No. of vessel	29	67	16	31
Average age	8.5	12.4	9.5	9.9 (9.4)*
Propulsion:				
diesel	29	67	8	20
turbine	0	0	8	11
Size distribution:				
under 25,000	(4) 13.8%	(14) 20.9%	(2) 12.5%	(2) 6.5%
25-49,999	(12)41.4%	(21) 31.3%	(2) 12.5%	(6)19.4%
50-79,999	(7) 24.1%	(19) 28.4%	(3) 18.8%	(10)32.3%
80-99,999	(0) -	(7) 10.4%	(1) 6.3%	(2) 6.5%
100,000+	(6) 20.7%	(6) 9.0%	(8) 50.0%	(11)35.5%
Average size	51,788	50,269	131,933dwt	106,028dwt
Average trading days	355	352	350	349.5
Average No. of crew	29	30	31	32

*Average age after excluding U.S. ships.
Notes: Figures in brackets are number of vessels.

data relating to different years as there are no operating cost indices for the shipping industry. This arose because some of the published data related to years before or after our base year of 1982.

This created a problem for standardising the data from published sources to reflect 1982 levels. To overcome this problem, weighted index numbers were constructed for all the six cost categories based on published average

cost figures by Drewry shipping consultants for the period 1973-82: Tankers, Drewry (1983a) and Bulk Carriers, Drewry (1984); see Appendix D.2 for the weighted indices. For tankers, cost figures for open registry operations and North European ships are given in 5 size categories as shown in the appendix. The relative proportions of the relevant cost element represented by the cost of each of the two groups in each size category were used as weights to derive the average weighted cost for the relevant size class.

As an example take the size class 20-39,999 for tankers in 1973 for the manning cost element. OR cost - $380,000 and TC cost = $660,000. The relative proportions are 0.37 (380/1040) and 0.63 (660/1040) respectively. Multiplying their respective costs by these weights give $140.6 and $415.8 correspondingly, hence a weighted average of $556,000 - the average of 558 shown in the Appendix and the others were calculated on the basis of four decimal places. These weighted cost figures provided the basis for the indices for both tankers and bulk carriers. The original tanker data from the Drewry source covered the period 1970-1981. To obtain cost figures for 1982 and later years, the annual growth rates for the different cost elements in the five size categories for the period 1973-1981, were used to arrive at 1982 and 1983 figures. The geometric average growth rate was used because it satisfies the time-reversal test which Fisher (1927) says satisfies the criterion for an ideal index number. This will enable 1982 costs to be deflated to earlier years should the need arise. The general form of reflation used was:

$$C_o \times \frac{I_i}{I_o}$$

where: C_o = cost in year of data

$\frac{I_i}{I_o}$ = ratio of index of cost in year i to the relevant data year

(Drewry (1983a, 1984).

Data was, as already stated, taken from these sources/to supplement the survey observations. In the case of tankers where costs are given in class intervals, the mid-points of such intervals were taken to represent

the average vessel size in the five classes. For bulk carriers, no classes are given but averages such as ±25,000 dwt; these sizes were taken as the best representatives of the costs associated with them.

As can be seen in the survey questionnaire, there are notes requesting shipowners to state whether reported cost figures for classification and survey and repair and maintenance are annual averages, costs incurred in the year of the data or costs representing provisions for continuous survey policy. For vessels reported to be on continuous survey and those for which annual provisions are made for special surveys, reported annual figures for classification and survey were included in repair and maintenance costs. But for those vessels for which classification and survey costs were incurred as due, only one-quarter of such costs was added to repair and maintenance costs in order to give a proper measure of annual costs and account for differences in management policies.

Estimation procedure

A difficulty which can be discerned from table 5.1 is how to compare ships of different sizes and age profile. To overcome this difficulty a functional form relating costs to ship size and age is necessary since our aim is to establish a common basis for comparing the costs of ships of varying sizes. After initial plotting of the cost data against vessel size, the best functional relationship came to be that expressed in terms of economies of size, ie. in terms of unit costs. Because of the curvilinear nature of the unit cost relationship with ship size, the regression form

$$Y = aX^{b}U \quad \text{was chosen} \qquad (5.4)$$

where: Y = cost per 1,000 dwt per ship per day (ie. $Y = \frac{Y}{X}$)

X = ship size per 1,000 dwt (dwt ÷ 1,000)

a = constant term

U = a stochastic error term with a mean equal to unity.

For computation purposes, this non-linear functional form can either be estimated directly or transformed into a log-linear relationship

by taking the logarithms of both sides of equation 5.4. A linear transformation was chosen, thus:

$$\log Y_i = \log a + b \log X_i + \log U_i \qquad (5.5)$$

Direct estimation of equation 5.5 is usually fraught with analytical difficulties as it makes the application of least squares regression techniques very problematic (Johnston, 1972). Hence the transformation of equation 5.4 and the application of least squares method to the estimation of equation 5.5 and the specification of an additive disturbance term.

5.3 Results and Statistical Validation of the Regression

The results of equation 5.5 are given in tables 5.2 and 5.3 for bulk carriers and tankers respectively. The level of variation explained by the manning regression for the total observation and the two flag data sets supports the fact that there are considerable economies of scale due to the crewing cost element of ship operations. It is convenient to discuss the regression results in terms of (a) the magnitude of the predicting coefficient b and the intercept a, (b) the standard error of estimate, (c) the statistical significance of the b coefficients and (d) the coefficients of determination or the measure of goodness of fit - R^2.

Table 5.2 shows that for the bulk carrier data set, manning, stores and provisions and total operating costs vary considerably with variations in size as the degree of variation for the three variables range from 76% to 90% with very significant t-ratios. For the remaining three cost variables of repairs and maintenance, administration and insurance, ship size only accounted for comparatively modest variations in costs with the insurance variable being the least affected by ship size variations. This is not unexpected. Goss (op. cit.) also found that of all the elements of operating cost, insurance cost is the least amenable to scale economies.

Comparing table 5.2 with table 5.3 for tankers, the results with regard to the crewing and total cost variables are similar in terms of their R^2s and magnitude of the values of the a and b coefficients, which are

Table 5.2 Bulk Carrier Regression Results of Operating Costs per 1,000 dwt on Ship Size

Dependent Variable	Total Observation	Open Registries	Traditional registries
Manning	$1685.81\ x^{-.912}$	$1224.15\ x^{-0.891}$	$1920.0\ x^{-0.808}$
	(42.12) (-19.26)	(24.49) (-11.49)	(53.62) (-24.00)
	R^2=0.80;s.e.0.3127	R^2=0.84;s.e.=0.2826	R^2=0.90;s.e.=0.2059
Repairs and Maintenance	$160.77\ x^{-0.544}$	$146.94\ x^{-0.574}$	$177.68\ x^{-0.543}$
	(13.94) (-5.62)	(10.76) (-4.67)	(10.55) (-4.17)
	R^2=0.26;s.e.=0.6219	R^2=0.48;s.e.=0.4401	R^2=0.23;s.e.=0.6848
Stores and Provisions	$134.29\ x^{-0.648}$	$117.92\ x^{-0.582}$	$135.64\ x^{-0.669}$
	(29.83) (-14.86)	(17.41) (-8.02)	(26.45) (-13.60)
	R^2=0.72;s.e.=0.2800	R^2=0.73;s.e.=0.2599	R^2=0.74;s.e.=0.2590
Insurance	$38.86\ x^{-0.393}$	$93.69\ x^{-0.540}$	$24.29\ x^{-0.313}$
	(9.16) (-3.70)	(11.15) (-5.00)	(6.07) (-2.24)
	R^2=0.14;s.e.=0.6820	R^2=0.56;s.e.=0.3861	R^2=0.08;s.e.=0.7348
Administration	$79.84\ x^{-0.612}$	$76.71\ x^{-0.545}$	$83.10\ x^{-0.654}$
	(11.09) (-5.83)	(10.55) (-5.00)	(8.17) (-4.55)
	R^2=0.28;s.e.=0.6747	R^2=0.51;s.e.=0.3905	R^2=0.26;s.e.=0.7557
Total Operating Costs	$2038.56\ x^{-0.768}$	$1540.71\ x^{-0.729}$	$2298.47\ x^{-0.782}$
	(62.58) (-23.64)	(40.26) (-15.08)	(55.69) (-21.07)
	R^2=0.85;s.e.=0.2167	R^2=0.89;s.e.=0.1783	R^2=0.87;s.e.=0.2039

Table 5.3 Tanker regression results of operating costs per 1,000 dwt on ship size

Dependent Variable	Total Observation	Open Registries	Traditional Registries	
Manning	$2465.13\ x^{-0.928}$	$1882.0\ x^{-0.896}$	$2670.0\ x^{-0.933}$	$1495.18\ x^{-0.824}$
	(23.68) (-12.34)	(22.55)(-12.09)	(16.46)(-8.40)	(22.10)(-10.92)
	$R^2 = 0.79$	$R^2 = 0.92$	$R^2 = 0.72$	$R^2 = 0.83$
Repairs and Maintenance	$742.48\ x^{-0.900}$	$1212.0\ x^{-1.09}$	$240.0\ x^{-0.571}$	$89.12\ x^{-0.363}$
	(7.09) (-4.11)	(4.63) (-3.17)	(4.75)(-2.04)	(4.17) (-1.42)
	$R^2 = 0.35$	$R^2 = 0.45$	$R^2 = 0.15$	$R^2 = 0.06$
Stores and Provisions	$295.89\ x^{-0.803}$	$788.0\ x^{-1.0}$	$137.0\ x^{-0.632}$	$142.59\ x^{-0.619}$
	(10.69) (-6.43)	(8.16) (-5.47)	(6.88) (-3.65)	(7.95)(-4.16)
	$R^2 = 0.57$	$R^2 = 0.75$	$R^2 = 0.41$	$R^2 = 0.52$
Insurance	$40.45\ x^{-0.376}$	$40.9\ x^{-0.405}$	$30.0\ x^{-0.285}$	$18.54\ x^{-0.202}$
	(5.71) (-2.51)	(3.70)(-1.90)	(3.67)(1.27)	(3.06)(-0.89)
	$R^2 = 0.16$	$R^2 = 0.22$	$R^2 = 0.33$	$R^2 = 0$
Administration	$1002.25\ x^{-1.12}$	$3134.0\ x^{-1.3}$	$620.0\ x^{-1.06}$	$445.86\ x^{-1.00}$
	(12.49)(-8.65)	(14.32)(-10.34)	(8.45)(-5.75)	(7.56) (-5.17)
	$R^2 = 0.71$	$R^2 = 0.91$	$R^2 = 0.64$	$R^2 = 0.63$
Total Operating Costs	$3983.83\ x^{-0.858}$	$4675.0\ x^{-0.914}$	$3328.0\ x^{-0.807}$	$1978.31\ x^{-0.708}$
	(30.54) (-14.36)	(26.33)(-13.68)	(22.74)(-10.00)	(31.48)(-13.16)
	$R^2 = 0.84$	$R^2 = 0.94$	$R^2 = 0.77$	$R^2 = 0.87$

also very significant statistically. There are, however, observable differences in the behaviour of the stores and provisions equation and that for administration costs. For stores and provisions, the explained variation by the equation has fallen in the case of tankers except for the open registry data. This is due to the virtual unimportance of lubricating oil for steam-turbine ships which comprise 50% of open registry ships and 35% of TC ships as against all diesel-engined ships for the bulk carrier data. Lubricating oils account for 30-50% of our stores and provisions cost for bulk carriers and as such will be expected to be correlated with size since larger engines consume more lubricants. This should have been the case for tankers with average vessel sizes of over 100,000 dwt (table 5.1) but as already noted in Appendix C, turbine ships seldom use lubricating oils. The high R^2 value of the OR data may be due to the relationship of stores and provisions to size rather than lubricating oil because this data set with an average vessel size of over 130,000 dwt contains the largest tankers in the observation (315,000 dwt is the largest size in the total sample).

The equation results for administration costs for tankers confirm the point made in Appendix C that this cost element is determined mainly by ship size. The 0.91 R^2 for the OR data set explains this fact. The performance of the insurance equation for tankers is worse than for the bulk carrier data. Because shipping costs are so interdependent, with one element influencing the expenditure on the other, size is not always the main cause of variations. Although the t-ratios for the insurance equation for bulk carriers are all significant, they are only significant for the pooled tanker data set and not for the OR and TC sets. This result is not surprising because it can be discerned from the factors outlined in Appendix C under insurance costs that these costs are more susceptible to exogenous factors than the other cost elements. In fact, ship size is an indirect determinant of insurance cost, since the influence of size is mainly in the way of determining hull values. Unfortunately, as equations 6.3 and 6.4 in the next chapter show, the influence of size in determining a ship's hull value can be trivial. In this case, it is practically zero, undoubtedly because of the depressed freight market conditions in 1982. For a new building, insurance will be expected

to correlate well with ship size as the cost of new buildings, although also influenced by freight market conditions, will be linearly related to size (see Ryder and Chappell, op. cit., for example).

The smallness of the standard errors of estimate suggests that the standard deviation of the observed Y values about the regression line is minimal. This is better illustrated by figures 5.1 and 5.2 for the **total** data sets in respect of total operating costs for bulk carriers and tankers respectively. As Heaver (1968) remarked, more reliance should be placed on the total cost equation since scale economies are better explained by the aggregate cost than its components because "the difficulty of estimating some individual expenditures ... and the wider variation in individual costs than the total operating costs made it expedient and sufficiently accurate to deal with total figures". Figures 5.1 and 5.2 underscore the validity of the functional form chosen. Since the penultimate aim is to establish the relationship between unit total cost and freight rates, the total operating cost differential is the most important in identifying the cost differences between ORs and TCs.

A supplementary equation was estimated to examine the influence of age on these cost elements, hence equation 5.6

$$Y_i = aX_1^b X_2^c U_i \qquad (5.6)$$

where: Y_i = cost of the ith cost component per 1,000 dwt per ship per day

X_1 = ship size per 1,000 dwt

X_2 = age

a and U_i = as in equatin 5.4.

The results of equation 5.6 are given in tables 5.4 and 5.5 for bulk carriers and tankers respectively.

Figure 5.1

REGRESSION LINE OF TOTAL OPERATING COSTS VS OBSERVED DATA
BULK CARRIERS

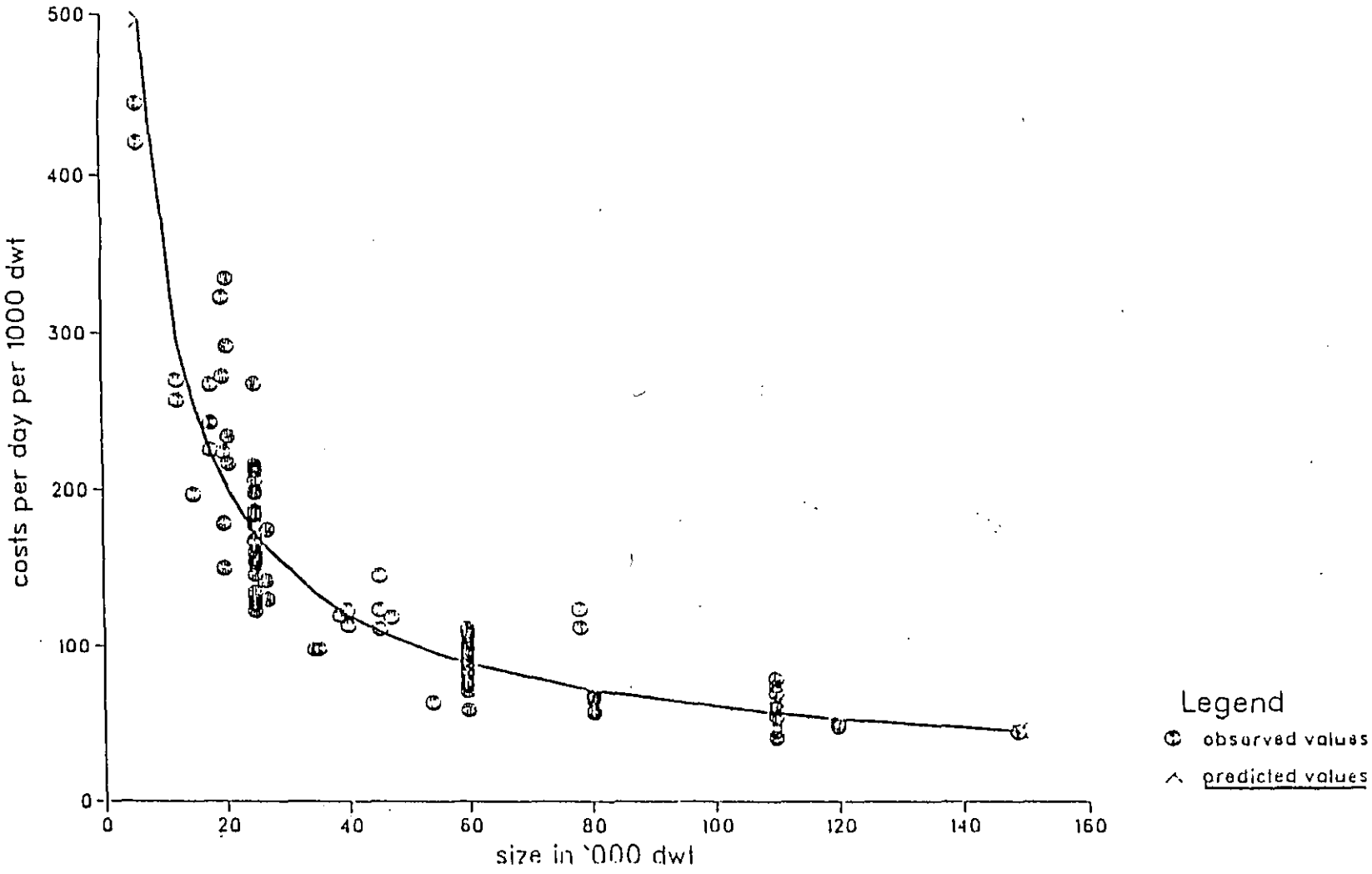
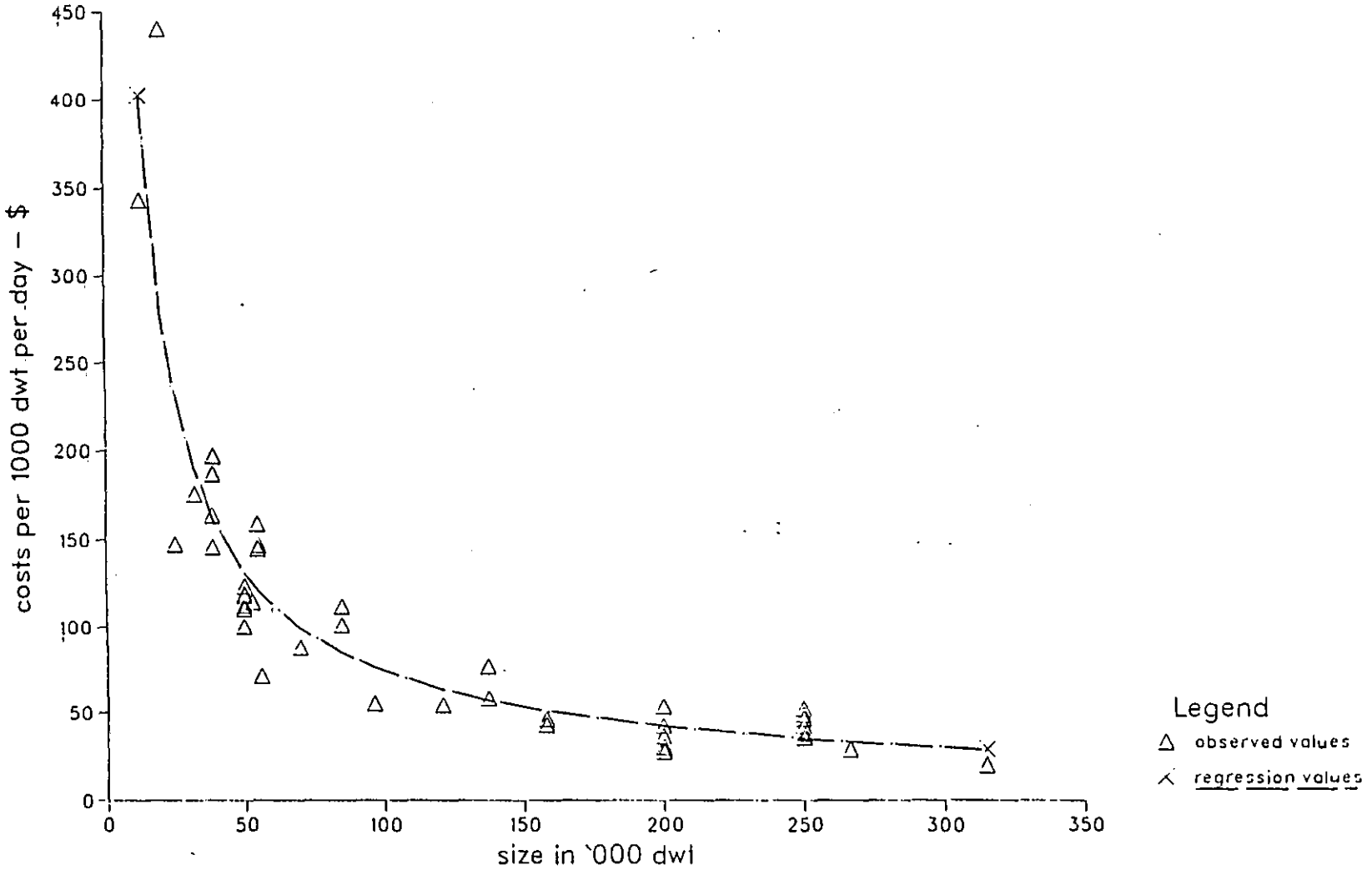


Figure 5.2
Regression Line of Total Operating Costs vs Observed Data
Tankers



Some interesting results have emerged from equation 5.6. In table 5.4 the inclusion of age in the manning equation has not added significantly to the explainable variation and the coefficient of the age variable is zero for both the pooled data and TC subset. For the OR regression, age did contribute significantly to the equation on the basis of an f-test and the t-ratio nearly significant at the 5% level (1.9). It is interesting to observe, on this basis, that the negative relationship of age and crewing costs means that older OR ships cost less to man. As expected, older ships are more expensive to maintain as the positive values of the age coefficient suggest. Older ships normally would be expected to consume more lubricating oils, require more spares and supplies such as paints, etc. Instead, the stores and provision equations show a negative relationship with cost, none of which is, however, significant. Also, older ships would tend to cost more to manage as more frequent arrangements would have to be made by management for supplies and spares, and more frequent drydocking. Only the OR regression attests to this postulation with a significant t-ratio.

The most revealing result is that of insurance costs. Referring to the same table, insurance cost shows that it is affected by vessel age. It is more plausible to expect age to be negatively related to insurance cost, a plausibility confirmed by the total data and the TC set but contradicted by the OR regression. The important thing about this result is that the age coefficient is statistically significant for the three regressions and therefore makes itself amenable to inferential logic. Hence, the fact that age is positively related to insurance costs for OR ships and otherwise for TC's despite the fact that the average bulk carrier in the OR data set is four years younger than that of the TC set (table 5.1), suggests strongly that there could well be an external factor assumed under the symbolic disturbance term (U_i) which in reality is taken into account in setting OR insurance costs. This could be related to the fact that older OR ships have a relatively higher loss ratios and thus poor history of claims and consequently higher premiums.

In table 5.5, the insurance equation takes a negative sign for age with a significant t-ratio only for the total observation. For tankers, the stores and provisions equations have the right sign and

Table 5.4 Regression results of cost per 1,000 dwt per day on ship size and age - Bulk carriers

Dependent Variable	Total Observation	Open Registries	Traditional Registries
Manning	$1669.03 \times {}_1^{-0.908} \times {}_2^{-0.001}$	$1826.21 \times {}^{-0.839} \times {}_2^{-0.281}$	$1881.83 \times {}_1^{-0.904} \times {}_2^{-0.0007}$
	(31.57) (-18.74) (0.02)	(22.47) (-10.16) (-1.91)	(37.32) (-22.97) (0.02)
	$\bar{R}^2 = 0.81$	$\bar{R}^2 = 0.85$	$\bar{R}^2 = 0.90$
Repairs and Maintenance	$50.40 \times {}_1^{-0.518} \times {}_2^{-0.466}$	$93.69 \times {}_1^{-0.661} \times {}_2^{-0.375}$	$35.16 \times {}_1^{-0.436} \times {}_2^{0.520}$
	(9.12) (-5.84) (4.27)	(8.58) (-5.05) (1.61)	(5.72) (-3.60) (3.72)
	$\bar{R}^2 = 0.38$	$\bar{R}^2 = 0.49$	$\bar{R}^2 = 0.56$
Stores and Provisions	$165.57 \times {}_1^{-0.652} \times {}_2^{-0.084}$	$154.47 \times {}_1^{-0.530} \times {}_2^{-0.224}$	$167.34 \times {}_1^{-0.683} \times {}_2^{-0.0684}$
	(24.31) (-15.06) (-1.57)	(16.14) (-6.87) (-1.63)	(19.76) (-13.54) (-1.17)
	$\bar{R}^2 = 0.72$	$\bar{R}^2 = 0.74$	$\bar{R}^2 = 0.76$
Insurance	$97.51 \times {}_1^{-0.413} \times {}_2^{-0.367}$	$51.94 \times {}_1^{-0.653} \times {}_2^{0.486}$	$95.58 \times {}_1^{-0.403} \times {}_2^{-0.439}$
	(9.24) (-4.05) (-2.92)	(9.14) (-6.11) (2.55)	(6.54) (-2.96) (-2.80)
	$\bar{R}^2 = 0.19$	$\bar{R}^2 = 0.59$	$\bar{R}^2 = 0.16$
Administration	$90.92 \times {}_1^{-0.615} \times {}_2^{-0.050}$	$40.45 \times {}_1^{-0.670} \times {}_2^{0.536}$	$130.32 \times {}_1^{-0.683} \times {}_2^{-0.145}$
	(8.80) (-5.82) (-0.39)	(8.76) (-6.37) (2.86)	(6.41) (-4.61) (-0.85)
	$\bar{R}^2 = 0.26$	$\bar{R}^2 = 0.61$	$\bar{R}^2 = 0.25$
Total Operating Costs	$1465.57 \times {}_1^{-0.751} \times {}_2^{0.117}$	$1571.84 \times {}_1^{-0.739} \times {}_2^{0.0079}$	$1525.38 \times {}_1^{-0.746} \times {}_2^{0.116}$
	(47.72) (-23.86) (3.11)	(32.65) (-13.69) (0.080)	(38.52) (-20.0) (2.77)
	$\bar{R}^2 = 0.86$	$\bar{R}^2 = 0.89$	$\bar{R}^2 = 0.88$

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Table 5.5 Tanker operating cost regression results of cost per 1,000 dwt on ship size and age

Dependent Variable	Total Observation	Open Registries	Traditional Registries
Manning	$2018.28 \times {}_1^{-0.963} \times {}_2^{0.169}$	$2038.56 \times {}_1^{-1.01} \times {}_2^{0.0447}$	$1939.4 \times {}_1^{-0.927} \times {}_2^{0.141}$
	(22.74) (-12.84) (1.94)	(32.98) (-17.09) (3.79)	(13.18) (-8.34) (1.02)
	$R^2 = 0.80$	$R^2 = 0.96$	$R^2 = 0.72$
Repairs and Maintenance	$713.37 \times {}_1^{-0.904} \times {}_2^{0.023}$	$1261.43 \times {}_1^{-1.12} \times {}_2^{0.054}$	$154.47 \times {}_1^{-0.539} \times {}_2^{0.141}$
	(6.60) (-3.99) (0.10)	(4.32) (-2.42) (0.12)	(3.35) (-1.83) (0.48)
	$R^2 = 0.32$	$R^2 = 0.50$	$R^2 = 0.11$
Stores and Provisions	$212.72 \times {}_1^{-0.850} \times {}_2^{0.249}$	$1164.0 \times {}_1^{-1.33} \times {}_2^{0.517}$	$40.45 \times {}_1^{-0.543} \times {}_2^{0.391}$
	(10.08) (-7.04) (2.04)	(11.18) (-7.48) (2.98)	(4.65) (-3.49) (2.50)
	$R^2 = 0.62$	$R^2 = 0.84$	$R^2 = 0.55$
Insurance	$119.10 \times {}_1^{-0.410} \times {}_2^{-0.410}$	$324.0 \times {}_1^{-0.409} \times {}_2^{-0.856}$	$88.0 \times {}_1^{-0.364} \times {}_2^{-0.346}$
	(6.23) (-2.93) (-2.28)	(3.90) (-2.15) (-1.75)	(3.97) (-1.66) (-1.55)
	$R^2 = 0.27$	$R^2 = 0.38$	$R^2 = 0.11$
Administration	$1286.91 \times {}_1^{-1.09} \times {}_2^{-0.191}$	$2807.36 \times {}_1^{-1.13} \times {}_2^{-0.066}$	$383.75 \times {}_1^{-1.02} \times {}_2^{0.155}$
	(12.57) (-8.38) (-1.46)	(19.86) (-10.89) (-3.31)	(6.08) (-5.35) (0.80)
	$R^2 = 0.72$	$R^2 = 0.95$	$R^2 = 0.63$
Total Operating Costs	$3165.29 \times {}_1^{-0.862} \times {}_2^{0.111}$	$3714.50 \times {}_1^{-0.917} \times {}_2^{0.0229}$	$2540.20 \times {}_1^{-0.806} \times {}_2^{0.124}$
	(24.76) (-14.50) (1.24)	(23.97) (-14.38) (1.48)	(18.48) (-10.04) (1.14)
	$R^2 = 0.83$	$R^2 = 0.94$	$R^2 = 0.77$

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are significant both in their t-ratios and their addition to the degree of explanation of variation obtained. By and large, the inclusion of age in the regressions, while it is illuminating, is inconclusive as a determinant of the variation of costs within the range of the data of this thesis, and of particular interest in this regard is that it does not contribute significantly to the variations in total operating costs for both bulk carriers and tankers. The analyses of the cost differential undertaken in the next section, therefore, is based on the regression results of tables 5.2 and 5.3.

5.4 Operating Cost Differentials between Open and Traditional Registries: Bulk Carriers

5.4.1 Manning cost

Using the equations given in tables 5.2 and 5.3 and a variant from them to provide values for cost per day, we analyse the savings due to open registry and traditional shipping operations. To derive costs per day of a ship's operation the equation:

$$Y = a\left(\frac{x}{1000}\right)^{1-b} = aX^{1-b} \qquad (5.7)$$

was used. The cost per day can also be calculated by simply multiplying the cost per 1000 dwt per day value by the relevant ship size ÷ by 1000. Savings or diseconomies due to differences in size per 1000 dwt per day are shown in table 5.6 along with savings per day.

This table shows that OR operators had lower manning costs in the year of our data right through the interpolated range of sizes. The range 5000-150,000 dwt was chosen in order to reflect the range of sizes in our data which is 6,300-149,000 dwt. Within this range ORs have savings between \$6-\$153 per 1000 dwt of ship size. This may seem small, but if the cost savings per day of operation are considered, the range of savings then covers \$765-\$980. Annually, this runs into savings of between \$270,810-\$346,920 - using 354 operating days which is the average operating days of the two flag groups for the entire sample (table 5.1).

The sample data shows that the cost per crew on European ships is $33, 555 on average with an average crew size of 30 per ship, and $24,292 per crew on OR ships carrying on average 29 crew per ship. These figures give a differential of $302,182 per annum compared to the predicted $308,865 (average of $270,810 + $346,920). This differential is equal to one-third of manning costs on Northwest-European ships and one-half of OR manning expenditure. Put another way, it will be sufficient to pay for 9 crew on board TC ships and 13 on board OR ships. This suggests that for every two bulk carriers operated under a traditional European shipping nation, open registry operators may realise savings in crew cost sufficient to man three ships under an open registry.

Table 5.6 Comparative manning costs for vessels of differing sizes ($)

Vessel size (dwt)	Cost/1000 dwt /day OR	Cost/1000 dwt /day TC	Savings (3-2)	Cost/day OR	Cost/day TC	Savings (6-5)
5,000	292	445	153	1460	2225	765
10,000	157	237	80	1570	2370	800
20,000	85	126	41	1700	2520	820
25,000	70	103	33	1750	2575	825
35,000	52	76	24	1820	2660	840
40,000	46	67	21	1840	2680	840
50,000	38	55	17	1900	2750	850
60,000	32	47	15	1920	2820	900
80,000	25	36	11	2000	2880	880
100,000	20	29	9	2000	2900	900
120,000	17	25	8	2040	3000	960
140,000	25	22	7	2100	3080	980
150,000	14	20	6	2175	3045	870

Scale effects due to manning cost are noticeable in the above table as daily costs for the two groups tend to stablise virtually at the 80,000 dwt + size range, an effect not so clear in the other operating cost elements. Suggesting that scale effects are exploited fully in this size range.

5.4.2 Repairs and maintenance

It was noted in Appendix C.2 that this cost element can vary considerably amongst ships of the same size due to a number of factors, not the

least management policy. Our treatment of the data relating to this cost element is expected to level out such differences. The involvement of an element of contingency in repair cost in terms of accidents, breakdowns, collisons, etc. also increases the variability of this cost head amongst ships of the same size because such contingencies when they occur can lead to repair costs as high as 50% of total operating costs.

Our sample, however, shows that OR repair and maintenance costs are lower for all vessel sizes within the interpolated range of sizes. Although the R^2 values are relatively smaller than those for crew cost, the predictors are all very significant at the 5% level. The lower cost obtained for ORs by the regressions may be due to two reasons. First, it may be due to the difference in vessel age profile in the data with average OR ship at 8.5 years and TC at 12.4 years, including ships up to 25 years old. Since older ships require more frequent servicing involving replacements of essential parts in order to comply with safety requirements, the results are justified by the data. Secondly, since repairs and maintenance costs often involve internal and external expenditure, it may be that according to company policy, OR crew are used more intensively for routine maintenance than TC crew, especially as their (OR) manning costs are lower than TC's. This aspect of the analysis involving factor substitution is taken up by a more sophisticated statistical model in chapter 7, and it will be seen in that chapter that the second reason seems to be a very plausible one for the repair cost differential.

Cost savings per 1000 dwt (table 5.7) range from $4-$16 and $80-$600 per day or $28,320-$212,400 per annum for vessels in the 5000-150,000 dwt range.

Table 5.4 shows the influence of age and although the OR coefficient for age is not significant, it has the right sign as in the other regressions. Using these regressions for repairs and maintenance, it was found that OR ships have higher costs at the lower size range between 5000-25,000

Table 5.7 Repairs and maintenance cost differentials ($)

Vessel size (dwt)	Cost/1000 dwt /day OR	Cost/1000 dwt /day TC	Savings (3-2)	Cost/day OR	Cost/day TC	Savings (6-5)
5,000	58	74	16	290	370	80
10,000	39	51	12	390	510	120
20,000	26	35	9	520	700	180
40,000	18	24	6	720	960	240
60,000	14	19	5	840	1140	300
80,000	12	16	4	960	1280	320
100,000	10	15	5	1000	1500	500
120,000	9	13	4	1080	1560	480
140,000	9	12	3	1260	1680	420
150,000	8	12	4	1200	1800	400

dwt. The savings due to OR ships at the over 25,000 dwt size range were found to be larger than those obtained from the regressions on size only.

5.4.3 Lubricating oil, stores and provisions

According to this regression result, TCs experience lower costs than ORs right through the entire spectrum of sizes interpolated. The savings that can be made by TC operators in this cost category range from $20-$150 per day or $7,080-$53,100 per annum - table 5.8.

The scheduling of the purchase of spare parts, essential stocks and general consumables is a function of management. Therefore, great economies can be realised by efficient management practice either by bulk buying (in which case some discounts can be obtained), proper scheduling of purchasing activities and having experienced and skilled buyers. Since ship management is an area of the industry in which traditional shipping nations excel, it is not hard to see their expertise coming through in this way neither is it surprising that 64% of OR ships were under the management of companies in traditional nations in 1984 - chapter 2, (UNCTAD, 1985).

5.4.4 Insurance costs

Although the insurance regressions produced the weakest results in terms of goodness of fit, some discussion based on the simple regression of

Table 5.8 Stores and provisions cost differentials ($)

Vessel size (dwt)	Cost/1000 dwt /day OR	Cost/1000 dwt /day TC	Savings (3-2)	Cost/day OR	Cost/day TC	Savings (6-5)
5,000	46	46	0	230	230	0
10,000	31	29	-2	310	290	-20
20,000	21	18	-3	420	360	-60
40,000	14	11	-3	560	440	-120
60,000	11	9	-2	720	540	-120
80,000	9	7	-2	720	560	-140
100,000	8	6	-2	800	600	-200
120,000	7	6	-1	840	720	-120
140,000	7	5	-2	980	700	-280
150,000	6	5	-1	900	750	-150

cost on size is necessary since the t-ratios of size are all significant. For illustrative purposes, it is noteworthy that traditional registry costs in this respect are lower for the vessel range under analysis; resulting in savings of $120-$270 per day or $42,480-$95,580 per annum. But since the inclusion of age has significantly added to the level of variation in insurance costs, the multiple regressions serve as a better basis for discussing this component.

The positive value of the age predictor in the case of ORs, as noted above, negates what obtains in practice under normal circumstances (ie. see Proctor (op. cit)). Drewry (op. cit) remarked that perhaps the most important determinant of insurance premiums is owners' reputation and record of operations. In table 2.10, discussed in section 2.4.2, it was noted that the open registry bulk carrier fleet has a generally much older age profile than its European counterparts, except Greece; the analyses of that section was later linked to marine casualties in chapter 3. On the basis of those analyses and the finding with respect to age being discussed here, it is clear that insurance premia strongly take account of operating records, owners' reputation, registry, etc. It is little wonder then that British cargo underwriters in the late 1970's charged cargo premiums 50% higher for vessels of over 15 years of age under the flags of Liberia, Panama, Cyprus, Singapore and Greece (Drewry, 1980).

Table 5.9 Insurance cost differentials

Vessel size (dwt)	Cost/1000 dwt /day OR	Cost/1000 dwt /day TC	Savings (3-2)	Cost/day OR	Cost/day TC	Savings (6-5)
5,000	56	18	-38	280	90	-190
10,000	35	14	-21	350	140	-210
20,000	23	10	-13	460	200	-260
40,000	14	8	-6	560	320	-240
60,000	11	7	-4	660	420	-240
80,000	9	6	-3	720	480	-240
100,000	8	5	-3	800	500	-300
120,000	7	5	-2	840	600	-240
140,000	6	5	-1	840	600	-240
150,000	6	5	-1	900	900	0

Note: age was held constant at 10 years

The above table shows that TC operations experience lower insurance costs compared with ships of similar size and age under ORs. The savings threshold in this respect has moved up to $190 per day with a maximum savings of up to $300 (ie. $67,260-$106,200 p.a.). The savings increase the older the ship for all vessel sizes.

This finding contradicts earlier findings in this respect by Metaxas and Doganis (op. cit), who argued that TC operators subsidised OR operators because the former spent more on insurance costs whilst the latter made more claims. Their study did not consider the possible effect of age in this cost variation, a factor which could have made their finding more tenable. Drewry (1984) supports our finding as OR insurance costs were consistently higher than those of TCs for all vessel sizes throughout the period 1973-1983, except for the 120,000 ± vessel class - a fact reflected by the large ships in table 5.9. It is noteworthy that 9 bulk carriers were obtained from Drewry sources which constituted only 9% of the total bulk carrier data, and this number of ships has not in anyway biased the data. The original 87 ships from the survey data showed very much the same results for all cost elements.

5.4.5 Administration costs

For this cost head TCs also have lower costs resulting in cost savings in the region of $2-$3 per 1000 dwt. Savings per day and per annum range from $15-$300 and $5,310-$106,200 respectively. The multiple regression reveals that for OR ships, older ships would tend to cost more to administer, a feature unsupported by the pooled data nor the TC data.

Not surprisingly the R^2 values for the bulk carrier administration costs are relatively smaller than those of tankers. The reason is that, as shown in table 5.1, bulk carriers are generally smaller than tankers in size with the largest vessel in the tanker data being over twice the size of the largest bulk carrier vessel (315,000 dwt against 149,000 dwt).

It is interesting to note that of the three cost heads in which TCs have savings, their greatest savings come from the cost of administration. Ship management has become a specialised arm of the shipping industry. A situation born of the need for efficient cost-effective management and made more important by the worst recession in shipping history.

The decision for an owner to set up his own ship management department or to delegate the function of management to a specialist company will depend on the size of the fleet and its composition. To an owner with a large fleet, it will be more economical for him to set up a ship management department because of the potential advantage of managerial scale economies; whereas to a one-ship operator (most of whom operate under open registries), it may be a more prudent decision to delegate management functions either to his shore staff or to a specialist ship management company; preferably the latter if the vessel is a specialised one.

The expertise of traditional shipping nations, developed through centuries of ship husbandry is exemplified by the fact mentioned above of over 60% of OR ships being managed by companies in traditional shipping nations and also by the fact that over 60% of the ships managed by Wallem Ship Management Ltd. (based in Hong Kong), the world's largest ship management

company, are OR ships - about 60% coming from Liberia alone (Seatrade, 1984).

On a yearly basis, this cost element yields savings of up to $106,200, compared with $95,580 for insurance (size only) and $53,100 for stores and provisions, totalling an overall savings of $254,880 per annum against OR operations or $265,550 incorporating the influence of age on insurance costs. If we set these figures against the total savings of OR operations from manning and repair/maintenance costs of $559,320 we will have an overall differential ranging from $294,000 - $304,000 in favour of OR operations.

Table 5.10 Administration cost differentials ($)

Vessel size (dwt)	Cost/1000 dwt /day OR	Cost/1000 dwt /day TC	Savings (3-2)	Cost/day OR	Cost/day TC	Savings (6-5)
5,000	32	29	-3	160	145	-15
10,000	22	18	-4	220	180	-40
20,000	15	12	-3	300	240	-60
40,000	10	7	-3	400	280	-120
60,000	8	6	-2	480	360	-120
80,000	7	5	-2	560	400	-160
100,000	6	4	-2	600	400	-200
120,000	6	4	-2	720	480	-240
140,000	5	3	-2	700	420	-280
150,000	5	3	-2	750	450	-300

The overall cost savings is, however, better shown by the total operating cost differential.

5.4.6 Total operating costs

Given the above analyses, it is tenable to expect overall cost advantage in OR operations. The high degree of cost variation accounted for by size in the total operating cost regressions and the very highly significant t-ratios of the coefficients, re-affirm the economies of scale associated with total operating costs.

The savings in favour of OR operations are from $6-$176, giving daily savings of $880-$980 or $311,520-$346,920 per annum. The savings are not as high as might have been expected a priori. This is because of the influence of size economies which, as can be seen in table 5.11, have caused the unit cost differential to stabilise around the larger size end from 100,000 dwt. Figure 5.3 graphically demonstrates this effect.

Table 5.11 Total operating cost differentials ($)

Vessel size (dwt)	Cost/1000 dwt /day OR	Cost/1000 dwt /day TC	Savings (3-2)	Cost/day OR	Cost/day TC	Savings (6-5)
5,000	477	653	176	2385	3265	880
10,000	288	380	92	2880	3800	920
20,000	173	221	48	3460	4420	960
40,000	105	128	23	4200	5120	920
60,000	78	94	16	4680	5640	960
80,000	63	75	12	5040	6000	960
100,000	53	63	9	5400	6300	900
120,000	47	54	7	5640	6480	840
140,000	42	48	6	5880	6720	840
150,000	40	46	6	6000	6900	900
160,000	38	43	5	6080	6880	800
180,000	35	40	5	6300	7200	900

5.5 Operating Cost Differentials between Open and Traditional Registries - Tankers

5.5.1 Manning costs

As with bulk carriers, OR operations are also subject to lower manning costs than operations under TCs in the tanker sector. Savings per 1000 dwt range from $1 for the largest observation in the sample to $150. The data size range is 13,000 - 315,000, dwt. Daily savings fall within $290-$750, obviously smaller than those for bulk carriers because of the influence of scale economies. This is discernible from the higher elasticities associated with tanker manning costs compared to those of bulk carriers, except for the regression of the TC data excluding the 3 U.S. ships - see the fifth column of table 5.3.

Figure 5.3
Comparative Bulk Carrier Total Operating Costs per day
for open and traditional registry operations

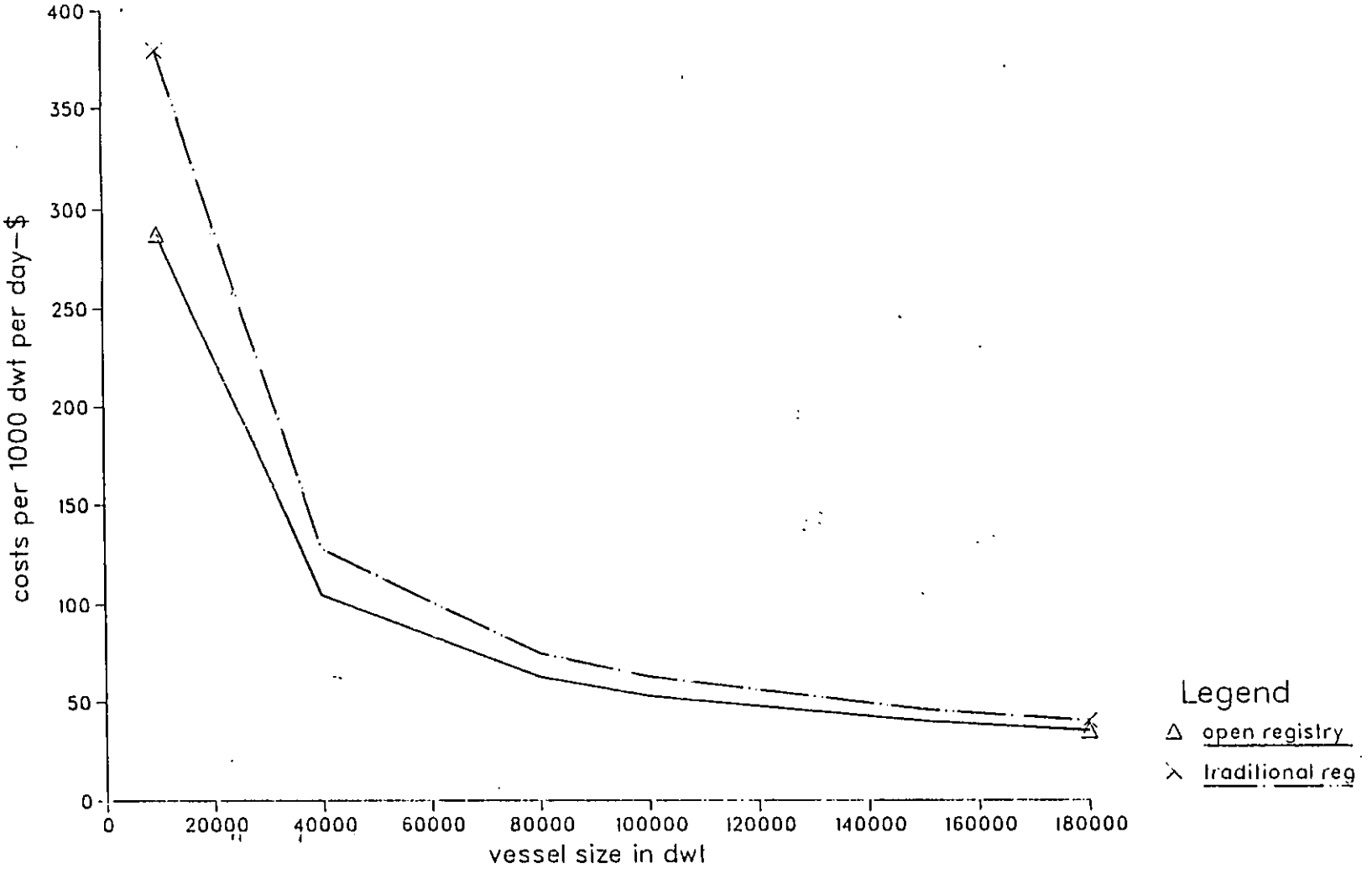


Table 5.12 Manning cost differentials ($)

Vessel size (dwt)	Cost/1000 dwt /day OR	Cost/1000 dwt /day TC	Savings (3-2)	Cost/day OR	Cost/day TC	Savings (6-5)
5,000	445	595	150	2225	2975	750
20,000	128	163	35	2560	3260	700
40,000	69	85	16	2760	3400	640
60,000	48	59	11	2880	3540	660
80,000	37	45	8	2960	3600	640
100,000	30	36	6	3000	3600	600
150,000	21	25	4	3150	3750	600
200,000	16	19	3	3200	3800	600
250,000	13	15	2	3250	3750	500
300,000	11	13	2	3300	3900	600
350,000	10	11	1	3500	3850	350

5.5.2 Repairs and maintenance costs

Here TC operators seem to experience lower costs at the lower size end up to 20,000 dwt, according to our data, with savings of up to $201,780 per annum. This finding may be due to the fact that, as noted in section 4.2.1(1) above, the handling, distribution and marketing of petroleum products carried specifically in product tankers (vessels up to 35,000 dwt) require complex organisational and managerial skills. Because of the dangerous nature of clean products (ie. the explosive nature of gases when mixed with oxygen), they are carried in specifically designed ships and hence require highly skilled and trained crews; a requirement OR operations can ill-afford. Most commodities carried in the product trade are corrosive and product tankers often need coatings. To maintain these coatings experienced and skilled crews are required, lack of which can significantly affect this cost head.

Normally, large ships would be expected to incur higher repairs and maintenance bills as they would require longer drydocking times and longer periods for preparation for drydocks, and also longer time for routine maintenance, ie. chipping and scraping, painting and tank cleaning, therefore requiring longer man-hours. But whether the costs of such man-hours are charged to the crewing account or that of maintenance is

Table 5.13 Repairs and maintenance cost differentials ($)

Vessel size (dwt)	Cost/1000 dwt /day OR	Cost/1000 dwt /day TC	Savings (3-2)	Cost/day OR	Cost/day TC	Savings (6-5)
5,000	210	96	-114	1050	480	-570
20,000	46	43	-3	920	860	-60
40,000	22	29	7	880	1160	280
60,000	14	23	9	840	1380	540
80,000	10	20	10	800	1600	800
100,000	8	17	9	800	1700	900
150,000	5	14	9	750	2100	1350
200,000	4	12	8	800	2400	1600
250,000	3	10	7	750	2500	1750
300,000	2	9	7	600	2700	2100
350,000	2	8	6	700	2800	2100

a matter of individual company policy. One fact that is clear in table 5.13 is that the daily costs of TC operators as expected increase with the size of ship whereas the behaviour of the daily cost on OR vessels seems somewhat indeterminate. This could well be due to a relatively higher degree of factor substitution between manning and repairs costs on OR ships as we will find in chapter 7.

Savings of OR operators in the cost category run up to $717,750 per annum for the very large vessels. This rather high figure is a result of some 3 extreme data points which exceeded the average in the TC data including one of the U.S. ships. As is shown in the tanker operating cost indices at appendix D, the differential in favour of OR operations in the 175,000 dwt+ category was $176,000 in 1982 according to Drewry. Even though one of the U.S. ships is 30 years old, age did not contribute to the variations as the exclusion of the 3 U.S. ships from the TC data did not improve the obtained explanation, rather it reduced it and further widened the differential between OR and European ships.

5.5.3 Stores and provisions costs

The differentials are given in table 5.14 below. Unlike the differentials for bulk carriers, here the picture is mixed. For ships at the lower size end up to and including 105,000 dwt, OR costs are higher by $1-$108 per 1000 dwt/$105-$540 per day, running into savings of up to $189,000

5.14 Stores and provisions costs differentials ($)

Vessel size (dwt)	Cost/1000 dwt /day OR	Cost/1000 dwt /day TC	Differential (3-2)	Cost/day OR	Cost/day TC	Differential (6-5)
5,000	158	50	-108	790	250	-540
20,000	39	21	-18	780	420	-360
40,000	20	13	-7	800	520	-280
60,000	18	12	-6	810	540	-270
80,000	10	9	-1	800	720	-80
100,000	8	7	-1	800	700	100
150,000	5	6	1	750	900	150
200,000	4	5	1	800	1000	200
250,000	3	4	1	750	1000	250
300,000	3	4	1	900	1200	300
350,000	2	3	1	700	1050	350

annually for TC operations. For vessels larger than 105,000 dwt up to 140,000 dwt, the costs for the two groups are the same, and for all sizes in the 145,000 dwt+ range, OR costs are lower - amounting to daily savings of $145-$500.

It does seem that this mixed picture is produced because of the influence of economies of scale, accentuated by the fact that there are more turbine ships in the OR data and therefore relatively lower costs at the large size end of the distribution because of the little or non-requirement of lubricating oil by the large tankers.

5.5.4 Insurance costs

The insurance regression results for tankers are in marked contrast with those for bulk carriers, as no statistically meaningful relationship was established by the chosen explanatory variables, except for the total observation. This state of affairs suggests that there are contrasting differences in the tanker and bulk carrier insurance markets in the sense that the two markets are affected by freight market conditions to varying degrees.

Contrary to the finding under bulk carriers, open registry operations enjoy lower insurance costs in the tanker sector than operations under traditional countries considering both size and vessel age. The most likely reason for this result is that insurance costs for tankers have been falling since

1974 in line with falling tanker hull values particularly in the VLCC/ULCC class. This is evident from published data from which the insurance cost indices were constructed. These indices given at appendix D2 reveal that in 1973 the average insurance costs for VLCC/ULCC were almost $1.0million per annum, but by 1982 they were only $323,000 on OR ships and $419,000 on European vessels. The largest and thus the most affected vessels are in the OR sub-set. This underlying lack of positive relationship between hull value and ship size appears to be the main reason for the apparent lack of fit of the tanker insurance regressions. But it must be noted that both size (indirectly) and age are determinants of this cost as supported by the results of the regressions of the total observation.

However, due to the unreliability of these two factors as predictors in the subdivided sets of data, it was not necessary to provide a table of differentials. Instead of the unit cost approach, a linear model relating daily insurance costs to vessel size and age was specified. As has already been argued, the influence of ship size as a direct determinant of insurance costs was minimal with age playing a far more important role, not surprisingly due to its implications for vessel hull values (see equations 6.3 and 6.4 in the next chapter) and proneness to marine accidents. The regression equations are:

All data: $Y = 560 + 0.00315 \text{ size} - 13.5 \text{ age}$
$(4.24) \quad (4.98) \quad (-1.60)$

$R^2 = 0.55$

Open registries: $Y = 582 + 0.00384 \text{ size} - 28.6 \text{ age}$
$(1.83) \quad (5.26) \quad (-1.23)$

$R^2 = 0.84$

Traditional registries (1): $Y = 628 + 0.00249 \text{ size} - 12.5 \text{ age}$
(including U.S. ships) $(3.69) \quad (2.11) \quad (-1.27)$

$R^2 = 0.33$

Traditional registries (2): $Y = 678 + 0.00265 \text{ size} - 25.2 \text{ age}$
(excludes U.S. ships) $(5.09) \quad (3.38) \quad (-2.85)$

$R^2 = 0.66$

Even though the age variable is not significant at the 5% level of significance which makes it an unreliable predictor, the difference in variation

explained by the above regressions as compared to those of the previous specification, supports the fact that insurance cost is the least amenable to scale economies. This specification also produced better explanations for the variations in bulk carrier insurance costs. The differentials per day based on an average vessel age of 10 years are given in table 5.15.

Table 5.15 Insurance cost differentials ($)

Vessel Size (dwt)	Cost/day OR	Cost/day TC[1]	Differential (3-2)[1]	Cost/day TC[2]	Differential (5-2)[2]
5,000	315.2	515.5	200.3	439.5	124.3
20,000	378.8	553.0	180.2	480.0	107.0
40,000	449.6	603.0	153.4	534.0	84.4
60,000	526.4	653.0	126.6	588.0	61.6
80,000	603.2	703.0	99.8	642.0	38.8
100,000	680.0	753.0	273.0	696.0	16.0
150,000	872.0	878.0	6.0	831.0	-41.0
200,000	1064.0	1003.0	-61.0	966.0	-98.0
250,000	1256.0	1128.0	-128.0	1101.0	-155.0
300,000	1448.0	1253.0	-195.0	1236.0	-212.0
350,000	1640.0	1378.0	-262.0	1371.0	-269.0
500,000	2216.0	1753.0	-463.0	1751.0	-465.0

The results in table 5.15 show that insurance costs for OR tankers are lower up to the VLCC class and higher for VLCC and ULCC vessels.

5.5.5 Administration costs

There is a much stronger fit in the regressions for this cost head - table 5.3 - with very highly significant t-ratios for the co-efficients. The reasons for this relatively higher goodness of fit compared to the bulk carrier regressions have already been touched upon. In much the same manner as in the bulk carrier data, TC operators experience relatively lower administrative costs. The savings per day in their favour per day of operation are in the region of $155-$1,370 for tankers from 5000 - 240,000 dwt, and for larger sizes up to 295,000 dwt unit costs for the two groups are the same due to the influence of size economies. For sizes between 295,000 - 355,000 dwt, the cost saving per 1000 dwt

is unity and zero for sizes larger than 355,000 dwt - table 5.16.

Table 5.16 Administration cost differentials ($)

Vessel Size (dwt)	Cost/1000 dwt /day OR	Cost/1000 dwt /day TC	Differential (3-2)	Cost/day OR	Cost/day TC	Differential (6-5)
5,000	387	113	-274	1935	565	-1370
20,000	64	26	-38	1280	520	-760
40,000	26	12	-14	1040	480	-560
60,000	15	8	-7	900	480	-420
80,000	11	6	-5	880	480	-400
100,000	8	5	-3	800	500	-300
150,000	5	3	-2	750	450	-300
200,000	3	2	-1	600	400	-200
250,000	2	2	0	500	500	0
300,000	2	1	-1	600	300	-300
350,000	2	1	-1	700	350	-350
500,000	1	1	0	500	500	0

5.5.6 Total tanker operating costs

As mentioned earlier, the total cost figures are more reliable since scale economies which form the theoretical basis of the regressions are more evident in total costs than in individual cost centres. Additional to this is the fact that, aside from the unstable nature of size as an explanatory variable, particularly in the case of insurance costs, the total cost observations for both the bulk carrier and tanker data sets provided the most complete of all the cost observations as some of the cost components were characterised by missing values. With R^2s of between 77% and 94%, the relationship of total tanker operating cost with size is indisputable. After excluding the 3 U.S. ships from the observations of the TC group, the degree of variation explained by the equation rose to 87% for the TC group, as shown in the fourth column of table 5.3. The very high significance of the co-efficients reinforces the relationship of size and total operating costs.

The TC data exhibit cost savings for vessels up to and including 20,000 dwt amounting to $830 per day or $290,000 per year. The specialised skills required for the operation and management of product tankers would

mean higher operating costs for open registry operations and therefore negate the fundamental attraction or advantage of open registry shipping. Apparently, due to the sophistication required in the carriage and handling of product cargoes (which by nature are hazardous) at acceptably safe levels, and their cost implications, open registry investment in this market appears to be minimal, a fact substantiated not only by our data but also by the structure of the open registry fleet by vessel type, analysed in section 2.4.1. There, it is stated that whilst in 1984, oil tankers accounted for 43% of total OR fleet, representing the largest vessel type in the fleet, product tankers (ie. chemical tankers) accounted for less than 2% of the fleet - see table 2.6.

However, OR costs are lower for vessels over 20,000 dwt with savings more than 300% higher than the maximum realisable savings by TC operations in the product trade - $1,050,000 per annum. The inclusion of the 3 U.S. ships provides a complete picture of the possible cost differentials covering all OECD countries. Now that a global reflection has been given with respect to the traditional shipping nations of the West, it is important to show how European operations compare with those of open registries.

The effect is that the exclusion of the U.S. ships resulted in the elevation of the threshold of savings in favour of TC operations. TC operations, according to the data, became lower for all vessel sizes up to 60,000 dwt (inclusive). It is notable that product carriers can range up to 60,000 dwt (see Drewry, 1981b - The Products Tanker Fleet). The savings range from $120-$2,205 per day. This means that at the smaller size end, North European operators, according to our data, experience lower costs with relative savings up to $771,750 per annum. In the medium and large size categories, ie. ships from 70,000 dwt and above, the daily savings made by OR operators exceed those made with the inclusion of the U.S. ships resulting in annual savings of between $49,000 and $1,543,000. The U.S. ships are in the size range of 25 - 70,000 dwt, with very high daily costs, in all cases far above average costs. Their removal has, therefore, meant an increase in the threshold of sizes for which TC costs were lower but at the same time re-emphasised

the relative cost advantage of OR operations at the large size end. Table 5.17 provides the regression values.

5.17a Total operating cost differentials ($)

Vessel size (dwt)	Cost/1000 dwt /day OR	Cost/1000 dwt /day TC	Differential (3-2)	Cost/day OR	Cost/day TC	Differential (6-5)
5,000	1074	908	-166	5370	4540	-830
20,000	302	297	-5	6040	5940	-100
40,000	161	170	9	6440	6800	360
60,000	111	122	11	6660	7320	660
80,000	85	97	12	6800	7760	960
100,000	69	81	12	6900	8100	1200
150,000	48	58	10	7200	8700	1500
200,000	37	46	9	7400	9200	1800
250,000	30	39	9	7500	9750	2250
300,000	25	33	8	7500	9900	2400
350,000	22	29	7	7700	10150	2450
500,000	16	22	6	8000	11000	3000

5.17b Total operating cost differentials, excluding U.S. ships ($)

Vessel size (dwt)	Cost/1000 dwt /day OR	Cost/1000 dwt /day TC	Differential (3-2)	Cost/day OR	Cost/day TC	Differential (6-5)
5,000	1074	633	-441	5370	3165	-2205
20,000	302	237	-65	6040	4740	-1300
40,000	161	145	-16	6440	5800	-640
60,000	111	109	-2	6660	6540	-120
80,000	85	89	4	6800	7120	320
100,000	69	76	7	6900	7600	700
150,000	48	57	9	7200	8550	1350
200,000	37	46	9	7400	9200	1800
250,000	30	40	10	7500	10000	2500
300,000	25	35	10	7500	10500	3000
350,000	22	31	9	7700	10850	3150
500,000	16	24	8	8000	12000	4000

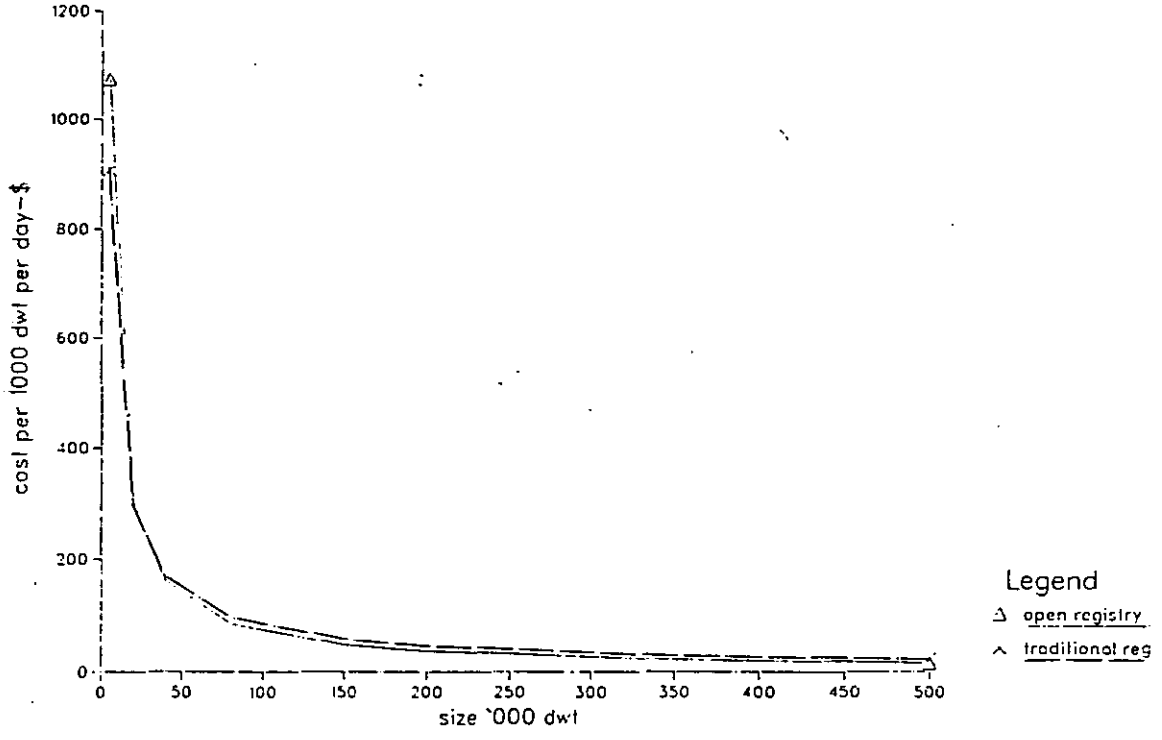
5.6 Discussion of the results

The differentials for total costs are better shown in graphic form as can be seen in figures 5.4a and b. The higher differentials at the large size end of the spectrum obtained for ORs after the exclusion of the 3 U.S. tankers ~~ships~~ does seem to underscore the possibility that north European shipping costs could be approaching those of the Americans, particularly in the manning sphere which for both bulk carriers and tankers constitute the single largest area of cost differential, except for the latter in which repairs and maintenance shows higher differentials at the VLCC/ULCC levels.

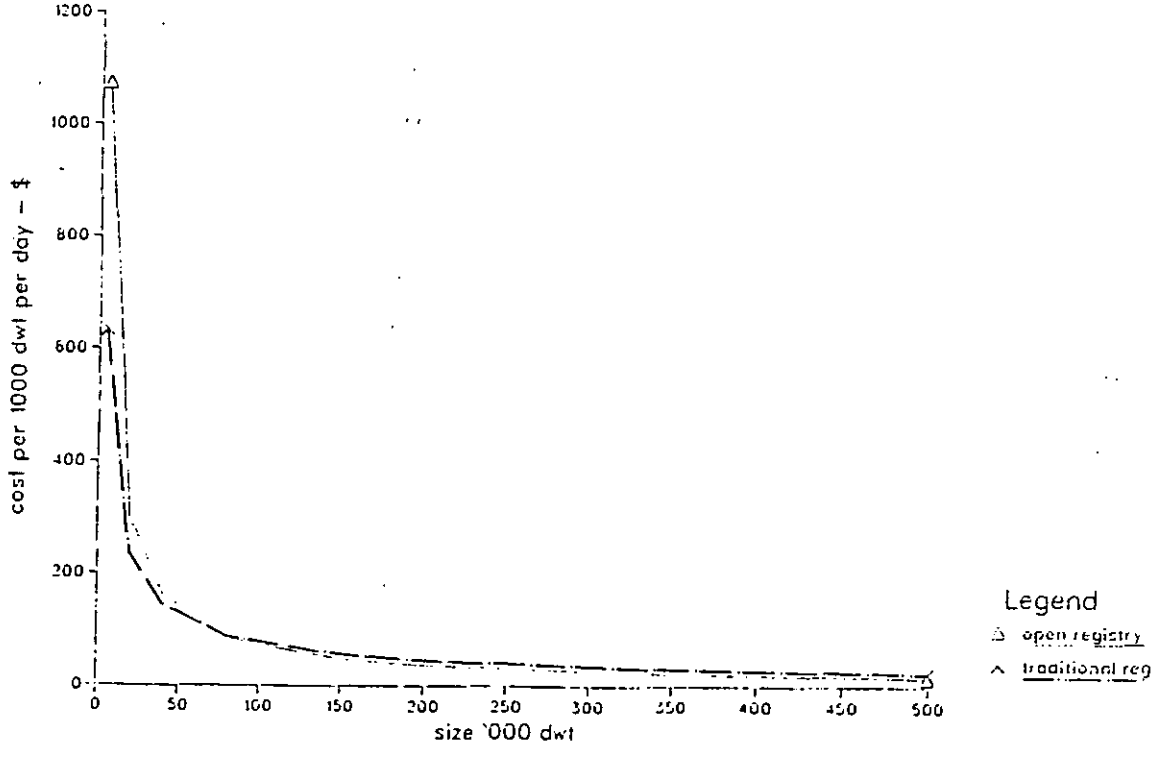
Repairs and maintenance differentials according to our data for tankers were higher than manning cost differentials in 1982. This can be attributed to the possible effects of the new tanker regulations of IMO discussed in chapter 3 which require that all existing tankers over 40,000 dwt must be fitted with COW, SBT or CBT by 1st May, 1983, and those over 70,000 dwt fitted with IGS by the same date. An examination of the world tanker fleet in 1980, revealed that whilst 41% of the VLCC/ULCC fleet met the IMO standards, only 19% of the fleet between 40,000 and 175,000 dwt was in full compliance (Drewry, 1983a).

In the light of the foregoing, and considering the size distribution of tankers in table 2.11 and their age profiles in table 2.9, it might have been that more tankers in the TC data were affected by the extra costs of meeting the IMO standards, since in 1984 60% of the OR tanker fleet was composed of VLCCs and ULCCs as compared to 52% for the world fleet. A feature mirrored by our data as table 5.1 shows. Therefore, it is probable that most large open registry tankers might have met the standards prior to the year of the data since, in 1980, 44% of the large carriers had already complied with the standards. or have not met the standards since in the same year (1980), only 22% of Liberian flag tankers were equipped with COW as against 64% for British tankers, for example (Drewry, ibid.). Another possibility for the wide differential in this cost centre for tankers could be due to the requirements to use national repair facilities for vessels built under some national assistance programmes, ie. in the U.S., France and Italy. In most cases repairs and maintenance effected in shipyards in the industrialised countries would be far more expensive than, say, that undertaken in South Korean or Taiwanese shipyards - an option open to an open registry operator, or possibly the higher differential

Figure 5.4
Comparative Tanker Total Operating Costs per Day
for open and traditional registry operations
a) all traditional observations



b) European vessels only



points to greater substitution of cheap labour for repairs.

Generally, the total cost differentials for the two vessel types underline the fact that operating cost differentials are the main economic attraction of open registry shipping. This was reinforced by the Federation of American Controlled Shipping (the owners of the bulk of U.S. ships registered in open registries) which stated that "Economic considerations (primarily operating costs) explain why American ... shipowners have had to resort to these registries in order to remain internationally competitive" (FACS, 1976). The importance of manning cost as the key determinant in the economic considerations underlying the competitiveness of a ship cannot be over-emphasised. This importance is shown in table 5.18.

Table 5.18 Structure of total operating costs (%)

	Bulk Carriers		Tankers		
Cost element	OR	TC	OR	TC^1	TC^2
Manning	43.83	52.0	43.12	47.73	44.20
R & M	18.73	23.63	17.10	22.50	21.00
S & P	13.70	9.21	12.56	9.18	10.21
Insurance	13.23	8.00	10.91	8.72	8.26
Administration	10.64	7.61	13.45	6.90	6.61

Note: The average proportions for tankers do not add up to 100 due to missing values in some of the cost elements.
TC^2 = TCs less 3 U.S. observations.

It will be apparent from table 5.18 that although crew costs represent the largest cost head, these percentages represent different absolute values and can, therefore, represent large differentials between the two groups because of the differences in total operating costs. Since the mid-1970's crew reduction experiments involving increased automation on board European and Japanese ships have been going on. In 1983, after six years of experiments, the Japanese Shipowners Association (JSA) was able to obtain new crewing legislation from the government. The new legislation now permits a legal minimum of 15 crew on board Japanese ships instead of the old average of 28-30 crew. The introduction

of 'dual-purpose' crewing arrangements, where officers and ratings can perform each other's roles interchangeably, is the main element in the new system (see Seatrade, August, 1983).

In the same year, the Norwegian government approved new manning levels for Norwegian flag ships with effect from March, 1983. Manning levels ranging from 5-18 crew for vessels of 200-20,000 g.r.t. engaged in European trade and 18-19 for ocean-going vessels of 20,000 g.r.t.+, (The Motor Ship, May, 1983). There are also more experiments going on in Japan with the aim of reducing crew further to an ultimate level of 11-12, see, for example, Det Norske Veritas (1984). The implication of this trend is more automation coupled with capital intensive ships and, seemingly, unemployment of national seamen. The aim, however, is to achieve reduced or competitive manning cost without the necessity of re-flagging under an open registry.

In view of the comparatively very cheap labour provided by countries like Taiwan and Philippines, where there are no trade union structures of the kind known in the industrialised countries and hence the latitude an operator under open registry has with respect to conditions of service, for instance, he can avoid having to operate a relief crew system, and contract crew on a voyage basis. There are doubts in shipping circles that such reductions in manning levels will significantly affect the manning cost advantage. Such a scepticism is echoed by a shipowner who remarked that "if the Norwegians cut their average crews to only 16 per vessel those 16 would still cost double my Chinese seamen" (Lloyds Shipping Economist, 1980). Such a state of affairs would seem to make the logic of the existence of an open registry more of an economic necessity, rather than a 'convenience' especially when exchange rate differentials and the vagaries of the freight markets can be unsympathetic to shipping costs.

The other revelation of the analyses carried out in this chapter is that tanker operating costs are generally higher than those of bulk carriers for similar vessel sizes. Tankers also have better economies of scale as indicated by their higher total cost elasticities, apparently

due to their relatively larger sizes and thus, their operations yield much larger savings for open registry operators at the larger end of the size distribution. Also it is worth noting that better results, particularly for the insurance element could have been obtained had there been less missing values for the tanker observations.

There is a strong agreement between the elasticities of our total operating cost regressions and those estimated by Metaxas and Doganis (ibid.) for bulk carriers - the only vessel type for which they had reliable data albeit very limited. Their regressions results based on 1972 costs were:

All data (43 observations)

$$Y = 208.5\ x^{-0.6999}\ ;\ R^2 = 0.87$$

Regulated registries (32 observations)

$$Y = 263.1\ x^{-0.7553}\ ;\ R^2 = 0.88$$

Open registries (11 observations)

$$Y = 192.3\ x^{-0.7177}\ ;\ R^2 = 0.85$$

Comparing these elasticities to ours: -0.729 for ORs and -0.782 for TCs, one finds a great similarity indeed. In fact the estimation of the regressions based on the original survey observations of 87 ships produced the following results:

$$Y = 12186.4\ x^{-0.770} \text{ for TCs}$$

and $Y = 1465.6\ x^{-0.717}$ for ORs.

In view of the fact that the coefficient b in equation (5.4) is a ratio of two marginal variations, a marginal change in cost in the numerator and a marginal change in ship size in the denominator, the measure of slope is a pure number independent of the units in which the variables of the regression equation are expressed, Dutta (1975). It follows that the fact that our costs are in U.S. dollars and those of Metaxas and Doganis in British sterling has no bearing on b.

The implication of the analyses of total operating costs is of particular relevance to the theory of lay-up rates touched upon in chapter 4.

Since the main determinant of the lay-up point of a ship is its operating costs vis a vis the level of freight rates, it is tenable to expect, in the light of the analyses of this chapter, that, during depressed market periods when laying up of ships takes place, open registry operators will be able to stay longer in the market because of their lower costs and hence offer lower freight rates. This hypothesis is the main thrust of chapter 8.

The log-linear regression model used in this chapter is similar to a Cobb-Douglas specification which requires constant elasticity of substitution between factors of production and in which the estimated parameter of scale economies characterises the whole sample without allowing for varying degrees of economies of scale as output levels and input prices vary. By such characterisation a Cobb-Douglas model also imposes a priori restrictions on the structure of production. Therefore, by implication the models used here are subject to all the theoretical limitations of a Cobb-Douglas. It is for these reasons that a more sophisticated cost model is formulated in chapter 7. It is pertinent in this regard to remark that every model has a purpose and the purpose of the regression models used here has been primarily to account for variations in cost due to differences in ship size and not to study elasticities of substitution, scale economies nor the structure of the shipping technology, hence the necessity for the analysis of chapter 7.

CHAPTER 6

ESTIMATION OF CAPITAL COST AND TOTAL COST DIFFERENTIALS

"Close attention to the market value of a ship as a measure of its real capital value is consistent with the economists' emphasis on the opportunity costs of assets."
Heaver (1985)

In the preceding chapter the differentials in total operating costs between ships operating under open and traditional shipping registries were examined. In order to reflect total shipping costs differentials between the two groups, knowledge of capital cost is required. This chapter, therefore, discusses the methodology employed for deriving capital costs associated with the ships of the operating cost survey. Since the operating cost data covered ships built in different years whose historic values were not disclosed, the study was faced with the problem of capital cost estimation. If the book or historic values had been given, they would still not have made things any easier since there are no published capital cost indices to enable their revaluation. Such values would not have reflected current values nor the effects of technological changes and market conditions on the value of ships over time.

6.1 Review of capital cost treatment in shipping

This has been partly discussed in chapter 5 via equations 5.1-5.3. More specifically, the estimation of capital cost in shipping can be broadly divided into estimating methods based on the cost of capital to an individual shipping company - private costs - and those based on social costs, in other words the opportunity cost of capital. These two methods can further be labelled the accounting approach and the economist approach. By the former approach, the private costs of capital, ie. loan repayments, interest on loans, depreciation and sometimes anticipated return on capital are taken into account in arriving at an annual capital cost. In some instances, because leases or loans

have finite repayment periods, analysts treat the loan or lease payment schedules as the de facto capital cost. Douglas (1985) argues that using loan or lease repayments as surrogates for the cost of capital is an inadequate measure because such treatment does not fully reflect the cost of capital. A more general shortcoming of the accounting method is its inclusion of depreciation as a real cost. To the economist this is not a real cost but merely a book entry which involves a debit entry in the profit and loss account and a credit entry in the relevant asset account. It does not involve any cash flows at all.

Another important argument against the treatment of capital costs as private costs is that such costs, in as much as they are based on the purchase price of vessels, are normally financed by some form of shipyard credit, and do not reflect the true social cost of capital and not infrequently are based on fixed-interest shipbuilding credits obtained at costs much less than their social opportunity cost. For instance, in 1979, the agreed minimum interest rate for shipbuilding export credits in those OECD countries which are parties to the OECD "Understanding on Export Credits for Ships" was 8%, whilst the average six-month London Inter-Bank Rate (LIBOR) was 12.8% in that year. In March, 1980, when the LIBOR rose to 19.7%, the export credit rate was still 8% (Drury and Stokes, 1983).

The economic cost approach is not based on the monetary disbursements of capital expenses but is predicated on the economic principle of opportunity cost which relates to the value of the ship in its best alternative use. The opportunity cost in terms of the capital employed in a ship involves the comparison by an owner of the returns he earns on a ship with the return he could possibly earn by investing the realisable value of the ship in the second-best activity with similar risks. Estimation of capital costs using the opportunity cost approach is usually based on discounted cash flow (d.c.f.) techniques as the discount rate employed, as shown in equation 5.1 above, reflects the opportunity cost of capital - the rate of return (r) that might reasonably be expected in the next best alternative investment. The d.c.f. computations involve the

calculation of a series of equal cash receipts that will equal a series of cash outflows plus the required return on equity, discounted to their present values over the 'economic life' of the ship. The discounting procedure automatically allows for both depreciation and interest, and thereby allows the recoupment of the initial value of the investment and the time value of money.

For this thesis, capital is estimated on the basis of the opportunity cost of capital as embodied in the first term on the right-hand side of equation 6.1 by the use of a constant annuity over the ship's life. Thus annual capital charge:

$$C_A = \frac{C_o}{\frac{1 - (1 + r)^{-n}}{r}} \qquad \ldots (6.1)$$

The advantage of a constant annuity is that it provides a constant annual capital charge over the ship's life without the necessity of calculating depreciation and interests separately every year as these are already part of the annuity. The economist approach for capital cost estimation has been adopted in this study because it gives a better measure of the cost of capital for the purposes of this thesis. One of the aims of this study is to suggest a methodology for the measurement of the impact of cost differentials on the price of shipping services offered by open and traditional registries, since this analysis discussed in chapter 9 is based on the costs and benefits of such differentials to the world community, the social cost method is unavoidably the appropriate approach.

Whether the approach used is the accounting or economist approach, an input in both methods is the capital value of the ship either as represented by its purchase price or its market value, ie. secondhand value. Herein lies one of the major problems in capital cost estimation. Although most shipping studies use ship purchase price as representative of the ship's initial cost of acquisition, this factor is very highly variable and volatile due to the influences of the freight markets on new building prices and the array of fiscal and financial packages

offered by the various shipyards of the world in order to attract business, particularly at times of poor market conditions. In fact these financial and fiscal packages which often include, subsidised interest charges, moratoria on principal repayments, extended loan terms, combined with differences in ship construction techniques, cost of raw materials and labour, currency exchange differentials and national maritime policies in so far as they can significantly reduce the cost of acquiring a vessel to the shipowner, make comparison of the prices of ships built in different countries baseless. This state of affairs is such that it is not unusual to find ships supplied at anything below 20-40% of cost price.

This situation as appropriately remarked "is one of the continuing paradoxes of the shipping market (such) that during a market depression shipowners can find it easier (and often cheaper) to acquire new tonnage - which has the effect of further exacerbating the tonnage imbalance - than to acquire good secondhand tonnage on commercial terms" (Drewry, op. cit.). It is further noted that the worse the depression gets, the more generous these new building financial packages become, and the more bankers favour negotiations for new building loans and the more stringent they get in negotiating secondhand loans, leading to a situation in which owners find secondhand tonnage more expensive than new ships in cash flow terms (see Drewry, 1983b for these financial and fiscal packages).

For this reason, some studies have had to resort to using ship construction costs derived from engineering design studies rather than delivered prices (ie. Gilman, 1980; Ferguson et. al. 1961; Eide; 1979; Carreyette, 1978; Benford, 1958, 1962, 1967). (See Benford, 1985, for a good number of studies employing this approach.) Others (ie. Ryder and Chappel op. cit) prefer to synthesise capital cost from the functional relationship between delivered prices, dwt and speed. Whereas in yet another group of studies (ie. Shneerson, 1983, and Giziakis, 1981) capital costs were derived from the secondhand values of ships. This was the approach favoured in this study. There is a general agreement amongst

economists that the market value of a ship at any point in time is the best indicator of the current value of the ship, and the best indicator of that value is, undoubtedly, its secondhand value. This is clearly acknowledged by Heaver (1985) who rightly remarks that: "Close attention to the market value of a ship as a measure of its real capital value is consistent with the economist's emphasis on the opportunity cost of assets." Thus the use of secondhand values in this study. An important advantage of secondhand values is that they implicitly take account of technological progress (which has taken place in shipping since the emergence of fuel-efficient economy class vessels) because by reflecting current natural market values, they also reflect the rate of technological obsolescence de facto.

6.2 The data and model

Data for deriving the value of ships was obtained from secondhand sales publi shed in Drewry's Shipping Statistics and Economics' published monthly, for the year 1982. A total of 424 observations were collected from this source for the months of January-December, 1982. The data was classified into secondhand value, size in dwt, age, speed, type of propulsion unit and the month of sale. Care was taken to exclude all sales on credit, those involving time charters, and all sales with some conditions such as: 'as is', 'where is', 'subject to inspection', 'subject to licences' and other conditions likely to introduce bias into the estimate. After these eliminations, the data was reduced to 377 observations composed of 235 bulk carriers, 126 tankers and 16 combination carriers - the latter were left out in the estimation.

Because, traditionally, secondhand values have tended to follow the underlying pattern of freight market conditions, it was thought necessary to examine this relationship with a view to bringing in freight rates as one of the independent variables determining the cost of secondhand values. The examination proved fruitful as can be seen in figures 6.1 and 6.2 which show the positive relationship between secondhand values and freight rates for the period 1972 - 1983 for bulk carriers and tankers, respectively.

Figure 6.1
The influence of frieght rates on secondhand values
1975 – 1982
Bulk Carriers

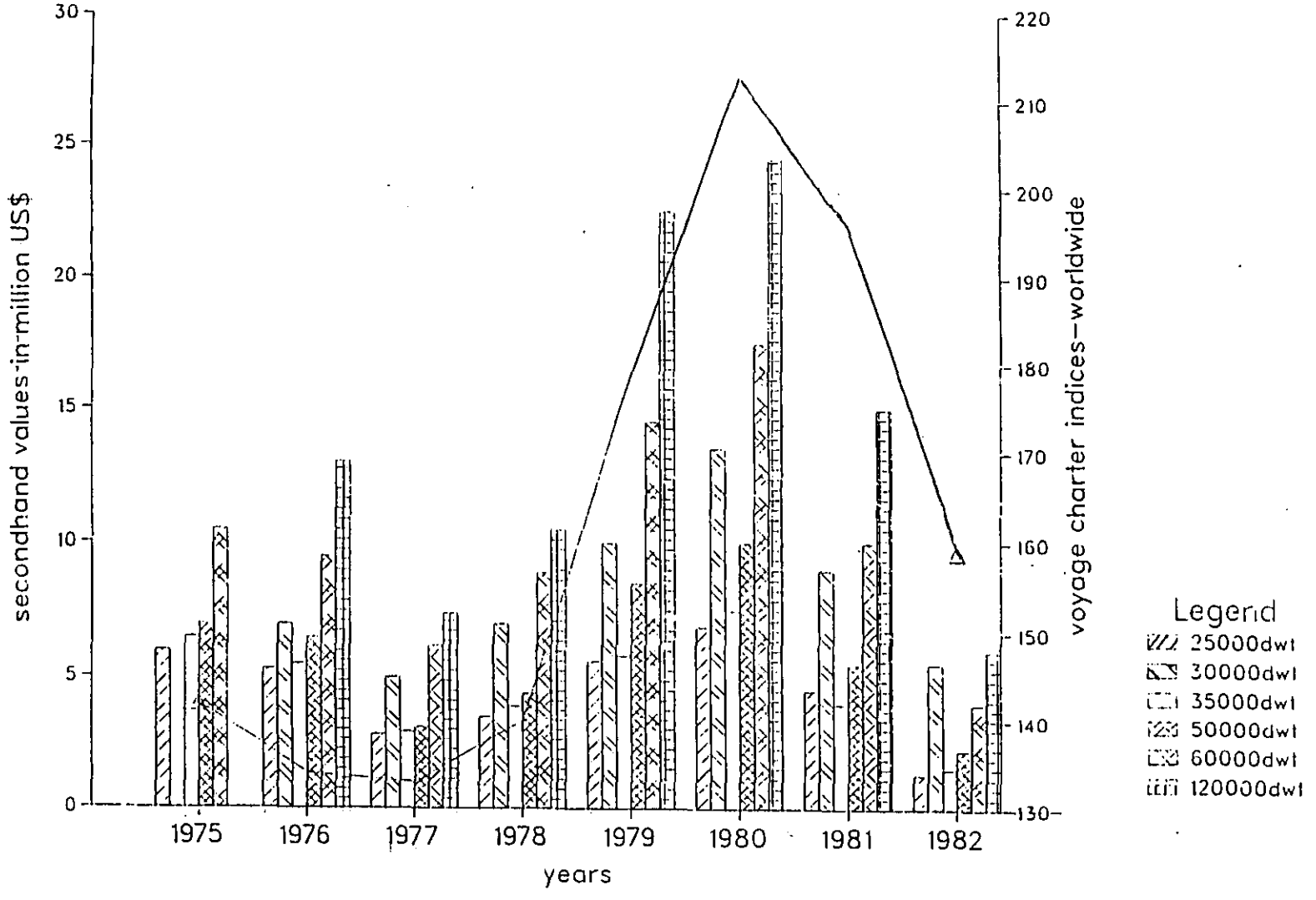
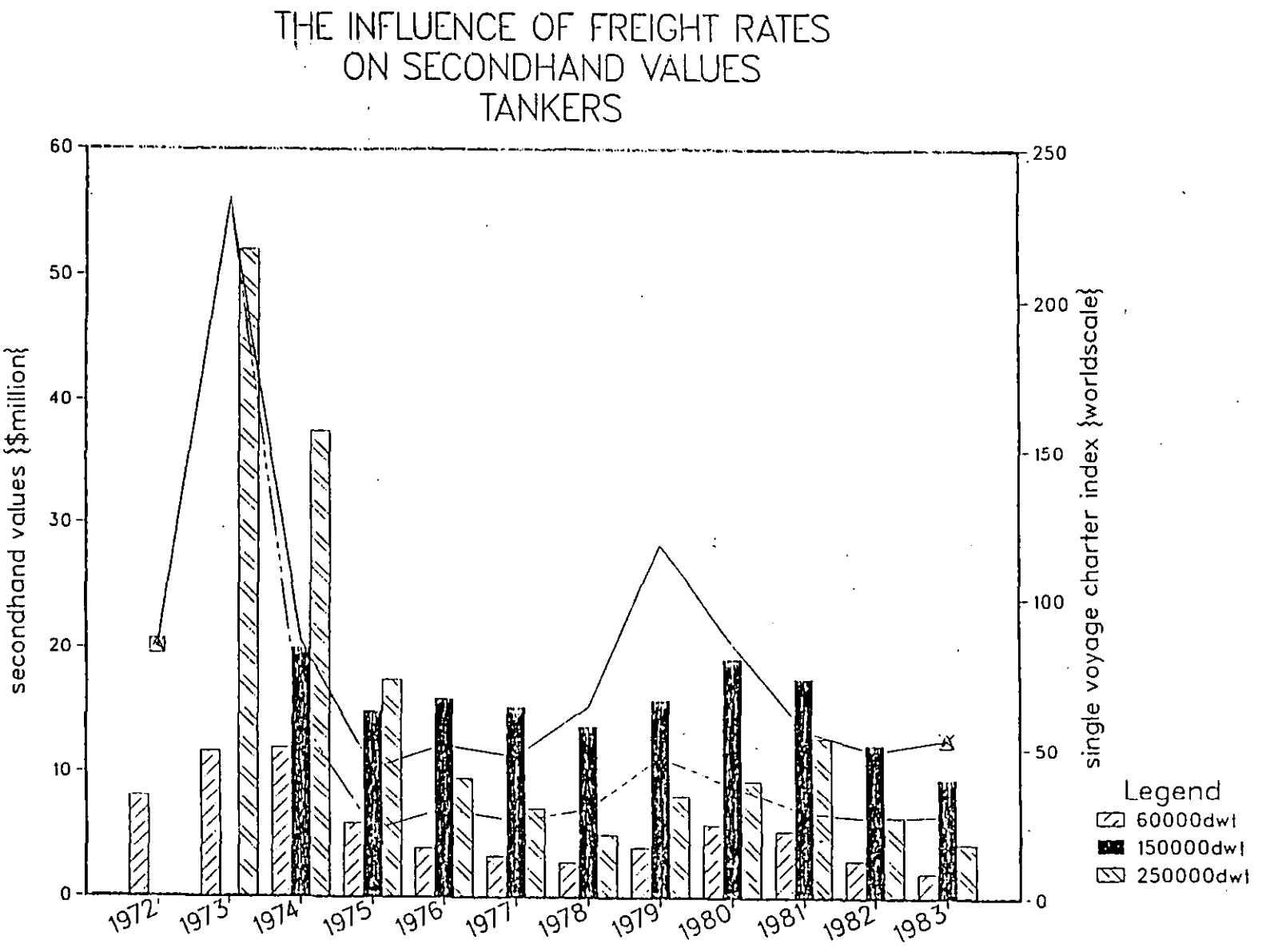


Figure 6.2


THE INFLUENCE OF FREIGHT RATES
ON SECONDHAND VALUES
TANKERS
secondhand values {$million}
single voyage charter index {worldscale}
0
10
20
30
40
50
60
0
50
100
150
200
250
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
Legend
60000dwt
150000dwt
250000dwt

For estimation purposes, a linear multiple regression equation of the form:

$$K = b_o + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + U_t \qquad \ldots (6.2)$$

was developed where:

K = secondhand value

X_1 = age of ship

X_2 = ship size (dwt)

X_3 = speed (knots)

X_4 = time charter index

X_5 = propulsion dummy (tankers only : 1 = steam turbine, 0 = diesel engine)

U_t = stochastic disturbance term at month t when the sale was made.

The time charter indices for bulk carriers were those of the Norwegian Shipping News taken from OECD's 'Maritime Transport' 1982. For tankers, AFRA (Average Freight Rate Assessment) rates published by the London Tanker Brokers Panel were used. For both bulk carriers and tankers monthly freight indices were matched with monthly secondhand sales. As the indices covered different size categories, the appropriate index was matched with its relevant ship size. This alignment of the data was necessitated by the need to fully encapsulate monthly variations in demand conditions.

6.3 Results and estimates of annual capital cost

It is clear from (6.2) that the predicted value of K will represent the average secondhand value for 1982. This is justified by the results. The multiple correlation coefficient R^2 (after adjustment for degrees of freedom) =0.93 for bulk carriers and 0.92 for tankers. This means that 93% of the variations in the secondhand market values of bulk carriers is explained by the above variables and a corresponding 92% for tankers. It also means that only 7% and 8% of the variations in bulk carrier and tanker market values, respectively, are due to errors not accounted for by the independent variables but subsumed under the portmanteau variable, U_t.

The regression results are:

Bulk Carriers:

$$K = 10.2 - 0.506\ age + 0.00037\ size - 0.374\ speed + 0.0218\ time\ charter$$
$$(8.79)\ (-47.32)\quad (14.25)\quad (-4.85)\quad (16.43)\quad \ldots (6.3)$$

Tankers:

$$K = 8.71 - 0.573age + 0.00021\ size + 0.0167\ AFRA - 3.72\ propulsion\ dummy$$
$$(19.72)\ (-24.56)\quad (13.18)\quad (6.77)\quad (-14.38)\quad \ldots (6.4)$$

As can be seen from the t-ratios in parentheses, all coefficients of equation (6.2) are significantly different from zero at the 1% level of significance and with the right signs.

It is noticeable that the importance of ship size in determining secondhand values is trivial for both vessel types because other variables, such as age which is an embodiment of technological progress or obsolescence, speed (which is a proxy for fuel consumption in the case of bulk carriers) and type of engine (also determining fuel consumption for tankers) have become far more important in the 1980's than ship size. The enormous loss in value of VLCC/ULCC was mentioned above in respect of insurance costs, and this result attests to that analysis.

The empirical significance of the results is very strong. The relatively high values of the speed and propulsion dummy coefficients for bulk carriers and tankers respectively, underlines the importance of the cost of fuel in marine transport, such that shipowners are highly sensitive to the speed and type of engine of a vessel because of their fuel consumption implications. In these times of slow-steaming, it is no wonder that a given tanker in 1982 cost $3.72 million less if it was a steam-turbine vessel. For bulk carriers, the average secondhand value will be $374,000 less for every additional knot of speed. Speed was dropped from the tanker equation after F-test showed that it did not contribute significantly to the tanker regression, instead the propulsion dummy was used. Such a dummy was not necessary for bulk carriers as the data is comprised only of diesel vessels.

The empirical significance of the results with respect to fuel consumption proxies is discernible from table 6.1 below.

Table 6.1 Fuel consumption per day, tankers (tons)

Vessel size (dwt)		60,000		150,000		250,000	
Engine type		diesel	steam	diesel	steam	diesel	steam
At Sea:	FO	60	95	98	132	119	161
	DO	2	--	3	---	3	---
In Port:	FO	12	19	34	46	50	72
	DO	2	--	2.5	--	3	--

NOTES: FO = heavy fuel oil

DO = marine diesel oil

Source: Drewry (1983c), Ship Scrapping

This table clearly shows that motor (diesel) engines are considerably more fuel-efficient and therefore incur lower fuel costs than steam-turbined engines. Their unsuitability for slow-steaming (a common practice in the tanker trade today) coupled with their high fuel consumption make them unable to compete in the depressed markets of the 1980's and hence led to relatively higher steam-turbine tonnages (78% of all ships scrapped in 1982) being scrapped. Our results are further substantiated by the inexorable decline of shipping, as a whole, propelled by steam-turbine engines. In fact, of the 2,600 ships ordered in 1982 according to Fairplay, only 19 were steam turbine ships, out of which 8 were designed to burn oil and gas, and 4 designed to use coal; that effectively leaves only 7 proper steam engine ships (OECD, 1983).

6.3.1 Estimation of annual capital cost

Equations 6.3 and 6.4 provided the basis for estimating the current values of the ships of the operating cost survey. After deriving the current values, a maximum ship life of 20 years was assumed for all vessels. It may seem more appropriate to use a ship life of 15 years because of the rapid technogical progress which has taken place in ship design in recent years and thus ipso facto brings about a quicker ship obsolescence. It should be noted in this regard that the concept of obsolescence in maritime economics is different from the physical meaning of obsolescence in that in shipping it is not necessarily a function of ageing which is an evolutionary process but rather can occur suddenly because of the

vicissitudes of the freight market. Thus the 20-year life assumed in this thesis. Moreover, it was found that the use of a 15-year assumption did not in any way change the results based on the 20-year life.

Annual capital costs were obtained by discounting ships' capital values by a constant annuity (as represented by the denominator in the capital term in equation 6.1) over the difference between the current age of the vessel and 20 years, ie. capital value divided by the relevant annuity. While it was recognised that vessels were likely to have some residual value after a 20-year life, the present value of a ship and hence its net present value after discounting would be comparatively small especially in the light of the technical advances in ship design mentioned above. Thus scrap values were not considered. In order to reflect the spatial and temporary variations in the opportunity cost of capital discount rates of 8, 10 and 12% were used. For the purpose of this study the 10% discount rate was chosen as the best representative average of the opportunity cost of capital in most countries because "to use, for any reason, too high a discount rate will introduce a systematic bias in favour of short-lived techniques (like secondhand ships) and against capital-intensive ones; to use too low a discount rate will favour long-lived and capital intensive ones" (Goss, 1985a, op.cit.).

One disadvantage with the constant annuity method is its assumption of constancy in the capital value of the ship and hence static technological progress over the life of the ship. This problem, as suggested by Goss, can be overcome by substituting a tilted annuity for the constant one by merely adding an 'annual rate of development' percentage to the discount rate employed in the annuity formula. Despite this seeming shortcoming of the assumption of constant annual capital charge, its main advantage as Laing (1975) noted is that it allows comparisons of different shipping systems to be made at <u>a point in time</u> as opposed to comparison <u>over a period of time</u>. Because the purpose of this study is not to forecast the changes in the capital value of ships over time but to fairly accurately estimate their annual capital costs at a particular point in time which is 1982, the approach is justified.

For the same reason, the plausibility of operating cost increases and variations in output levels as represented by equation 5.2 was not essential to the purpose of this study. In fact in the case of equation 5.2, specifying a single growth rate (in real terms) would be presumptuous in the sense that it would create the unrealistic impression that the cost differentials between the two flag groups would remain the same as those of the base-year throughout the lives of the ships. As Appendix D shows, the costs of the two groups grow at different rates, therefore different rates of growth are needed to fully capture cost variations in real terms over the trading lives of the ships, if comparison of differentials over a period of time is the aim.

All calculations are made in real terms, and no attempt was made at forecasting inflation rates. This would have been necessary if fixed-interest or floating-interest loans were considered. For the reasons already enumerated, mainly the fact that loans can be obtained at sub-optimal rates, coupled with the fact that it is argued that the advantages of such finance tend to be passed on to shippers, albeit because of competition, loans, because of this implied transfer effect, are not part of the capital cost calculations.*

Annual capital costs were reduced to daily capital charge and added to daily total operating costs as described by the daily cost per ton method. To be able to compare costs of ships of different sizes, total ships' costs per 1000 dwt were regressed on ship size per 1000 dwt following equation 5.4. The unit costs obtained are the shadow freight rates defined in section 5.1. Theoretically, a shadow freight rate is that which will bring about a net cash flow, which after allowing for a given level of profit and discounting at a chosen discount rate, gives a net present value of zero or an internal rate of return precisely equal to the opportunity cost of capital. Generally this is given as:

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* See Goss (ibid) for reasons why loans from a social cost standpoint may be left out of capital cost calculations.

$$NPV = \text{zero} = \left[\sum_{i=1}^{i=n} A_i \, (1 + r)^{-i}\right] - C_o \qquad \ldots (6.5)$$

where A_i = net cash flow (ie. excess of cash revenue over cash costs in year i);
and all other terms as previously defined.

If we write f = freight rate per dwt

Q_i = output in year i (dwt)

C_{pi} = total operating costs in year i

then the expression A_i becomes $(fQ_i - C_{pi})$.

Equation 6.5 can then become:

$$NPV = \text{zero} = \left[\sum_{i=1}^{i=20} (fQ_i - C_{pi})(1 + r)^{-i}\right] - C_o \qquad \ldots (6.6)$$

6.6 can be rewritten to provide the shadow freight rate (Sf) as:

$$Sf = \frac{\frac{1}{Q}\left\{\frac{C_o}{\left[\frac{1 - (1 + r)^{-n}}{r}\right]} + C_{pv}\right\}}{Q_d} \qquad \ldots (6.7)$$

where Q in our case is ship size per 1000 dwt and other terms as previously defined.

The unit total cost derived by the above method represents the long-run equilibrium freight level because at any freight rate above it, higher rates of return obtainable would increase the opportunity cost of a shipping investment and thereby would tend to increase the supply of ships in the market. Since bulk freight markets are competitive, such increases would bring about a fall in rates. Conversely, at rates below Sf shipowners would be less willing to put more ships on the market; the supply of ships would be reduced and the competitive market mechanism would force rates to rise. The shadow freight rate is therefore the equilibrium long-term rate about which market rates will tend to fluctuate, and thus a suitable basis for comparing open registry and traditional registry costs with their freight rates.

The validity of the methods employed in this study are borne out by the results. The regression results establishing different Sf values

for varying levels of Q are:(Y=total costs/1000dwt; X=size/1000dwt)

Bulk Carriers:

All data: $Y = 3011\ X^{-0.751}$
(99.82)(035.08)

$\bar{R}^2 = 0.93$; S.E. = 0.1429

Open Registries: $Y = 2893\ X^{-0.756}$
(66.27)(-23.71)

$\bar{R}^2 = 0.95$; S.E. = 0.1176

Traditional Registries: $Y = 3103\ X^{-0.749}$
(82.72)(-28.86)

$R^2 = 0.93$; S.E. = 0.1425

Tankers

All data: $Y = 4817.45\ X^{-0.842}$
(53.96) (-24.65)

$\bar{R}^2 = 0.94$; S.E. = 0.1797

Open Registries: $Y = 7555\ X^{-0.952}$
(37.40)(-19.14)

$\bar{R}^2 = 0.97$; S.E. = 0.1402

Traditional Registries (i): $Y = 4964\ X^{-0.833}$
(33.28)(-14.69)

$\bar{R}^2 = 0.89$; S.E. = 0.2246

Traditional Registries (ii): $Y = 4105.16\ X^{-0.800}$
(40.21) (-17.55)

$\bar{R}^2 = 0.93$; S.E. = 0.1771

(Note: (i) regressions including U.S. ships, and
(ii) excluding them - European ships only)

Further evidence of the statistical and empirical validity of the shadow price estimations can be seen in figures 6.3 and 6.4 which show the spread of the actual data points along the regression line for all the observations in the two vessel categories for a 10% discount rate.

6.4 Total cost differentials

Bulk carriers

Table 6.1 shows the total shipping cost differentials between open registry ships and those under the traditional shipping nations.

Figure 6.3

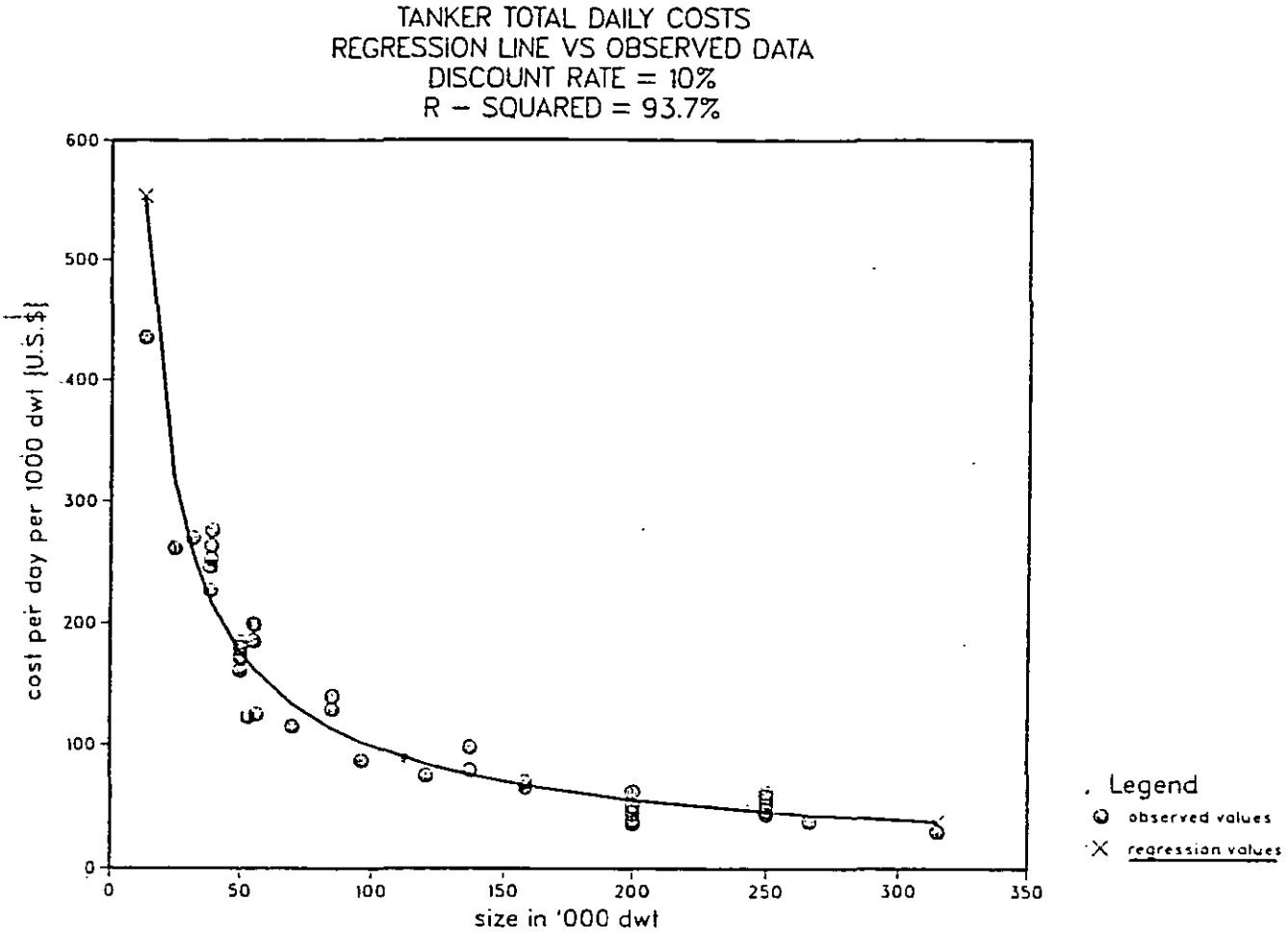


Figure 6.4

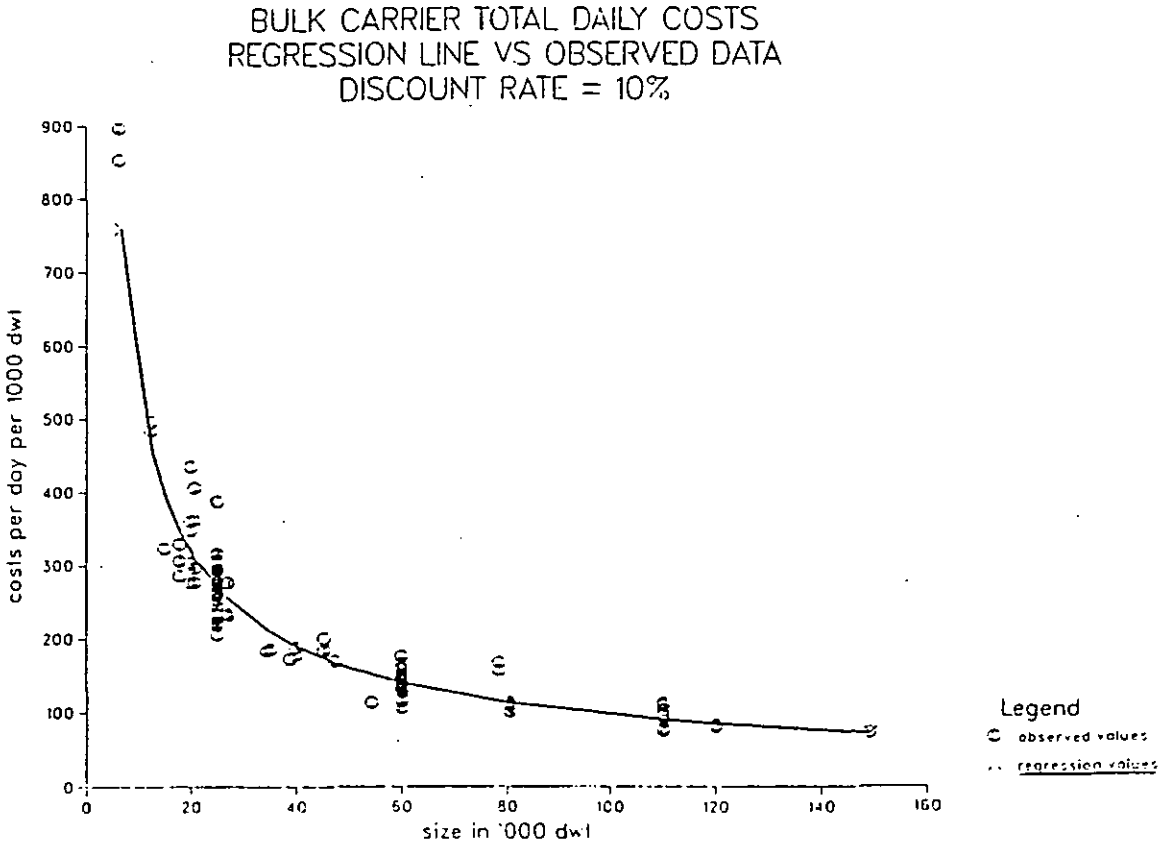


Table 6.1a Bulk carrier total operating and capital cost differentials ($)

Vessel size (dwt)	Cost/1000 dwt / day OR	Cost/1000 dwt /day TC	Differential (3-2)	Cost/day OR	Cost/day TC	Differential (6-5)
5,000	857	930	73	4285	4650	365
10,000	507	553	46	5070	5530	460
20,000	300	329	29	6000	6580	580
40,000	178	196	18	7120	7840	720
60,000	131	145	14	7860	8700	840
80,000	105	117	12	8400	9360	960
100,000	89	99	10	8900	9900	1000
120,000	78	86	8	9360	10,320	960
140,000	69	77	8	9750	10,950	1120
150,000	65	73	8	9750	10,950	1200
160,000	62	69	7	9920	11,040	1120
180,000	57	63	6	10,260	11,340	1080

As will be expected the costs per 1000 dwt and costs per day are higher than those of total operating costs because of the relative greater total shipping costs. Within the range of our data, table 6.1 confirms that on a total shipping cost basis open registry operations also result in large savings in bulk carrier operations. The annual savings range from a low of $127,750 - $420,000.

Tankers

Tanker total cost differentials are given in tables 6.2 and 6.3. In the same manner as the results for total operating costs, tables 6.2 and 6.3 show that open registry tanker opeations at the lower size end are more expensive and thus less attractive than operations at the larger size end. With the exclusion of the high cost U.S. ships, table 6.3 shows that operations under traditional nations are far more economical for product carriers, for the reasons given above. The high savings realisable by open registry operations of well over $1 million for VLCC and ULCC's lend credence to the higher concentration of open registry ships in these categories.

By and large, the results of these analyses are, to a large extent, supported by empirical reality as has been demonstrated in this chapter.

Table 6.2 Total tanker operating and capital cost differentials ($)

Vessel size (dwt)	Cost/1000 dwt /day OR	Cost/1000 dwt /day TC	Differential (3-2)	Cost/day OR	Cost/day TC	Differential (6-5)
5,000	1632	1298	-334	8160	6490	-1670
20,000	436	409	-27	8720	8180	-540
30,000	296	292	-4	8880	8760	-120
40,000	225	230	5	9000	9200	200
60,000	153	164	11	9180	9840	660
80,000	117	129	12	9360	10,320	960
100,000	94	107	13	9400	10,700	1300
150,000	64	76	12	9600	11,400	1800
200,000	49	60	11	9800	12,000	2200
250,000	39	50	11	9750	12,500	2750
300,000	33	43	10	9900	12,900	3000
350,000	29	38	9	10,150	13,300	3150
500,000	20	28	8	10,000	14,000	4000

Table 6.3 Total tanker operating and capital cost differentials excluding U.S. ships ($)

Vessel size (dwt)	Cost/1000 dwt /day OR	Cost/1000 dwt /day TC	Differential (3-2)	Cost/day OR	Cost/day TC	Differential (6-5)
5,000	1632	1133	-499	8160	5665	-2495
20,000	436	374	-62	8720	7480	-1240
40,000	225	215	-10	9000	8600	-400
50,000	182	180	-2	9100	9000	-100
60,000	153	155	2	9180	9300	120
80,000	117	123	6	9360	9840	480
100,000	94	103	9	9400	10,300	900
150,000	64	75	11	9600	11,250	1650
200,000	49	59	10	9800	11,800	2000
250,000	39	50	11	9750	12,500	2750
300,000	33	43	10	9900	12,900	3000
350,000	29	38	9	10,150	13,300	3150
500,00	20	28	8	10,000	14,000	4000

However, some more rigorous analyses of the structure of costs, their inter-dependence in the sense of substitution possibilities and those of complementarity, scale economies are necessary for a better understanding of the cost differentials between the two flag groups and their possible causal factors in the light of the analyses undertaken so far. Moreover,

whilst the analyses of this chapter have revealed total cost differentials at varying size levels, it is important to know the composition of these differentials in terms of the proportions of the differentials that can be attributed to each of the cost components, in order to identify the most important cost element in the differential. These are the analyses taken up in chapter 7.

CHAPTER 7

A TRANSCENDENTAL LOGARITHMIC COST MODEL

"Econometric research on production functions is growing ever more sophisticated as far as functional forms and statistical methodology are concerned. Nevertheless the results of this research are not comforting. The increasing degree of sophistication has, by producing many widely diverging results, served to reveal and expose our ignorance in this field rather than to produce firmly established knowledge."

Johansen (1972)

In the last two chapters the cost differentials between open and traditional shipping registries have been analysed. The cost models used there are restrictive in that they inherently contain a priori assumptions regarding the structure of the production technology and elasticity of substitution akin to a Cobb-Douglas type of model. The main aim of those chapters, however, was not to carry out a detailed and rigorous modelling of the shipping industry vis a vis the two flag groupings, but to derive cost differences due to differences in vessel size.

In this chapter a more sophisticated econometric cost model based on the neoclassical production theory is undertaken. Whilst theoretical and empirical studies of the dynamics and mechanics of the freight market have received considerable attention, as will be seen in the next chapter, detailed econometric work on shipping costs is very scant. Work by Hettena and Ruchlin (1969), Johansen (1972) and Eide (1979) needs to be mentioned however. For the purpose of this thesis such a rigorous and detailed analysis of costs is necessary on four grounds.

First, to further explain the possible causal economic factors underlying the cost differentials discussed earlier; by way of throwing light on factor substitution possibilities in shipping generally and for the registry groupings particularly.

Secondly, to examine how shipowners react in their demand for factors following a change in their prices and those of others.

Thirdly, to examine the degree of scale economies in the industry for the respective registry groups; and finally, to provide a breakdown of the total cost differential between the groups and show the proportion due to the different elements of cost with a view to identifying the largest contributing element to the total differential; in other words, the main cost centre for which the open registries have a competitive edge. For this purpose a functional form called the transcendental logarithmic cost function (translog) is used.

7.1 The Translog Cost Function and its Suitability for the Bulk Shipping Industry

The technological and economic characteristics of a shipping service employing several factors to produce a single output can be represented by the physical relationship between inputs and outputs or similarly by a relationship between input prices and cost. The latter alternative is made possible by the recent application of the theory of duality in production and cost studies in economics (see Diewert (1974) for a survey of the literature on duality). The essential contribution of this theory to the study of production costs is that the structure of production can be studied empirically either by the use of a production or a cost function as the two functions are dual to each other (Shephard, 1953). It is noted that for econometric reasons the use of the cost function is more attractive when output levels and factor prices are exogenously determined and the production function better when output and input levels are endogenous (Christensen and Greene, 1976 and Viton, 1981).

Until the introduction of flexible functional forms, the modelling of production has been based on highly restrictive functional forms of the Cobb-Douglas and Constant Elasticity of Substitution (CES) models (see Cobb and Douglas (1928), Douglas (1976), and Arrow et al (1961)). Whilst these single equation models appear to be suitable for modelling the

production alternatives of a two-input single-output firm, ~~it~~ they imply, in the context of several inputs, that the partial elasticities of substitution between all pairs of factors are equal. This means that the degree of substitution between any pair of factors is constant, thereby, ruling out a priori the possibility of complementarity between factors. Both Uzawa (1962) and McFadden (1963) have shown that these functional forms are highly restrictive in modelling the structure of production.

Since the 1970's several econometric models which avoid such restrictions have been developed. Amongst this family of models is the translog (see Fuss et. al. for a survey of these functional forms). The translog as a flexible functional form does not place any a priori restrictions on the structure of production and thus enables the researcher to test different hypothesis regarding the structure of the producing unit and the nature of economic relationships between factors. As will be seen, since the specification can be considered an approximation to an arbitrary cost structure, the problem of assuming a particular production technology is avoided. Furthermore, the existing cost models (ie. Cobb-Douglas) can be treated as restrictive cases of the translog model as demonstrated later in this chapter.

Unlike the classical theory of production, neoclassical production theory is based upon the assumption that there are no fixed, nonaugmentable factors of production (Ferguson, 1969); and makes very few assumptions about the structure or technology of production, in that restrictions on the functional model of production are not made a priori but are based on behavioural assumptions about the firm, ie. cost minimisation, profit maximisation or output maximisation from given inputs (production efficiency). It follows that in the econometric estimation of a given technology, knowledge of both the technology and the economic environment in which it operates is essential in order to avoid imposing constraints that are empirically indefensible. It is thus essential to discuss neoclassical theory of production in the context of bulk shipping.

In the opening chapters of this thesis it has been emphasised that of all the commercial attractions of open registry shipping, cost minimisation is the primary motive behind operating ships under open registries. Ten years ago, according to Drewry (op. cit), the operating cost differential between open and North European registries was something in the order of 50%, in recent years this gap has been reduced to 20% due, mainly, to inflationary pressures on costs. Yet, despite this narrowing gap between the two groups and international and trade union pressures in recent years, owners in high cost countries are still registering new ships or reflagging old ones under these registries. The main attraction, undeniably, as the analyses of this chapter and the next will confirm, is the cost advantage. In shipping, where freight revenues are determined by market forces, outside the control of the shipowner, cost minimisation is an essential objective of managment more than profit maximisation.

On this score, a cost model capable of modelling the behaviour of shipping firms towards changes in costs is desirable. The translog model which derives its theoretical basis from neoclassical production theory is a cost minimising model based on the neoclassical assumption that given free market prices of factors of production, producers will always employ the cost minimising input level for the prodcution of a given output. If, therefore, bulk shipowners are cost minimisers because of the near perfect competition conditions of the factor and freight markets which they operate in, then the translog cost function can be used to represent that behaviour.

Another suitability of the translog for modelling shipping costs in the bulk sector derives from the fact that it implicitly assumes, in accordance with production theory, that the factors of production are bought and sold in competitive markets. Meaning that the factor prices should be exogenously determined. As a neoclassical cost function it also requires that the level of output be exogenous. In shipping all factors of production: crew costs, repairs and maintenance, stores, provisions, spare parts, fuel, insurance and management services are

externally determined by the market. Equally, output levels (ie. the volume of cargo and the distance) are also determined by demand, which again is outside the control of the shipowner. Given these conditions, the bulk shipping sector meets the conceptual requirements of neoclassical production theory and thus justifies the application of the translog cost model.

The translog functional form is a production function which represents the production possibility frontier by functions that are quadratic in the logarithms of the quantities of inputs and outputs or equivalently in the prices of inputs and costs. The arguments of the cost function are the levels of output and factor prices. Thus in view of the exogenous nature of these arguments, the cost function application is appropriate, (Christensen and Greene (ibid), Viton (ibid)). This model, first proposed by Christensen et al (1973), can either be used as an exact cost function representing the true function or as a second-order local Taylor series approximation to an unknown underlying function about a point, ie. the sample mean of the arguments (see Chakrabarty, 1983, for a comprehensive survey of the literature on translog production functions). The principal advantage of the translog model over other functional forms lies in its flexibility, as noted above in connection with the Cobb-Douglas and CES forms. It does not impose ex ante untested assumptions about the structure of production, substitution patterns and scale effects. It is intended, therefore, not only for the examination of cost variations between the two flag groups but more importantly to provide insight into the nature of the structure of shipping services and the various economic relationships between factors and output. It is noteworthy that whilst the translog has been widely applied to land and air transport (for example, Friedlander and Spady, 1981; Harris, 1977; Caves et al, 1984, 1981, 1980; Berechman, 1983; Williams and Dalal, 1981; and Viton, 1981; see Button and Pitfield eds. (1985) for a survey of railway applications), there is no known maritime application.

7.2 The General Model

By accepting that effective cost-minimisation management describes the way the shipping industry operates, a neoclassical cost function can be used to estimate the characteristics of the production technology of bulk shipping services by invoking Shephard's (1953) duality theorem.

The transformation function of a general production structure can be written as:

$$Q = F(X_1, \ldots, X_n) \tag{7.1}$$

where F is the production function of a single-output (Q) and multiple-input (X_i) firm. If the cost-minimising input mix is employed for any given level of output, resulting in a convex input structure, then there exists a unique cost function dual to (7.1) (Diewert, 1974; Lau, 1976; and McFadden, 1978).

$$C_T = G(Q, W_1, \ldots, W_n) \tag{7.2}$$

where Q is a vector of output quantities and W a vector of factor prices, with C_T representing total cost. It is important to note that equation (7.2) provides the solution to

$$\min_x \sum_i W_i X_i \quad \text{subject to } F(Q,X) = 0 \tag{7.3}$$

It gives the shipping companies' minimum cost of producing Q services at factor prices W, assuming they face no binding constraints in their choice of X. Equation (7.2) is nondecreasing in its arguments and concave in W for all Q. If cost-minimisation is not practised, then the total cost function is invalid (see Caves et al, 1981). However, if the firm is restricted in its choice of the levels of some factors (for instance due to their fixed or quasi-fixed nature), but is able to choose the quantities of the variable factors to minimise expenditures on them (variable factors), conditional upon the level of output and the other inputs, then there exists a variable or short-run cost function dual to (7.1), thus:

$$C_V = H(Q, W_1, \ldots, W_n, Z_1, \ldots, Z_m) \tag{7.4}$$

which solves

$$\min_{x_V} \sum_i W_i . X_{V_i} \quad \text{subject to } F(Q, X_F, X_V) = 0 \qquad (7.5)$$

where the Z_is are fixed or quasi-fixed factors ~~prices~~ and the subscripts F and V denote fixed and variable factors, respectively (and $C_V = \sum_{i=1}^{n-m} W_i . X_i$).

Both the total and variable cost specifications provide information necessary for inferring the production characteristics of the technology.

The function is treated as a second-order local approximation to an abritrary underlying function. In the approximation approach, the properties of the underlying function (ie. the value of the function and its first and second derivatives) are inherited by the approximating function at a point - in our case at the sample means of the Q and W vectors. This approach is favoured here because it is more convenient for analytical purposes to talk about the "typical operator" operating at average cost and output levels within the range of our data. The approach also has its theoretical advantage in that, although the function can be treated as an exact representation of the true cost function, Friedlander and Spady (1981) argue that "... it is difficult to argue that a translog cost function is an exact representation of a cost function throughout the conceivable range of its arguments.", since concavity in W (which is an important technical property which any well-defined cost function must have) cannot hold globally. Therefore, they argue that an approximation interpretation of the translog is inevitable.

The general form of the translog function for the two specifications is:

$$\ln C_T = \ln\alpha_0 + \alpha_Q \ln Q + \sum \beta_i \ln W_i + \tfrac{1}{2}\xi (\ln Q)^2 + \tfrac{1}{2}\sum\sum\gamma_{ij} \ln W_i \ln W_j + \sum \rho_{iQ} \ln W_i \ln Q \qquad (7.6)$$

$$\ln C_V = \ln\alpha_0 + \alpha_Q \ln Q + \emptyset \ln F + \sum \beta_i \ln W_i + \tfrac{1}{2}\xi(\ln Q)^2 + \tfrac{1}{2}\pi_F(\ln F) + \tfrac{1}{2}\sum\sum\gamma_{ij} \ln W_i \ln W_j + \sum \rho_{iQ} \ln W_i \ln Q + \sum \lambda_{iF} \ln W_i \ln F + \theta_{FQ} \ln F \ln Q \qquad (7.7)$$

where F in (7.7) denotes fixed or quasi-fixed factors. To correspond to a well-behaved production function, the cost function must be positive and homogenous of degree one, non-decreasing and concave in factor prices

(W_i) (see McFadden, 1980, pp. 75-76 for the properties of a well-behaved cost function), implying that the following parametric restrictions must hold,

$$\Sigma\beta_i = 1; \Sigma\gamma_{ij} = 0(\forall_j); \Sigma\rho_{iQ} = 0; \Sigma\lambda_{iF} = 0 \qquad (7.8)$$

Shephard (ibid) has shown that a convenient feature of the cost function approach is that the derived demand functions for the factors of production can be easily derived by partially differentiating the cost function with respect to factor prices. The result known as Shephard's lemma yields the factor share equations, thus:

$$\frac{\partial \ln C_T}{\partial \ln W_i} = \frac{\partial C_T}{\partial W_i} \cdot \frac{W_i}{C_T} = \frac{W_i X_i}{C_T} = S_i \qquad (7.9)$$

where X_i is the cost minimising input level of the ith factor required to produce Q units of output, and S_i the share of the ith factor in total cost. In the context of the normalised cost function S_i can be written as:

$$S_i = \beta_i + \sum_j \gamma_{ij}(\ln W_j - \ln \bar{W}_j) + \rho_{iQ}(\ln Q - \ln \bar{Q}) + \varepsilon_i \qquad (7.10)$$

for the total cost function (7.6). Where ε_i is the relevant disturbance term and $\bar{W}$ and $\bar{Q}$ are the sample means.

Once estimated, the parameters of the cost function provide information required for the estimation of scale economies, factor demand, substitution and price elasticities. Uzawa (1962) has shown that the Allen (1938) partial elasticities of substitution can be derived from the cost function as:

$$\sigma_{ij} = \frac{CC_{ij}}{C_i C_j} \qquad (7.11)$$

where $C_i = \frac{\partial C}{W_i}$; $C_{ij} = \frac{\partial^2 C}{\partial^2 W_i \partial W_j}$; $\sigma_{ij} = \sigma_{ji}$

In terms of the translog function this means:

$$\sigma_{ij} = (\gamma_{ij} + S_i S_j)/S_i S_j; \; i \neq j \qquad (7.12a)$$

$$\sigma_{ii} = [\gamma_{ii} + S_i(S_i - 1)]/S_i^2 \qquad (7.12b)$$

The importance of this measure lies in the fact that positive σ_{ij} means substitution while a negative value indicates complementarity. $\sigma_{ij}=0$ indicates that the inputs are in fixed proportions. Allen has also demonstrated that the factor price elasticities are analytically related to the partial elasticities of substitution in (7.12) as:

$$E_{ij} = S_j\sigma_{ij}; \text{ and } E_{ii} = S_i\sigma_{ii} \qquad (7.13)$$

with $\sigma_{ij} = \sigma_{ji}$ and $E_{ij} \neq E_{ji}$

Furthermore, scale economies (S_e) are measured as unity minus the elasticity of total cost with respect to output, viz:

$$S_e = 1 - \frac{\partial \ln C}{\partial \ln Q} \qquad (7.14)$$

Where in our case:

$$\frac{\partial \ln C}{\partial \ln Q} = \alpha_Q + \xi_{QQ}(\ln Q)\rho_{KQ}(\ln K) + \rho_{MQ}(\ln M) + \rho_{RQ}(\ln R) + \rho_{SQ}(\ln S) \text{ for}$$

individual output levels; with positive values of S_e implying scale economies and negative values diseconomies (Christensen and Greene, 1976).

7.3 Data and Estimation Procedures

The data for the analyses of this chapter was obtained from the operating cost survey and capital costs synthesised from secondhand values as treated in chapters 5 and 6 above. Due to missing values for the six components of operating costs as defined in section 5.2, the total sample size of 147 ships was reduced to 117; consisting of 86 bulk carriers and 31 tankers - 60 traditional vessels and 26 open registries' in the bulk carrier set and 20 traditional and 11 open registry tankers. Because of the smallness of the tanker data set, it was found to be difficult to carry out any reasonable estimation of the cost function separately on the two flag groups. To overcome this difficulty it was necessary to interpolate cost values for the missing observations in the total tanker sample of 47 ships - see table 5.1. This was done by using the regression equations in table 5.3 to derive daily cost values for manning, repairs and maintenance, stores and provisions, and administration costs. For the cost of insurance, the linear models given in section 5.5.4 were used for prediction because of their stronger explanatory power

and hence reliability, coupled with the fact that the insurance cost component is the least amenable to size effects, as discussed in chapter 5. Daily costs so derived were annualised by multiplying them by the average trading days of 350 days for the data sub-sets - table 5.1. This exercise brought the TC tanker observation to 24 and that of the OR to 23.

Capital cost for the synthesised data was obtained by applying equation (6.4) in chapter 6 to the characteristics of the ships with missing values (ie. their size, age and propulsion unit). For the remaining data, averages were used (ie. the average age of the sample sub-set as given in table 5.1) and for size, sizes over 100,000 dwt were used as the average tanker size for the two groups (table 5.1) is over 100,000 dwt. This use of tankers over 100,000 dwt also simplified the assumption on propulsive systems. As mentioned in appendix C.2.2 the majority of the world's tankers in the large-size category are turbine-engined. The additional ships were, therefore, assumed to be turbine ships. Having predicted capital values, the annuity method as described in section 6.3.1 was used in deriving annual capital costs.

The definition of a cost function implies that the right-hand side variables are unit input prices and accordingly four factor prices are defined; Capital (K), Manning (M), Repairs and Maintenance (R), Lubricating Oil, Stores and Provisions (S). In order to obviate the problem of insufficient degrees of freedom, the parameters of the cost function were limited to a manageable size, by aggregating insurance and administration costs with capital costs. This approach is tenable on the grounds that a ship's hull value is one of the determinants of insurance premium (appendix C.2.4). Even though ship size was used in the analyses of chapter 5 as a proxy for hull value, the regression results of section 5.5.4 and those of chapter 6 relating to capital cost estimation, demonstrate that a ship's hull value and size are closely related, so a strong link exists between capital costs (particularly new vessels) and insurance premia. Eide (op. cit) also found this approach convenient. Further administration cost is more a function of fleet or vessel size (appendix

and sections
C.2.5,/5.4.5 and 5.5.5). Thus since relationships have been established between a ship's size and its hull value (chapter 6) and between size (and hence its hull value) and insurance and administration costs in chapter 5, this aggregation remains valid. Unit costs used were based on physical units (ie. capital cost per dwt, manning per man, repairs and maintenance costs per ship's operating day and stores and provisions per dwt).

Against these unit costs, an output measure is required. In measuring transportation demand, shipping analysts have for long recognised that shipping tonnage is demanded for the transportation of goods over a given distance (for example see Tinbergen, 1934, and Koopmans (op. cit) p. 20), therefore the ton-mileage is used to measure output as it reflects the economic motive for demanding shipping services. To derive the distance component of the output measure it is necessary to use a fixed distance because the ton-mile is not a satisfactory unit of output when different distances are involved. Because the cost of 1 ton of cargo carried over a distance of 100 miles is not the same as the cost of 100 tons over a distance of 1 mile. For this reason and that of a common basis of comparison for ships of varying sizes, a round voyage of 10,000 nautical miles was assumed. Output is thus ship size x 10,000 miles.

Although, of course, cost analysis may be conducted at any level of aggregation, conventionally, economic analysis treats the firm as the basic behavioural unit - the firm essentially determines the appropriate mix of inputs and makes decisions regarding production levels. The crucial question, however, is what exactly constitutes the 'firm'. The nature of charter arrangements (particularly time charters in which the charterer decides the production levels) in the bulk cargo sector of the shipping industry, its competitive nature and ownership structure (with small independent companies, most of them one-ship companies, owning between 65-70% of the bulk fleet and their real owners (in the case of open registries) difficult to identify) suggest that the ship is the appropriate unit over which to estimate costs rather than investigating the production functions of the beneficial owners. It is for those

reasons that Zannetos (op. cit., pp.182-3) has argued that the ship is in most cases the firm in the tanker industry. Earlier studies (eg. Johansen, 1972; chapter 8; and Eide, 1979) have also followed this approach. The very widespread existence of one-ship companies, particularly under open registries, also validates this approach.

Given the data available, the exact specification of equation (7.6) is given as:

$$\begin{aligned}\ln C_T = {} & \alpha_o + \alpha_Q(\ln Q) + \tfrac{1}{2}\xi(\ln Q)^2 + \beta_1(\ln K) + \beta_2(\ln M) + \beta_3(\ln R) \\ & + \beta_4(\ln S) + \tfrac{1}{2}\gamma_{KK}(\ln K)^2 + \tfrac{1}{2}\gamma_{MM}(\ln M)^2 + \tfrac{1}{2}\gamma_{RR}(\ln R)^2 + \\ & \tfrac{1}{2}\gamma_{SS}(\ln S)^2 + \gamma_{KM}(\ln K)(\ln M) + \gamma_{MR}(\ln M)(\ln R) + \gamma_{MS}(\ln M)(\ln S) \\ & + \gamma_{RS}(\ln R)(\ln S) + \rho_{KQ}(\ln K)(\ln Q) + \rho_{MQ}(\ln M)(\ln Q) + \\ & \rho_{RQ}(\ln R)(\ln Q) + \rho_{SQ}(\ln S)(\ln Q) + \quad CT \qquad (7.15)\end{aligned}$$

with the associated share equations:

$$\begin{aligned}S_K = {} & \alpha_K + \gamma_{KK}(\ln K) + \gamma_{KM}(\ln M) + \gamma_{KR}(\ln R) + \gamma_{KS}(\ln S) + \\ & \rho_{KQ}(\ln Q) + \varepsilon_K \qquad (7.16a)\end{aligned}$$

$$\begin{aligned}S_M = {} & \alpha_M + \gamma_{MM}(\ln M) + \gamma_{KM}(\ln K) + \gamma_{MR}(\ln R) + \gamma_{MS}(\ln S) + \\ & \rho_{MQ}(\ln Q) + \varepsilon_M \qquad (7.16b)\end{aligned}$$

$$\begin{aligned}S_R = {} & \alpha_R + \gamma_{RR}(\ln R) + \gamma_{KR}(\ln K) + \gamma_{MR}(\ln M) + \gamma_{RS}(\ln S) + \\ & \rho_{RQ}(\ln Q) + \varepsilon_R \qquad (7.16c)\end{aligned}$$

A necessary condition for the cost function to reproduce comparative statics effects at a point of approximation without restrictions across these effects is that it produce (n+1) (n+2)/2 parameters, (Fuss et al, 1979). With our four-input and one-output technology, this requires 21 parameters to be estimated. Further, the translog function requires the approximation to be made at a local point, which, in our case is taken at the sample means of the variables of equations 7.15 and 7.16. Normalisation, therefore means that $\ln W_i$ and $\ln Q$ in those equations (and also 7.14) become $(\ln W_i - \bar{W}_i)$ and $(\ln Q - \bar{Q})$, respectively.

For estimation of the translog function, the cost and share functions of equations (7.15) and (7.16) are estimated simultaneously as a multivariate regression system. Joint estimation of the cost and factor share equations has the advantage of increasing the available degrees of freedom without adding to the number of parameters due to the symmetry restrictions across equations. Simultaneous estimation requires the omission of one share equation, accordingly, the stores equation (S_s) was dropped from the estimation. Barten (1969) has shown that the parameter estimates are invariant to the share equation omitted. It has also been demonstrated that since the contemporaneous covariance matrix is likely to be correlated, Zellnar's (1962) iterative Aitken estimator increases the efficiency of estimation (Berndt and Christensen, 1973). Both Kmenta and Gilbert (1968) and Dhrymes (1973) have proved that the iteration of the Zellnar technique until convergence to an identity matrix yields maximum likelihood estimates; while Christensen and Greene (1976) have shown that such iterations are computationally an efficient method for obtaining maximum likelihood estimates, hence the use of the Zellnar iterative procedure. See White (1982) for the computer software used.

7.4 Results - Bulk Carriers

Four models were estimated under a variety of assumptions for the three data sets - the total observations and the two flag groups, for the purpose of ascertaining the structure of the shipping technology. Model 1 (non homothetic): this is the maintained hypothesis and the restrictions are those required for homogeneity of degree 1 of the cost function in all prices as listed in equation 7.8 on p.144, together with the condition for continuity of the cost function ($\gamma_{ij} = \gamma_{ji}$). These restrictions are not tested.

Model 2 (homothetic) $\rho_{iQ} = 0$, for all i = 1...n

(in addition to those already imposed on Model 1)

Model 3 (linear separability (weak)) See Berndt and Christensen (1973).

$\gamma_{ij} = 0$ for all i, j, i $\neq$ j

(in addition to those already imposed on Model 1)

Model 4 (Cobb Douglas technology)

$\gamma_{ij} = 0$ for all i, j; $\xi_{QQ} = 0$

(in addition to those imposed for Model 2)

These assumptions are expected to provide answers to the question: is the structure of production in the shipping industry and for the two flag groupings homothetic, non-homothetic, linearly separable in outputs and inputs or subject to constant elasticities of substitution? To

test for the validity of these assumptions, the likelihood ratio (Ψ) was estimated for each of the restricted models as the ratio of the unconstrained maximum value of the likelihood function (Ω) to the constrained value of the likelihood function (w), ie.

$$\Psi = \frac{L_{max}(\Omega)}{L_{max}(w)} \qquad (7.17)$$

Wilks (1938) has shown that under the null hypothesis ($-2\log\Psi$) has an asymptotic distribution that is χ^2 with the number of the relevant degrees of freedom equal to the number of restrictions tested. Table 7.1 shows the Ψ statistics and χ^2 values at the 1% level of significance. According to Theil (1978) if the constrained maximum is too much below the unconstrained, it should be concluded that the sample yields evidence against the null hypothesis. Following this criterion it will be seen from tables 7.2 and 7.3 in appendix E that models 2-4 are not supported by the sample data. Also the results reported in table 7.1 reveal that since at the 1% critical level, the significant limit of χ^2 is between 11.35 and 23.21, far below the test statistic for all restricted models, the imposed hypotheses are rejected. This means that the production structure of bulk carrier operations throughout the shipping industry, irrespective of country of registry, is not separable in outputs nor inputs and that shipping costs are sensitive to factor substitution possibilities, factor shares and to utilisation levels. The rejection of homotheticity indicates that the production of bulk carrier services do vary with factor shares and intensities. Further, the overwhelming evidence against unitary elasticity suggests that it would be wrong to model the bulk shipping sector by a Cobb-Douglas or CES functional form, since returns to scale will not only vary with output but also with factor prices.

This suggests that the limited amount of econometric work in the shipping field based on single-equation Cobb-Douglas type of formulations are open to question and must be treated with caution. These formulations, as mentioned earlier, are defective for the study of economies of ship size. Hence the need for the more sophisticated model used here. Thus

Table 7.1 Test Statistics for Homotheticity, Linear Separability, Homogeneity and Unitary Elasticity of Substitution - Bulk Carriers

Hypotheses	$= -2\log\Psi$	X^2 (0.01) 1% level	No. of restrictions
Homotheticity (Model 2)			3
All Bulk Carriers	387.94	11.35	"
Traditional Registries	247.62	11.35	"
Open Registries	93.20	11.35	"
Linear Separability (Model 3)			4
All Bulk Carriers	761.40	13.28	"
Traditional Registries	514.72	13.28	"
Open Registries	258.88	13.28	"
Unitary Elasticity and Homogeneity (Model 4)			10
All Bulk Carriers	1698.32	23.21	"
Traditional Registries	1199.22	23.21	"
Open Registries	591.30	23.21	"

the results clearly show that a non-homothetic, nonseparable and a non-unitary model appropriately represents the production technology of the bulk shipping industry.

The approximation interpretation of the translog function facilitates the straightforward computation of elasticities, because with the normalisation of variables and their expression as natural logarithms, the first order linear coefficients can be interpreted as cost elasticities evaluated at their sample means. (These elasticities of total cost with respect to factor prices are also equivalent to mean factor shares in total cost.)

Thus, from tables 7.2 and 7.3 considerable differences in factor shares between open registry and traditional registry ships can be observed. For the latter, capital accounts for 44% of total cost, manning 34%, repairs and maintenance 16% and stores and provisions 6%. In contrast, the open registry sample shows higher proportions for capital and stores but lower shares for manning and repairs. The reasons for these differences can be found in table 5.18 which shows that stores, insurance and administration costs for open registry ships are higher on average than those of the TC group. Since insurance and administration form part of capital, coupled with the fact that the average OR ship is younger than that of the TC group (8.5 years against 12.4 years), table 7.4, the OR capital share is bound to be higher. In general, the coefficients are highly significant and their positive signs satisfy the regularity conditions for a well-behaved cost function.

Tables 7.5 and 7.6, respectively, present estimates of the Allen-Uzawa partial elasticities of substitution and the price elasticities of factor demand for the sample means. The substitution possibilities are generally small and almost zero in many cases. From a technical point of view, the non-negative sign of the stores demand elasticities in table 7.6 fails to meet the theoretical requirement of negative semi-definiteness of the Hessian matrix. This suggests violation of essential conditions at extreme data points in the sample and does not indicate that cost minimisation is uncharacteristic of bulk carrier or bulk shipping operations, because Friedlaender and Spady have pointed out that no restrictions of the parameters of the translog function will guarantee global negative semi-definiteness of the Hessian. Wales (1977) also, in his simulation study, has shown that translog estimates of important elasticities are generally very good if the violations of the technical conditions occur only for a small number of points - this is the position in our case (see Caves and Christensen, 1980, for the global properties of the translog).

The revelation of the restricted substitution possibilities for bulk carrier operations and indeed for tankers, as will be seen shortly, is supported by the observation made by Goss in 1968 in his study of the economic criteria for optimal ship design. There he points out that

the effectiveness of a factor of production in, or around, a ship is largely determined by the design of that ship and that since a ship is designed for a given number of crew, it is difficult to vary the number of crew or the proportions of the various grades. Whilst this may not apply strictly to all registries and operators in the light of what has been said about open registry operations, sub-standard operations, and other conditions of ship operations, the observation clearly indicates that there is not much scope for substitution on ships, ex post. Rather substitution possibilities can be explored ex ante. Certainly, there is no doubt, from our discussion of crew reduction schemes of several traditional maritime countries in section 5.6, that this ex ante substitution possibilities have been greatly explored in recent years.

In the light of these facts it is not hard to understand the reason for the severely restricted substitution possibilities between capital and manning and indeed other factors in an ex post scenario.

But despite the ex ante exploration of substitution possibilities in recent years between capital and labour, which manifests itself in technical advances in computerised operational systems and 'designing out' of work spaces by having labour-replacing technologies on board ships (ie. automatic equipment and unmanned engine spaces) combined with declared policies of lower manning scales, the substitution between capital and labour remains low for traditional ships. One would have, normally, expected that in the light of these facts and the fact that manning cost is the main reason for these innovations, a greater substitution potential could have been realised between these two factors, particularly in view of the sophistication in crew management attained by shipping companies of the industrialised economies.

To compare ships of the same age profile, all vessels over the age of 16 were excluded from the TC data in order to correspond to the maximum age of the OR data set, as age differential can affect the degree of substitution between capital, manning and repairs. The result of the substitution patterns for the new TC data (TC_2) is given in the fourth

column of table 7.5. in appendix E The result is the same with the OR value being approximately twice that for TC_2.

These results underline the basic difference between traditional and open registries with respect to conditions for ship registration and hence commercial flexibility. These results seem to suggest that the rigidities which accompany legislation regarding manning levels, working conditions and crew nationality, coupled with effective union structure in traditional maritime countries, will continue to make flagging-out to open registries an attractive commercial alternative. National legislative restraints aside, international conventions (ie. IMO's SCTW) would tend to reduce the flexibility open to operators under regulated registries. This tenor of thought is mirrored by the σMR values with the OR data supporting the fact that there is greater substitution potential under ORs between manning and repairs. Thus, it is not surprising that the average cost of repairs per operating day is $813 and manning $24,000 per crew on OR ships against $1,252 and $34,000 on TC ships - table 7.4. The younger TC_2 data paints the same picture.

This finding supports the postulation made in section 5.4.2 that the reason behind the lower repairs and maintenance costs for OR ships could be due, in the main, to their greater flexibility in the use of labour. Attesting further to this flexibility and higher productivity is the relatively higher price demand elasticity for repair costs shown in table 7.6 for ORs, and the longer operating days shown below.

Table 7.4 Unit costs and characteristics of the 'average firm'

Variable	All data	TC_1	TC_2	OR
Capital ($)	35.21	33.57		39.00
Manning ($)	33,754	33,555	35,719	24,292
Repairs ($)	1119.60	1252.20	1103.90	813.42
Stores ($)	4.80	4.60	4.47	5.42
No. of crew	29.50	30.00	28.00	29.00
Operating days	353.00	352.07	353.00	355.23
Output (million ton-miles)	507.29	502.69	582.39	517.88
Average Vessel Age (Years)	11.20	12.43	8.8	8.5

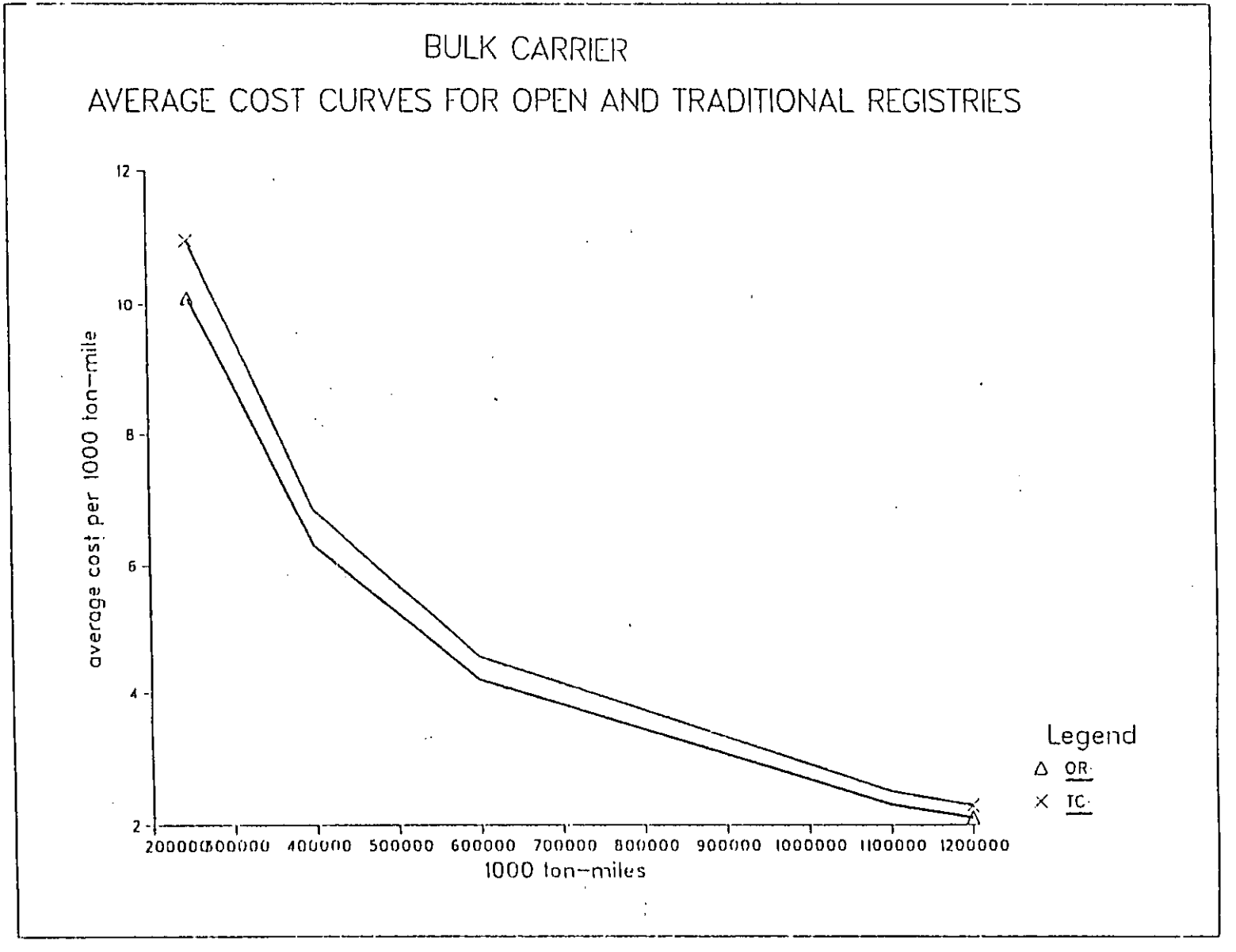
Notes Capital cost per dwt; manning per crew; repairs per operating day and stores per dwt. TC_2 = TC data set after the exclusion of vessels over 16.

One of the advantages of the translog modelling framework is that it permits detailed examination of scale economies. The scale effects for the average shipping firm in the respective data sets can be directly inferred from the elasticities of total cost with respect to output, given by the first-order coefficient of the output variable $-\alpha Q$ in tables 7.2 and 7.3. the economies of scale measure to be as shown by equation 7.14. The value of this coefficient for all ships (0.5892) indicates that bulk carrier shipping operations are subject to increasing returns to scale and the values for the two flag groups coupled with their quadratic terms, indicate that the average ships in both groups operating at average factor prices are operating on the declining portion of a U-shaped average cost curve. The higher value of this elasticity for the average OR ship or firm suggests that, apparently due to lower average total cost, the average operator is on the lower segment of the curve than the TC operator. This is in order since it has been proven above by the rejection of the imposed hypotheses that scale economies are subject to changing output levels and input prices. Using equation (7.14), scale effects were calculated individually for each observation in the two flag data sets and it was found that OR operators had higher cost elasticities right through the range of our data; meaning that they are commercially in a stronger position than their traditional counterparts to have exploited more of their scale economy potential. This is graphically represented in Figure 7.1. Average costs used there were fitted from the respective equations.

The positive scale effects associated with increasing ton-mileage are clear but, of equal importance, is the fact that at all levels of output, costs for OR operations are lower than those for TC operations. It is pertinent, in this regard, to note that: "Economies of scale are the principal determinant of unit cost of transportation" (Hettena and Ruchlin, op. cit).

Because of the composite nature of capital cost employed here and the possible bias which its synthesisation might have induced into the estimation, capital cost was dropped from the estimations and insurance and administration considered separately. At the heart of the open registry controversy is the operating cost advantage of ships under open registries,

Figure 7.1


BULK CARRIER
AVERAGE COST CURVES FOR OPEN AND TRADITIONAL REGISTRIES
average cost per 1000 ton-mile
12
10
8
6
4
2
200000
300000
400000
500000
600000
700000
800000
900000
1000000
1100000
1200000
1000 ton-miles
Legend
OR
TC

and it is thus important that this should be examined on its own. The results are given in table 7.7. The table shows that the shares of factors in total operating cost have changed with labour cost constituting the major cost centre - 53% for TCs and 44% for ORs. It makes more sense to express these relative shares in absolute terms. The total operating cost for TC_1 at the sample mean is \$1,867,000, TC_2 - \$1,898,000 and OR - \$1,552,900. These bring the absolute cost of labour on TC ships to between \$989,828 and \$1,006,258, compared to \$683,276 on OR ships - a differential of over \$300,000. If insurance and administration cost is taken as the cost element for which the TCs hold the strongest edge against the ORs: 15% against 24%, it will be seen that the absolute difference is not as large as it is for crewing cost - \$30,948 - \$92,556.

Table 7.8 provides the substitution patterns and factor price elasticities for the operating cost estimate. Further insights into the operating strategies of shipping companies under different registries can be gained from this table. The very high value of $^{\sigma}MR$ for the OR data in relation to TC data should be seen against the background of what has already been discussed. Notably, the value ($^{\sigma}MR$) of the OR data is more pronounced in relation to those of the TC group. The intricate relationship between repair and maintenance costs and the cost of insurance has been discussed in appendix C.2.4 and in the analysis of chapter 5. Because of this relationship, a prudent shipowner would tend to take out maximum cover for all risks at the lowest possible price, particularly if the shipowner is registered under a traditionally regulated registry. It would be cheaper for such an operator to cover all forms of repair.

Apparently, because of their restrained substitution possibilities between manning and repairs, traditional operators appear to have used insurance and administrative costs (their low cost centres) to substitute for manning and repairs and maintenance (their high cost centres). The value of $^{\sigma}MIA$ is 0.1145 for TC_1; higher than OR's even though the latter's share of IA in total cost is much higher. This approach is further reflected in higher values of $^{\sigma}RIA$ and E_{IAIA} (0.2784, 0.1250) for TC_1. For TC_2, because of their complementarity between M and R, they would tend to

substitute between M and S. This suggests that if the cost of manning falls (or crew is obtained more cheaply from cheap labour countries) then they can afford to spend less for more crew or the same crew level and spend more on stores and provisions for both the maintenance of the crew and the vessel - the $^{\sigma}MS$ value for TC_2 is 0.1377 compared to 0.1282 for ORs. Seemingly, since the inclination of TC operators is to carry out most repair work in drydocks (because of high labour cost and legislation rigidities), it is not difficult to understand why $^{\sigma}RS$ is high for the TC_2 data, leading to a relatively large $^{\sigma}RIA$ of 0.5.

It should be clear from the foregoing analysis, that the crew cost element is the major contributor to the cost differential between OR and TC bulk carrier operators. What is not clear is the magnitude of the differential from the equations of the translog and how much of that difference is attributable to each operating cost component. Predictions from the respective translog equations showed that at the sample mean of the total operating costs, TC_1 total costs are higher than ORs by 20.89% ($307,597) against the actual of 20.28% ($314,900) and 22.66% ($333,657) against the actual of 22.26% ($345,700) for TC_2. To decompose this composite figure, an equation used by Caves et al (1982) for the decomposition of the cost differential between Trunk and Local airline operators within the translog framework was used. The formula is thus:

$$-\tfrac{1}{2}[(\partial \ln C/\partial \ln X)_1 + (\partial \ln C/\partial \ln X)_2]\ (\ln X_1 - \ln X_2) \qquad (7.18)$$

where C = total cost

X = any characteristic except output. For output X = Q

1,2 = 1 = group 1; 2 = group 2; in our case 1 = OR and 2 = TC.

Expanding 7.18 for manning, for example, in our case gives:

$$-\tfrac{1}{2}[(\beta_M + \gamma_{MM}(\ln M) + \gamma_{KM}(\ln K) + \gamma_{MR}(\ln R) + \gamma_{MS}(\ln S) + \rho_{MQ}(\ln Q)_{OR}$$
$$+ (\beta_M + \gamma_{MM}(\ln M) + \gamma_{KM}(\ln K) + \gamma_{MR}(\ln R) + \gamma_{MS}(\ln S) + \rho_{MQ}(\ln Q))_{TC}]$$
$$(\ln M_{OR} - \ln M_{TC}) \qquad (7.19)$$

(Note that lni is the geometric mean of the ith factor and output)

It emerged, using (7.18) that the manning cost element is the largest contributor to the differential - 40.5% against TC_1 and 64.3% against

TC_2. It is noteworthy that Goss (1985b) remarked that the manning cost element can account for between 61-65% of the operating cost differential between an open registry operator and a European operator.

The alternative short run specification of equations (7.4) and (7.7) based on the principle of partial static equilibrium has been explored elsewhere (see Tolofari, Button and Pitfield, 1986). This specification is not pursued here because this study is only concerned with long run cost-minimising behaviour. The above analyses based on static equilibrium assumptions, are based upon the assumption that shipping companies are minimising costs with respect to all inputs and therefore are in static equilibrium with respect to their demands for inputs. In the short run, however, as has been dealt with in chapter 4, the supply of shipping capacity is inelastic at any given point in time. Upon this theory rests the assumption of the variable cost function examined in Tolofari et. al. (ibid) with capital treated as a quasi-fixed input. The model provided a good overall statistical fit for all three data sets and the t-ratio of the quasi-fixed factor indicates that treating capital as a fixed input is statistically tenable whilst the negative sign associated with capital inputs offers empirical confirmation of the underlying assumption of the variable cost function. The most important revelation is that the difference between the two flags in respect of the substitutability between manning and repairs is wider, which, most probably, reflects the particularly short-term rigidities of labour contracts in traditional maritime nations. Generally the substitution coefficients for the variable cost function are lower than those for the total cost functions. This is in consonance with optimising behaviour of ship operators in the long and short runs bearing in mind the time it takes to adjust factor usage in the latter (Hicks, 1946, p. 206, observed that generally, long-run elasticities of substitution tend to be greater than short-run elasticities).

7.5 Results - Tankers

As with the bulk carrier data, four models were calibrated for the tanker data and, in much the same manner, all the imposed hypotheses were rejected

in favour of a non-homothetic technology - table 7.9.

Table 7.9 Test Statistics for Homotheticity, Linear Separability, Homogeneity and Unitary Elasticity of Substitution - Tankers

Hypotheses	$-2 \log \Psi$	X^2 (0.01) 1% level	No. of restrictions
Homotheticity (Model 2)			
All Tankers	136.08	11.35	3
Traditional Registries	98.42	11.35	3
Open Registries	111.80	11.35	3
Linear Separability (Model 3)			
All Tankers	266.48	13.28	4
Traditional Registries	164.72	13.28	4
Open Registries	215.28	13.28	4
Unitary Elasticity & Homogeneity (Model 4)			
All Tankers	551.00	23.21	10
Traditional Registries	370.10	23.21	10
Open Registries	484.32	23.21	10

Because of the same age profile of average vessels in the two flag groups, it was not necessary to align the average age of one data set with the other. The sample averages are given in table 7.10 and the results of the unrestricted and restricted total cost models given in tables 7.11 and 7.12 for TC and OR data respectively. The estimates are highly significant with high degrees of explanation of cost variations. With a value of 0.4990 for the elasticity of total cost with respect to output for the total observations, tanker operations are clearly subject to greater economies of scale in accordance with the findings of section 5.5.6. The relatively larger average size of tankers in comparison to bulk carriers is, no doubt, largely responsible for this disparity, as was noted in chapter 5. Very much in line with the scale effect

Table 7.10 Characteristics of the average firm (vessel)

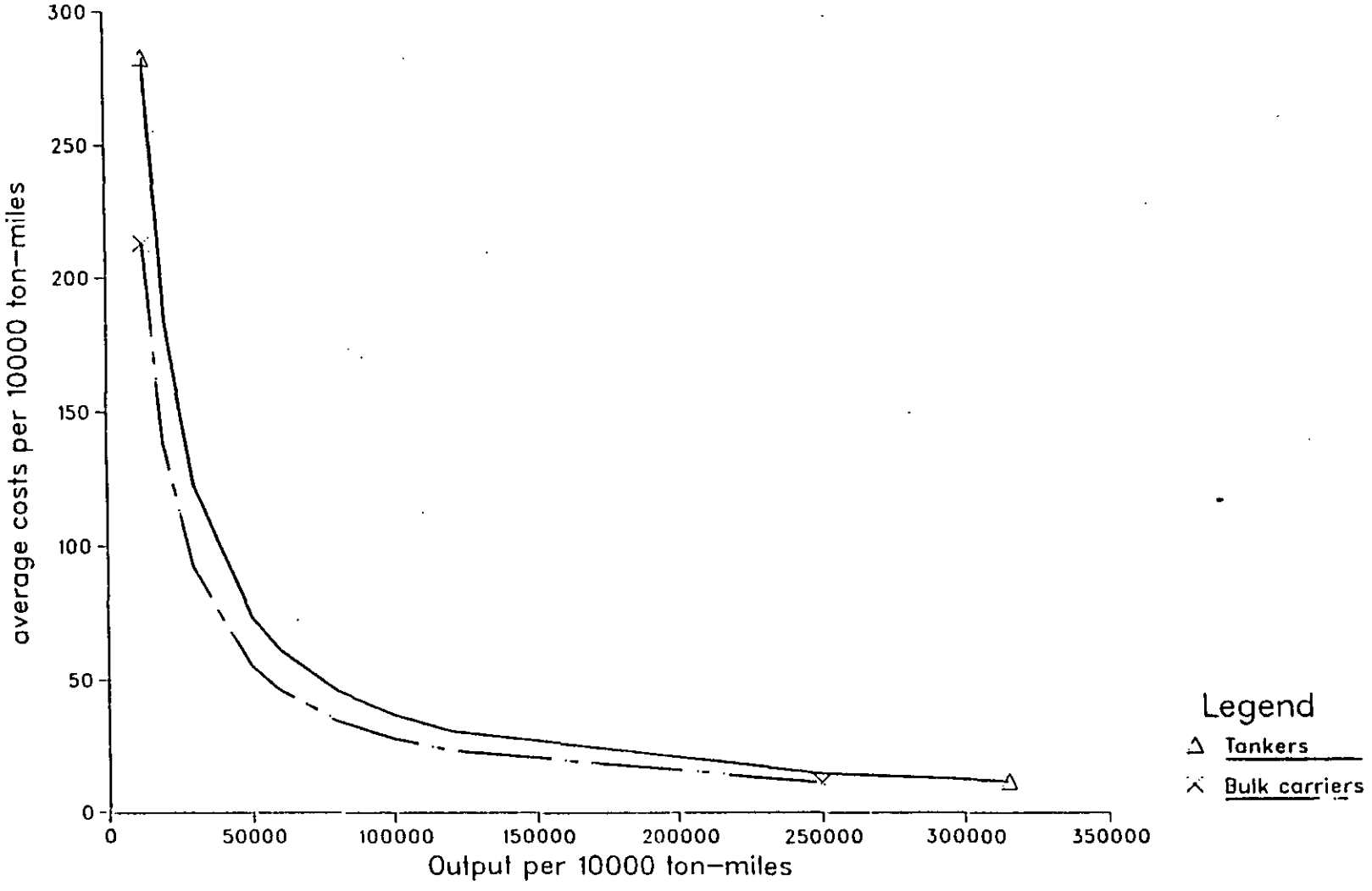
Variable	All Data	TC	OR
Capital ($)	30.75	23.90	34.80
Manning ($)	44,494	49,124	34,578
Repairs ($)	1624.8	1931.30	1120.40
Stores ($)	4.788	4.10	5.99
No. of Crew	31.36	31.48	31.23
Operating Days	349.81	347.91	352.36
Output (million ton-miles)	91,864	95,081	110,500
Age (Years)	10.58	10.69	10.09
Cost ($) p.a.	3,672,900	3,820,900	3,305,100

analysis of the preceding section, open registry tanker operators, according to our data, seem also to have exploited more of their scale potentials than operators in the traditional group for much the same reasons as those advanced for bulk carriers. It will be noticed, however, that the cost elasticity (α_Q) is lower in the case of tankers for both OR and TC data. This may very well be due to the fact that, generally, tanker costs are higher than those of bulk carriers as demonstrated in chapter 5 and by figure 7.2 - see also Button, Tolofari and Pitfield (1986). This is a likely cause of the lower elasticity values and hence, generally, greater potential for scale economies, since it has been proven that scale economies are not only affected by output levels but also by factor prices. As α_Q is less than unity at the respective mean output levels, it means that average cost (AC) is less than marginal cost (MC) at those points and that AC decreases as output increases (Allen, op. cit., p. 261), therefore scale effects for varying output levels are better portrayed by figure 7.3. As with bulk carriers, OR average tanker costs are lower for all levels of activity.

Table 7.13 shows estimates of the Allen-Uzawa partial elasticities of substitution. All the σ_{ii}s have the required negative signs and ~~are~~ all are significant. For capital and manning, the relationship for

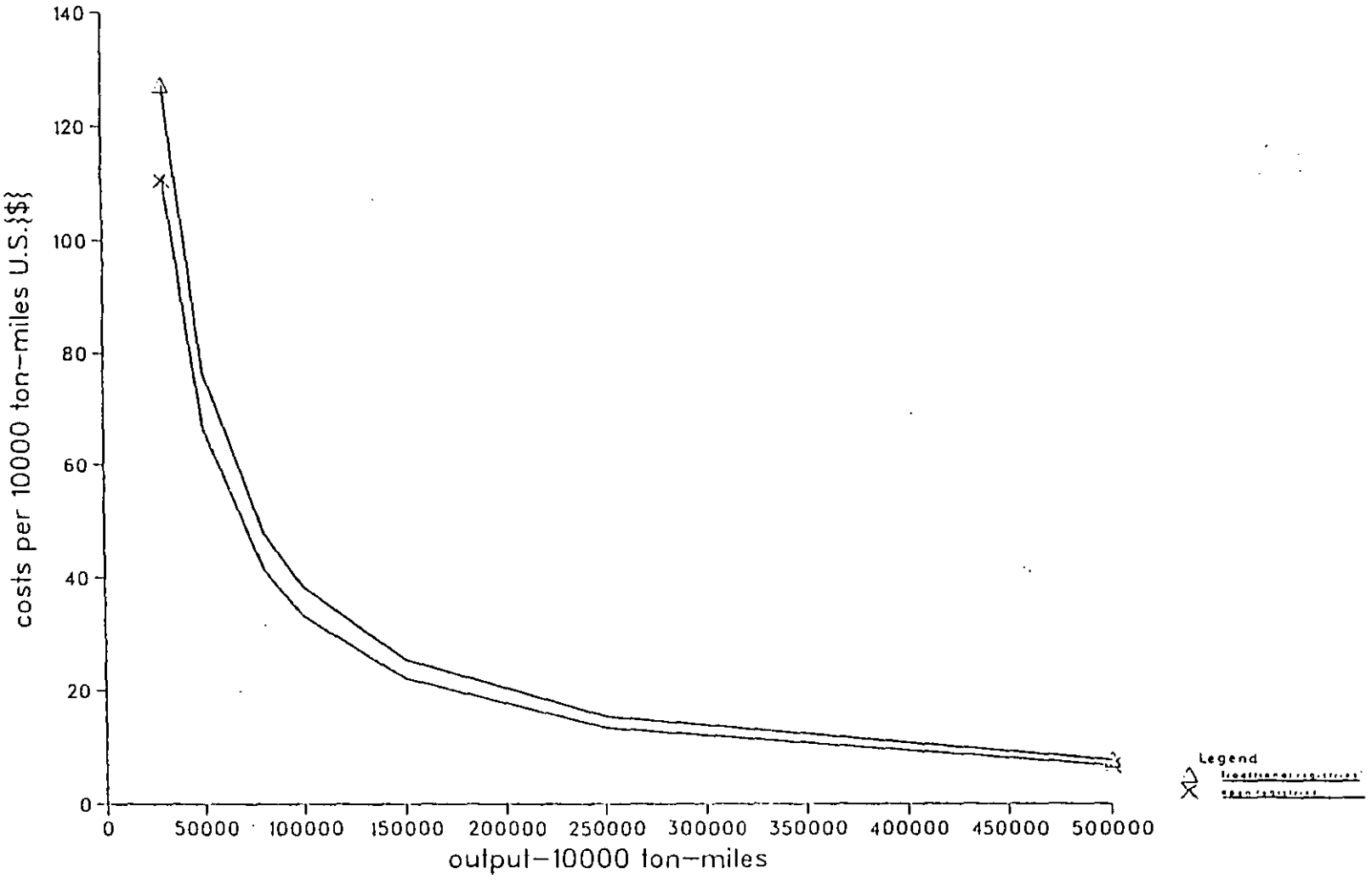
Figure 7.2

COMPARATIVE AVERAGE COST CURVES FOR TANKERS AND BULK CARRIERS



Note: Output levels above 150,000 are for illustrative purposes as bulk carriers do not normally exceed 150,000 dwt in size.

Figure 7.3
Average cost curves for open and traditional registries;Tankers



tankers is that of complementarity with the value for ORs being essentially zero. Whilst this may be an extension of what has already been noted in regard to the generally restricted ex post substitution possibilities in shipping, the complementarity between the two factors appears to have a special significance here. In chapter 3 (section 3.2), international conventions for the regulation of maritime safety with respect to tanker operations were exhaustively discussed. It is plausible, in the light of that section, that requirements such as SBT, CBT, COT and inert gas systems on existing and new tankers, in addition to the new international regulations on minimum crew standards, would have had the effect of reducing drastically the degree to which capital can replace labour and vice versa.

As expected, capital and repairs are substitutable. The extent of substitution between the two factors would depend very much on the age of the vessel and the degree of manning flexibility regarding substituion between manning and repairs. Obviously older ships require more repairs and frequent maintenance. The shipowner in such a circumstance would, naturally, be faced with the need to trade off higher repair costs with replacing his vessel with a new one. Such a trade-off requires repairing and maintaining the vessel in drydocks and/or using the ship's crew for essential repairs and maintenance. The analysis of bulk carrier costs has shown that traditional operators are very limited in the latter regard compared to their counterparts, the higher substitution values for σ_{KR} and σ_{MR} for ORs therefore confirm the same flexibility for tankers.

Another interesting result in table 7.13 is the substitution between repairs and maintenance, and stores and provisions. This is interesting because generally one would expect repairs and stores to be complements as shipowners use their time in drydocks to stock essential spare parts, lubricants and general provisions as supported by the bulk carrier results; although, in practice, this depends upon the extent to which ships are repaired in drydocks and the type of propulsion. But the

relatively very high substitution values for these two factors in the case of tankers, may be due to the fact that lubricating oil is not as important for the operation of turbine tankers as it is for diesel-engined ships like the bulk carriers of our data. Substitution between the factors would also be enhanced if more maintenance and repair work is done outside the drydocks, except, of course, the mandatory classification surveys. The OR value is nearly 1 and if one considers that 50% of the OR data is made up of turbine-engined tankers against one-third for the TC data (see Table 5.1) plus the fact that the interpolated data are for tankers over 100,000 dwt (almost all tankers above 100,000 dwt are turbine tankers), then the high substitutability between the two costs will not be totally surprising. It is also revealing to find very high substitution between manning and stores for the TC group. Since manning is comparatively expensive and rigid in its conditions of use, it makes economic logic to substitute stores and provisions (a cost centre for which the group has a competitive advantage) for manning.

The own (or direct) price and cross-price elasticities are given in table 7.14. The large values of the own-price elasticities of demand for the two registry groups suggest that tanker factor demand is very sensitive to variations in their own prices. For the TC group, repairs and maintenance demand is the most sensitive to price changes, and for the OR group it is stores and provisions. These high elasticities tie up with the observations made in the preceding paragraph in respect of the high degree of substitutability between Manning and Stores for the TC group and Repairs and Stores for the OR group. The OR stores demand is very sensitive to price variations seemingly because most of their ships are turbine ships and also because stores (eg. spare parts, etc) can be cheaply obtained (eg. secondhand parts); hence the substitutability between repairs and stores and the reason for E_{RS} being lower than E_{SR}. For the TC group, repair demand is very sensitive to price changes because of institutional rigidity regarding manning and repairs and maintenance. The most likely option in this respect would be to take out more insurance cover to cover all repairs especially

when premia are low. Such behaviour pattern appears to underlie the higher elasticity of demand for insurance for the TC group as shown in table 7.17. Note also that whilst a change in the price of stores would not make much of a difference in TC manning demand (E_{MS} = 0.0701), a change in the price of manning would affect the demand for stores (E_{SM} = 0.3474) and hence the higher degree of substitutability between manning and stores for the TC group.

Results of the operating cost model are given in tables 7.15 - 7.17. In table 7.15 it will be seen that, as with the bulk carriers, the elasticities of total operating cost with respect to the four cost elements have changed with manning costs representing the highest cost centre. For the OR group, insurance and administration cost constitute the second largest cost centre whilst for the TC group repairs and maintenance is the second most expensive cost element. The significant addition to what is already known, is that repairs and insurance costs are also substitutes in the case of tankers but with OR operators showing a higher degree of substitution, table 7.16. The elasticity is, however, far lower than that of the TCs for the bulk carrier set, and notably both elasticities (TC, OR) are not significant. But it may be pertinent to suggest that this outcome may be due to the cheapness of insurance premia in recent years, particularly for OR tankers in the large size category as appendix D shows; a line of thought not unsupported by the analysis of section 5.5.4, bearing in mind the fact that a prudent shipowner would take out sufficient cover at a time when insurance costs are cheap in relation to his manning costs (and hence maintenance and repair costs), or vice versa substitute more repairs and maintenance for non-obligatory insurance cover through the manning cost element. Table 7.17 showing the price elasticities is a mirror-image of table 7.14 (except for the E_{RR} value in 7.14) and re-emphasises ORs greater flexibililty regarding manning and repair costs.

The data shows that the total operating cost of a TC operator operating at mean output levels and factor prices is higher than that of the mean OR operator by \$557,400-\$2.91m against \$2.35m or 24% higher.

It is clear that this differential is far higher than that obtained for bulk carriers and supports the conclusion of chapter 5 that tanker operations yield larger savings to OR operators (particularly at the large size end of the size spectrum); and this may not be an unlikely reason for the concentration of OR tankers in the larger size ranges - table 2.11. If the manning cost per man given in table 7.10 is multiplied by the average number of crew for TCs and ORs, it will be found that annual manning cost on the average TC vessel is $1,522,844 compared to $1,071,918 on OR ships -amounting to a differential of $450,926. It is no wonder that when equation (7.18) was applied to tankers that the manning cost element accounted for 73% of the 24% total operating cost differential. (A far more detailed comparison of the cost structure of the tanker and bulk carrier sectors has been carried out elsewhere in Button, Tolofari and Pitfield, ibid. and the tanker sector separately examined without the flag dichotomy applied here in Tolofari, Button and Pitfield, 1985).

7.6 Concluding Remarks

In chapter 2 the conditions for ship registration were treated and in chapter 5 it was proven that open registry ships are operated at lower operating costs within the range of our data. Whilst the former diagnosed the primary cause of the variations in costs between open and regulated traditional shipping registries, the latter prescribed the effect. That effect was further scrutinised by the analyses of this chapter with the commitment of eliciting reasons underlying the differences in cost. As appropriately suggested in chapter 5, there could be two reasons for the disparity in costs: differences in the age profiles of vessels in the data sets or better substitution flexibility for one group. Indeed, the analyses undertaken here have shown that the latter is very tenable.

The strength of the latter effect derives from three facts: first, that the rejection of linear separability (which means that operators will adjust their use of a subset of inputs, say capital and repairs, in response to changes in their relative prices without considering the prices of other inputs outside the subset) confirms that bulk shipping costs are sensitive to substitution patterns and factor shares. In

other words the share of a factor in total cost is affected by patterns of substitution and complementarity and intensity of usage. This empirical substantiation of a non-separable shipping technology is a vital one because, in shipping, there is a high degree of inter-relationship between costs. It is pertinent in this respect to quote Drewry (1984) in some detail: "Though market forces ... set the general level of operating costs ... it is important to recognise the inter-dependence of cost categories and that the level of expenditure in one category may influence the costs in another... Thus, each of the main cost component cannot be regarded as entirely separate from one another." The above analyses have shown a consistent exploitation of that inter-dependence by open registry operators for the manning and repair cost categories for both bulk carriers and tankers.

Equally, of vital significance is the rejection of constant returns to scale hypothesis. The consistently higher exploitation of scale economies by open registry operations, derives mainly from the lower costs associated with such operations since at all levels of activity they experience lower costs and thus are prone to exploiting more of their scale economies.

The application of the translog model has justified its purpose. For, it has shown, apart from identifying the structure of production, that although the degree of substitution possibilities in shipping is comparatively modest, flexibility in substitution is the economic reason why some costs are lower for one group and higher for the other. It has confirmed that manning and repairs and maintenance costs are consistently lower for open registry operators due to the greater substitutability that exist between the two factors for both types of vessel, as also reflected in the relatively higher value of the own-price elasticity of demand for repairs and maintenance in all OR data sets. Furthermore, it has revealed that tanker operations are subject to greater substitution possibilities than bulk carrier operations. While our finding of scale economies for all vessel types lends empirical support to earlier studies of size economies, the translog went further to reveal the extent to which available scale economies have been exploited by the two flag

groups by the use of U-shaped average cost curves. It has shown that, as a result of lower average costs at all levels of output, open registry firms have used up more of their scale economies since scale effects are not only determined by varying output levels but also by factor prices. Finally, and by no means the least contribution, is the further quantification of the fact that the cost of manning is the principal contributor to the disparity in cost between the two flag groupings. It must also be remarked that the total agreement between the analyses of this chapter and those of the preceding two chapters (particularly chapter 5) indicates that the interpolated tanker data is as good as the data it came from.

While the analyses of costs up to this point reveal that open registry operations, as one might expect given the gravitation towards these registries, do result in lower costs at all levels of output, they do not of themselves, provide an argument for retaining the system or maintaining the status quo. Rather, in view of the opposing views held by differing sections of the shipping industry, as mentioned in the introductory chapter, it is necessary, for the purpose of this study, to examine the relationship between lower costs and freight rates because such a relationship would have a far more important cost-benefit implication for the open registry controversy. It is to this task that the next chapter is addressed.

CHAPTER 8

FREIGHT RATE ANALYSES

"Companies using flags of convenience can offer lower prices than others because their costs are lower."
European Parliament (1979)

In the introductory chapter it was stated that the absence of detailed quantitative work on the cost differentials of ship operators operating under open and traditional shipowning countries and the absence of evidence on the relationship between such differences and their relevant freight rates, provided the justification for this study. Whilst the analyses of the preceding chapters have shown that open registry costs are generally lower than those of their traditional counterparts, the question as to whether or not such lower costs are passed on to the consumers of international shipping services by way of lower freight rates still remains. It is to this question that this chapter is addressed.

In contrast to cost studies in shipping, the freight market has received considerable attention from shipping economists over the years. Since the first quarter of this century, economists have been investigating the dynamics and mechanics of the functioning of the freight market as evidenced, for example, by theoretical and empirical studies by Kojima (1926), Tinbergen (1934), Koopmans (1939), Thorborn (1960), Ferguson et. al. (1961), Sturmey (1965), Zannetos (1966, 1967), Bennathan and Walters (1969), Bates (1969), Devanney (1973), Waters II et. al. (1974), Hawdon (1978), and Shimojo (1979). One common thread which runs through the majority of these studies is the unequivocal consensus, as noted in section 4.1, of the fact that in a competitive market such as the bulk shipping markets, cost is a major determinant of freight rates, especially in the long-run. This consensus is founded on the theory of normal or equilibrium price which holds that in a competitive market price will always tend towards the cost of production. Any fluctuations about this price, as stated in section 4.1, should not be mistaken for a lack of natural tendency of price to adjust to the long-run equilibrium cost, even though such adjustment is not instantaneous.

Tinbergen writing in 1934 points out that the supply of shipping capacity is determined by two quantities: the total transport capacity and operating costs; noting that "operating costs influence the freight price because they partly determine the level to which competition is capable of pushing down freight rates." A hypothesis eloquently agreed to by most of the works cited above and pertinently by Bennathan and Walters who postulate that:

> "Cost is the bedrock of freight rates. In a competitive market freight rates will be driven down to the level of costs. The tramp market is substantially competitive, and the rates probably are explained almost entirely by the cost of operation."

It was not without theoretical foundation that when, in 1979, the European Parliament, in their review of the open registry issue as it affects European shipowners, conceded that "companies using flags of convenience can offer lower prices than others because their costs are lower". European Parliament (1979).

It is against this background that the aim of this chapter rests. With ten-year and nine-year freight data for tankers and bulk carriers respectively, for the two groups of registries, the chapter aims to provide evidence as to whether or not open registry freight rates over the period have been lower than those of traditional operators and also show the correlation between cost and freight rates.

8.1 The Data and Model

The data for the analysis of freight rates is derived from time-charter fixtures published monthly in Drewry's 'Shipping Economics and Statistics' for the period 1972-1982. Time charter rates were chosen because as stated in chapter 4 (section 4.2.1) the spot market represents only a small proportion of world seaborne trade. In fact over 90% of all oil is carried on a long-term basis whilst the same proportion of the independent tonnage operate in the long-term markets - tanker and dry cargo. The nature of the spot market, particularly, the erratic fluctuations of freight rates which tend to blur the relationship between costs and rates also

makes it far less appropriate for the purpose of the study. Moreover, the thesis is concerned with long-run costs as shown by the preceding cost analyses; equally the theoretical justification for examining the influence of these costs on long-term rates have been amply provided by the literature cited here and in previous chapters. Also from a cost-benefit standpoint (a view this thesis is expected to reflect), the long-run is most appropriate.

The total data covers a sample of 2,664 time charter fixtures comprised of 1,625 tanker fixtures and 1,039 dry cargo charters out of a total 2,202 reported fixtures for the period December 1972 - December 1982, for tankers (ie. 74% of all fixtures) and 1,797 for bulk carriers for the period December 1973 - December 1982 - 58% of reported dry cargo fixtures. To form a matrix of variables, the characteristics of each charter and the vessel involved were gleaned from the source statistics, thus producing a matrix covering the size of the vessel in dwt, year of build (ie. age), duration of charter, lead time between signing of the charter party and actual vessel delivery to the charterer, the type of cargo (ie. dirty or clean in the case of tankers only), vessel speed, and the charter rate. All bare-boat charters were excluded from the sample. Care was also taken to drop all those fixtures made in a previous month and cancelled later on and all vessels on relet and charters taking retrospective effect. All fixtures for sub-optimal uses such as storage and bunkering were also excluded as only vessels chartered for trading were included in the sample. As it was feared that the inclusion of charters for a few days might have a close affinity with the spot market and hence be influenced unduly by it, all charters for durations less than 30 days were also excluded. All Government charters (because of the subsidy element involved) and charters involving 'tie-in' arrangements where a company charters its own vessel were also excluded.

The second stage of the data preparation exercise involved identifying the registries of the chartered vessels as these do not form part of the published information. This was done by the use of Clarkson's "The Tanker Register" and "The Bulk Carrier Register" published annually by

H. Clarkson & Co. of London and supplemented where necessary by the "Lloyd's Register of Shipping", (courtesy of the Marine Library, Department of Transport, London). The problem encountered in this exercise was the problem of change of registry. As ships change their registry from time to time, it was of utmost importance that a ship's registry was taken as that published in Clarkson's or Lloyd's register for the particular year of the charter. If the ship was not found in the register relating to the year the charter was reported, then such vessels were dropped as it was very possible that the ships may have changed registry in the next year or later years. The registers were also very useful in confirming the characteristics of vessels. Where discrepancies exist between the Drewry statistics and the characteristics of the vessels as registered in the shipping registers used, the particulars given in the latter were preferred.

In some instances, the reported fixtures did not specify the period of delivery but merely stated the date of delivery of the vessel to the charterer. In such cases, the period between the date the fixture was reported and the reported date of delivery has been taken as the lead time. This may be erroneous as it is known that the date a charter is reported does not necessarily correspond to the date the charter agreement was concluded. It is reasonable to assume, however, that the discrepancy would not induce significant margins of error into the calculations. For fixtures whose freight rates were reported as a lump sum per day, the vessel size and charter duration were used to convert such lump sums into the standard time charter unit of $/dwt/month. Time charter rates are usually given in U.S. dollars but in the very few cases in our sample where they have been reported in other currencies, the appropriate exchange rate for the month and year of the charter as published in IMF's International Financial Statistics was applied.

Having identified their flags, all ships registered in countries other than the traditional shipowning nations, as defined in this thesis, and open registries were further eliminated from the sample; reducing the total observations to 1,973 vessels - 1,115 tankers and 858 bulk carriers.

The total data was then coded for the two flag sets. Table 8.1 provides the annual breakdown of the sample size.

Table 8.1 Annual charter data by flag grouping

	Tankers			Bulk Carriers		
Year	Total reported fixtures*	TC	OR	Total reported fixtures	TC	OR
1972	8 *	5	1	-	--	--
1973	398	29	30	10*	4	4
1974	143	32	23	344	57	41
1975	112	32	25	192	40	27
1976	214	90	45	193	80	43
1977	169	56	34	161	39	30
1978	205	66	52	160	44	41
1979	297	120	53	290	92	43
1980	319	117	74	226	68	39
1981	463	86	111	119	63	36
1982	255	45	90	102	47	35
	2 583**	678	538	1797	534	339

* Note: December only; ** includes fixtures with missing values.

Comparison of the open market rate between ships of the two flag groups would have been far more straightforward than comparing their time-charter rates. The reason is that unlike the open market rate which is given in homogeneous units of cost per ton of cargo carried, the time-charter rate is not homogeneous but varies with the size of vessels, charter duration, vessel delivery period and type of propulsion. This circumstance makes direct comparison of published rates impossible; except, of course, if we can find sufficient time charters of the same duration, delivery lead time, type of propulsion and for the same vessel size. As is well known and as can be seen in table 8.1, the number of time charter fixtures is a function of rates (see total reported fixtures for 1973/74 and 1979, 1980 and 1981 in table 8.1), implying that there are periods when only very few transactions occur. Under these circumstances it is almost impossible to establish any meaningful basis of comparing time-charter rates without considering the differences in vessel size and charter characteristics. Hence the necessity for a theoretical freight rate.

To predict freight rates, therefore, a log-linear multiple regression model was used; specifying freight rates as a function of 6 independent

variables in the case of tankers and 4 for bulk carriers. The linearised log form was adopted because it provided the best mathematical relationship for the data after examining plots of the dependent and independent variables. This was not unexpected since according to theoretical considerations, expectations, which greatly influencelong-term rates, are fundamentally exponential functions (Zannetos, 1967 and Polemis, 1976), viz:

$$\ln F_R = \ln b_0 + b_1 \ln X_1 + b_2 \ln X_2 + \ldots + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + \ln U_t \qquad (8.1)$$

where: F_R = freight rate

X_1 = ship size in dwt

X_2 = duration of charter in months

X_3 = delivery lead time in days

X_4 = vessel age

X_5 = speed (a proxy for type of propulsion)

X_6 = dummy for type of cargo (for tankers only)
1 = clean product and 0 = crude oil

U_t = stochastic disturbance term at time t encompassing qualitative impacts of uncertainty and buyer/seller expectations on rates.

8.2 Results: Tankers

In order to gain a clear knowledge of the influence of the above independent variables in determining the freight rates offered by the two groups over the period, different variations of equation (8.1) were computed. First, the equation was calibrated for the full data set over the period 1972-82 for each flag category and the resultant equations are given as follows:

Traditional registries:

$$\ln F_R = \underset{(6.45)}{10.5} - \underset{(-14.42)}{0.834 \ln X_1} - \underset{(9.48)}{0.017 \ln X_2} - \underset{(-1.16)}{0.03 \ln X_3} - \underset{(-1.99)}{0.071 \ln X_4} + \underset{(0.34)}{0.179 \ln X_5} + \underset{(2.01)}{0.177 \ln X_6} \qquad (8.2)$$

$R^2 = 0.61$; $S = 0.5721$

(t-ratios in parentheses)

Open registries:

$$\ln F_R = 11.5 - 0.924\ln X_1 + 0.080\ln X_2 - 0.011\ln X_3 - 0.109\ln X_4 + 0.032\ln X_5$$
$$(7.28) \quad (-14.83) \quad (1.97) \quad (-0.49) \quad (-3.15) \quad (0.05)$$
$$+ 0.345\ln X_6$$
$$(3.41)$$
$$\bar{R}^2 = 0.65; \quad S = 0.5047 \qquad (8.3)$$

Fitted freight rates from these regressions showed that over the period 1972-1982 open registry servies were sold at higher rates up to (and including) vessels of 20,000 dwt but accepted lower rates than their traditional counterparts for all vessel sizes from 25,000 dwt and above. Whilst this result could have strongly supported all the citations made in this chapter and previously, it is limited in the sense that there are known qualitative influences in the freight market which affect rates in periods of low demand (excess supply) and high demand for tonnage. Influences such as the price-elastic expectations of shipowners and potential charterers, delayed reaction by shipowners to changing freight rates, operating even when rates can barely cover operating costs require that freight rates should be examined in two periods - when they are low and when they are high because these two market conditions affect the behaviour pattern of both shipowners and charterers and thus induce qualitative differences into the impacts of some of the variables of equation (8.1) on long-term rates. Moreover, it is expected that the influence of cost on freight rates should be more pronounced during periods of depressed freight rates than bouyant periods when charging 'what the market will bear' would seem to be the strategy for most shipowners. Accordingly, the data was split into periods of low and high rates. The periods 1973-4 and 1979-80 were chosen as high periods whilst the remainder were taken as low periods. Reference to figures 6.1 and 6.2 in chapter 6 would authenticate this division, with respect to the 1979-80 high period for bulk carriers and 1973-74 and 1979-80 for tankers, respectively.

The resultant equations for low periods are:

Traditional registries:

$$\ln F_R = 9.30 - 0.779\ln X_1 - 0.036\ln X_2 - 0.0289\ln X_3 - 0.0728\ln X_4 + 0.248\ln X_5$$
$$(4.94) \quad (-10.36) \quad (-0.81) \quad (-3.99) \quad (-1.73)$$
$$+ 0.365\ln X_6$$
$$(3.23) \qquad (8.4)$$
$$\bar{R}^2 = 0.74; \quad S = 0.4693$$

Open registries:

$$\ln F_R = 12.1 - 0.985\ln X_1 + 0.103\ln X_2 - 0.0403\ln X_3 - 0.0888\ln X_4$$
$$(5.54) \quad (-11.10) \quad (2.13) \quad (-1.45) \quad (-2.06)$$
$$- 0.049\ln X_5 + 0.314\ln X_6 \qquad (8.5)$$
$$(-0.06) \quad (2.42)$$

$\bar{R}^2 = 0.68$; $S = 0.4565$

Comparing equations (8.2 - 8.3) with (8.4 - 8.5), it is clear that the division according to market conditions has enhanced the predictive precision of the regression models not only by their acquiring higher explanatory power but also by reducing the standard errorsof estimate. The value of the partial coefficients have also changed, for example, X_1 and X_6, with the speed variable (X_5) changing sign in the open registry data of equation (8.5). The elasticity of size for the OR data is much higher than that of the TC which indicates higher exploitation of scale economies. Interestingly the discussions of chapter 4 regarding higher rates for petroleum products as compared to crude oil has been proved with the positive value of the dummy variable which in all cases has been very significant.

The coefficients of the above equations are not all significant and do not all have the right signs. It is difficult on purely theoretical considerations to pin-point what the sign of variables such as charter duration and lead time would be because of the qualitative influence of expectations on them of what might happen to rates - whether they will remain depressed or rise in the foreseeable future. The uncertainties and expectations on the part of shipowners and charterers concerning the possible changes in spot rates during the tenure of the charter agreement will, undoubtedly, affect the long-term rate. In chapter 4 it was stated that the long-term charter has differing life-spans covering short, medium to long-term durations. The short to medium term duration can range from, say one month to three years or so, whilst the long-term proper can be something of a duration of ten years and above. This tends to suggest that not only will expectations affect the long-term rate in different market conditions but will also affect it according to the

length of the duration of charters.

It is expected that the duration variable will be positively related to the long-term rate for short to medium term durations and negatively related to it for longer period charters. This means that during periods of excess supply, the shorter the duration the lower the rate and the opposite holds for longer duration charters. This is to be expected because for a short duration charter of, say, a few months, the rate will be more or less an embodiment of the prevailing depressed market conditions and would not have any of those securities of long-term charters mentioned in chapter 4 - ie. mortgageability etc. The shortness of the duration also reduces the period of uncertainty and expectations about freight rate changes in the spot market. As the period of duration increases, rates will be affected more by uncertainties and expectations concerning an upturn in rates over the charter period, such that shipowners will demand higher rates to compensate them for loss of earning in the near future when rates might have changed. This is in fact what obtains in practice. Because our data contain cases where rates are graduated from say one rate for the first two years, a higher one for the next two years and yet a higher rate for the last two years for, say, a six-year charter in the low rate period.

Theoretically, Zannetos (p. 208 et. seq) postulates that during depressed market conditions this positive relationship holds up to a point as the duration of the charter increases and turns downwards thereafter. This turning point occurs around the longer duration extreme (in his case from nine years and above). This turning point, it is argued occurs because of the advantages (objective savings) which long-term charters provide to both shipowner and charterer and also due to anticipations of the impact of technological obsolescence expected to occur during the tenure of the charter. The longer the duration, the older the ship gets and the greater the possibility of technological obsolescence (depending of course on the age of the ship at the time of the agreement). Therefore, if there is enough probability that the vessel will become obsolete during the period of the charter, the shipowner will tend to settle for a lower rate both in periods of low and high rates. The likely

reaction of the parties to a charter to technological changes can be reflected through the impact of the age variable on rates which has the right negative sign in all cases. But because of the influence of the qualitative differences amongst the parties to a long-term charter, the relation between long-term rates and variables like charter duration and delivery time are best determined empirically.

In much the same manner as the duration of a charter is expected to affect its rate, so is the vessel delivery time because of uncertainties and expectations regarding changes in rates over the delivery time period. The relationship between lead time and rates is expected to be positive under depressed market conditions and negative for buoyant periods. For similar reasons as those advanced for duration of charter; when rates are depressed, the longer it takes to make the vessel available, the higher the rate is expected to be; because the shipowner will demand a reasonable compensation to make up for an eventual rise in rates between the lead time between signature and delivery which, as stated in chapter 4, can be as long as two years or more. The prospective charterer who can build or buy a new or secondhand ship in that period may be inhibited by cost considerations as compared to a charter. Whilst during periods of buoyant market conditions, prompt delivery attracts a premium, such deliveries in times of low freight rates are paid the prevailing market rates.

Speed is the most unreliable predictor. This is not unexpected. If we go back to section 6.3, it will be seen that it was mentioned that speed was dropped from the capital cost equations after F-tests showed that it did not contribute significantly to the regressions and instead a propulsion dummy was adopted. For the analysis of rates, speed was included because propulsion systems did not form part of the published charter information. Speed has proved to be a poor proxy for the type of propulsion because of the small variation in speed amongst bulk vessels with the majority of vessels having design speeds of 15 knots. There is no doubt that the type of engine will play a very important role in deciding what rate a shipowner would accept and a charterer pay in

view of the enormous fuel consumption differential between turbine and diesel engines as demonstrated by table 6.1. It is expected that the R^2 values would have been much higher had the propulsion systems been known. It is possible to identify the propulsion systems of the ships, but this could not be done within the time limit available for the study.

Even though only two of the independent variables in the TC data are significant and four of those of OR, F-tests reveal that all the variables except speed are significant to the regression, whilst an examination of the partial correlation matrix showed that the two most important contributors to the variations in the data are: vessel size and the type of cargo. It is expected that the influence of duration of charter and lead time will be stronger in periods of excess demand (high rates). Because, generally, as noted in chapter 4, the average shipowner tends to be interested in time-charters when freight rates are high for the simple reason that a charter contracted at a sufficiently high rate provides a security cushion for him during low rates. This is true of our data. The regression for all the flags for the 'low' period produced statistically insignificant results for duration and lead time but the two variables became significant predictors in the 'high' period regression. Also it was found, after dividing the data further into durations of less than 12 months and those of 12 months and above, that the R^2s were 42.4% and 47.7% for the former period for TC and ORs respectively, whilst they explained 61% and 70% of the variation in the latter for the two registry divisions correspondingly. This much was expected because for short term charter durations the close affinity with the spot market tends to suggest that there are conflicting forces weakening the influence of duration as a rate predictor.

8.2.1 Analysis of Residuals

To ascertain how reliable our fitted model is in predicting the dependent variable it is important to examine the residuals which will tell us the 'observed error' between the actual and the predicted values. In regression analysis it is usual to assume that the "true" residuals are independent, have zero mean, a constant variance, σ^2, and are normally distributed. If the fitted model is correct, the residuals will also

tend to exhibit tendencies that confirm those assumptions or, at least, indicate that they are not violated. The residuals are examined here by plotting them against the predicted freight rates. This is the basic residual plot in multiple regression analysis; but for other plots see Draper and Smith (1966). To have a standard of judging whether a residual is small or big and to be able to spot outliers, each and every residual was standardised. This was done by dividing each residual (e_i) by its standard deviation (s_i) to produce standardised residuals, ie. e_i/s_i, $i = 1,2,\ldots,n$. Since 95% of an N(0,1) distribution lies between the limits of (-1.96, 1.96), it may be expected that roughly 95% of the standardised residuals can lie between the interval of -2, +2 if the model is satisfactory. The limit -2, +2 is therefore our criterion for normality of the residuals. Residuals outside this range represent outliers. It is notable that the form of standardisation adopted here is different from the division of the plain residuals by S, the standard error of the regression line. The latter gives less information about the influence of residuals at extreme X values (Hoaglin and Welsch, 1978).

Figures 8.1a and b show the residual plots for the TC and OR regression equations (8.4, 8.5). The figures show that a great majority of the predicted values in both cases fall within the -2, +2 band. The precise figure is 96% and 93% for the TC and OR sub-groups, respectively. The 'horizontal band' of residuals in both cases indicates no abnormality, and our least squares analysis does not appear to be invalidated. The validity of the fitted equation lies in the fact that first, the residuals do not fan out, a picture which would have indicated inequality of variance with variance increasing with increasing values of the predicted variable. Secondly, there is no observable systematic departure from the fitted equation, ie. with negative residuals corresponding to lower values of the predicted rates and positive residuals to higher values which would have indicated error in the analysis. Thus the model is reliable for its purpose. See Anscombe and Tukey (1963) for the examination and analysis of residuals.

Figure 8.1a

Residuals for Traditional Registries — Low Rate Period;Tankers

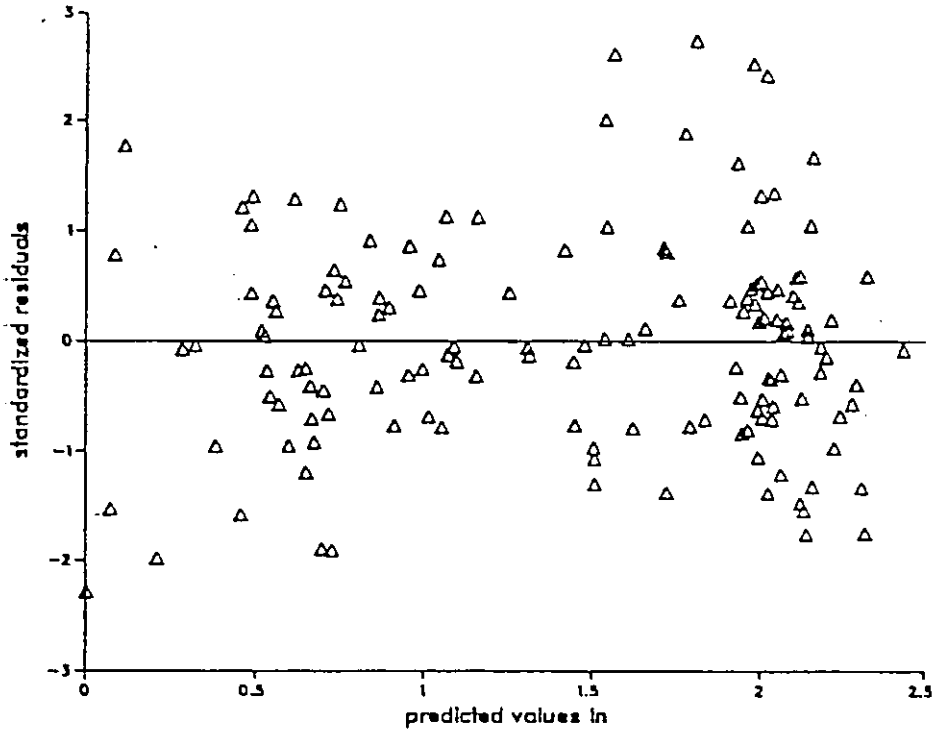
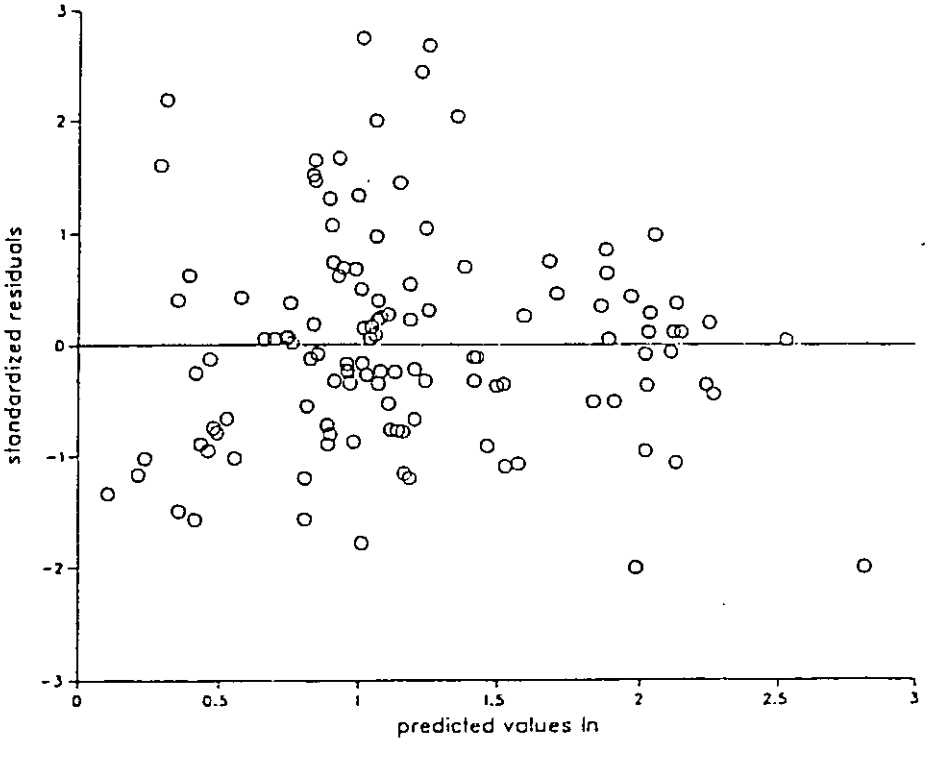


Figure 8.1b

Residuals for Open Registries — Low Rate Period;Tankers



8.2.2 Freight rate differentials - low freight period

These are given for various vessel sizes in table 8.2. Predicted rates are based on: 24 month-charter duration, 30 days delivery time, average vessel age of 10 years and speed of 15 knots. The dummy coefficient was added up to vessels of 50,000 dwt. An examination of this table in conjunction with table 6.3 immediately conjures the impression of a near-perfect fit between the two tables. This is so because table 6.3 shows that TC total costs are lower for all sizes up to and including 50,000 dwt, after which ORs exhibit lower costs for all sizes, 60,000 dwt and above. It is remarkable that the freight data for the depressed market period, to which 1982, the reference year of our cost analysis corresponds, with all the olympian detachment between the two samples also confirms that open registry freight rates were higher for vessels up to and including 85,000 dwt, and lower than TC's thereafter. The discrepancy is very much reduced if table 5.17b on total operating costs is compared with table 8.2. The threshold in the former is 60,000 dwt, and from 70,000 dwt OR costs are lower.

Table 8.2a Predicted time-charter rates for open and traditional registries: low rate period

Vessel size (dwt)	Rates ($/dwt /month)		Total Cost ($/dwt /month)		Total Operating Cost ($/dwt/month)	
	OR	TC	OR	TC	OR	TC
5,000	35.61	19.59	48.96	34.00	32.22	18.99
15,000	12.27	8.53	17.22	14.10	11.79	8.73
20,000	9.32	6.89	13.08	11.22	9.06	7.11
30,000	6.36	5.13	8.90	8.10	6.27	5.34
40,000	4.87	4.17	6.75	6.45	4.83	4.35
50,000	3.97	3.56	5.46	5.40	3.93	3.72
60,000	3.06	2.28	4.59	4.65	3.33	3.27
80,000	2.30	2.23	3.51	3.69	2.55	2.67
85,000	2.38	2.48	3.30	3.51	2.43	2.71
100,000	1.85	1.87	2.82	3.09	2.07	2.28
150,000	1.24	1.36	1.92	2.25	1.44	1.71
200,000	0.93	1.09	1.47	1.77	1.11	1.38
250,000	0.75	0.92	1.17	1.50	0.90	1.20
315,000	0.60	0.76	0.96	1.23	0.72	1.02
500,000	0.38	0.40	0.60	0.84	0.48	0.72

Table 8.2a in columns 4 - 7 show total shipping cost and total operating costs expressed in time-charter equivalents of $/dwt/month. These values were derived from tables5.17b and 6.3 and their relevant cost equations

in chapters 5 and 6 respectively, by simply multiplying the relevant 'cost per day' by 30 days and dividing by the ship's dwt. The cost equation based on the TC observations excluding the 3 U.S. ships was used in columns 5 and 7 because the freight rate regression for the 'low period' was based on TC data with only 4 U.S. observations out of a total of 18 for the period. This was caused by the fact that 14 of these observations had missing values for the speed variable. The effect is that because the 4 observations used were so typical of European observations that they did not have any impact on the analysis; whereas in fact they should, because U.S. observed rates are much higher and atypical of European rates, obviously as a result of subsidised operations. Therefore, the rates are more a reflection of the European situation. Hence the almost perfect agreement between the cut-off points underscored by broken lines in the cost and rate columns in table 8.2a.

In order to reflect a global picture in respect of traditional shipowning countries, the speed variable was dropped. This was also necessary particularly as it did not contribute significantly to the R^2, plus the fact that a goodly number of observations was excluded from the calculations because of missing values of the speed variable. The regression on the five remaining independent variables produced the following equations for the depressed rate period:

Traditional registries:

$$\ln F_R = 8.76 - 0.690\ln X_1 - 0.0165\ln X_2 - 0.0282\ln X_3 + 0.0291\ln X_4 + 0.443\ln X_6$$

(15.94)(-15.08) (-0.57) (-1.39) (1.01) (5.60)

$R^2 = 0.70$; $S = 0.5048$ (8.6)

Open registries:

$$\ln F_R = 10.3 - 0.821\ln X_1 + 0.0231\ln X_2 - 0.0617\ln X_3 - 0.0286\ln X_4 + 0.345\ln X_6$$

(16.82)(-16.31) (0.67) (-3.02) (-0.91) (3.64)

$R^2 = 0.70$; $S = 0.4714$ (8.7)

The residuals are plotted in figures 8.1c and d for TCs and ORs respectively. As in equations 8.4 and 8.5, the intercept, size and type of cargo variables are very significant at the 99% confidence level with far

Figure 8.1c

Residuals for Traditional Registries – Low Rate Period;Tankers

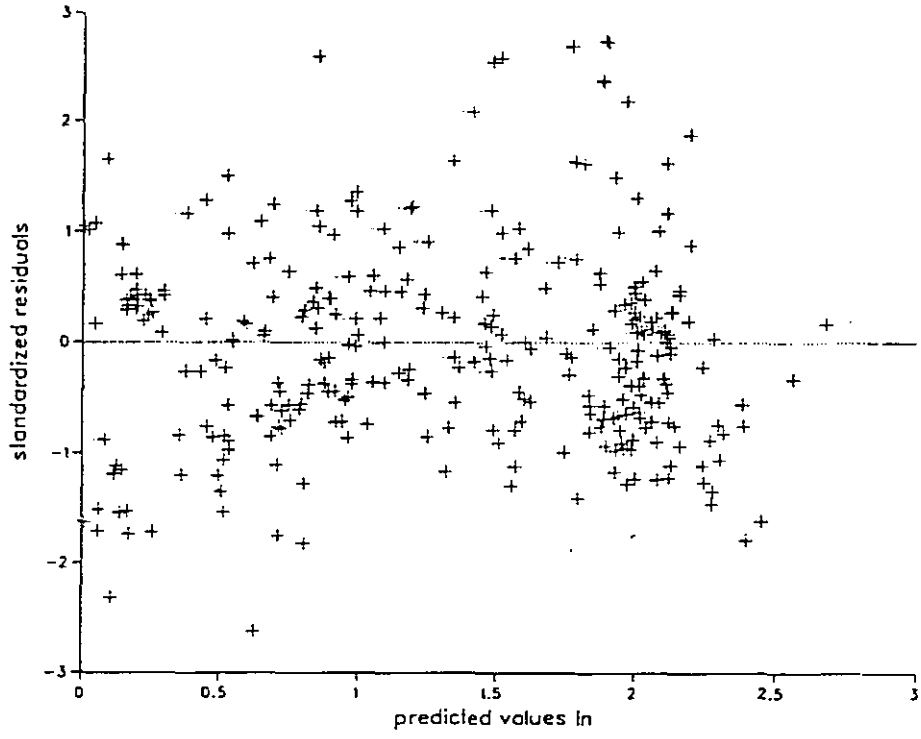
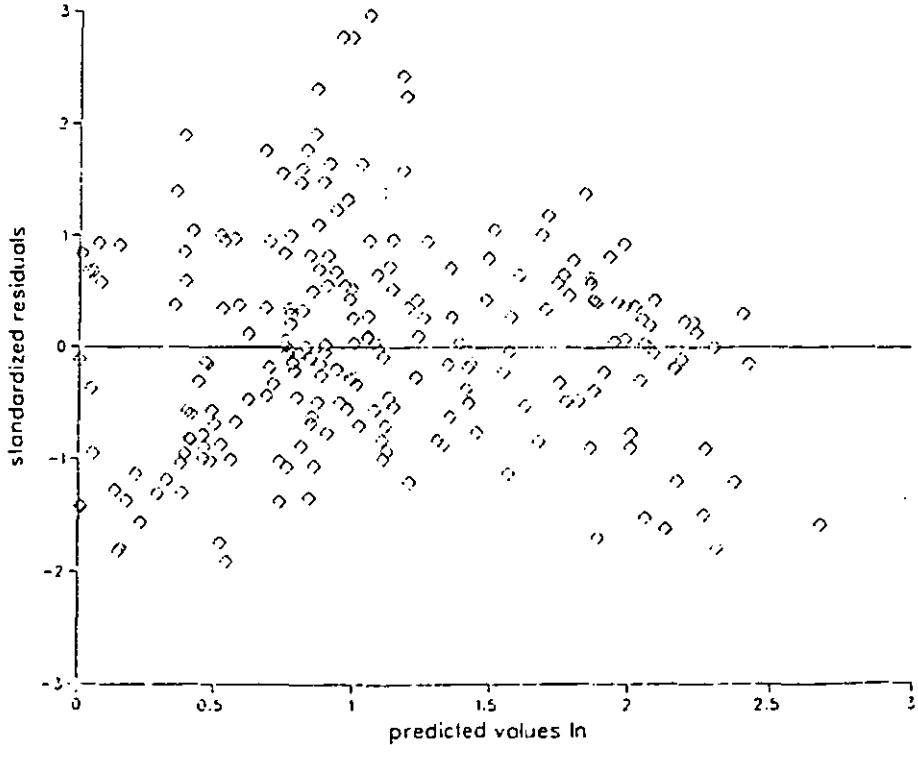


Figure 8.1d

Residuals for Open Registries – Low Rate Period;Tankers



higher t-ratios.

Table 8.2b Time charter rate differentials during depressed rates

Vessel size (dwt)	Rates ($/dwt/ /month OR	TC	Total Cost ($/ dwt/month OR	TC	Cost Savings $/ dwt/month	Rate diff. $/dwt/month	Savings/month to consumers
5,000	22.66	19.55	48.96	33.99	-14.97	-3.11	-15,550
30,000	7.29	7.08	8.88	8.76	-0.12	-0.21	-6,300
35,000	6.42	6.37	7.68	7.71	0.03	-0.05	-1,750
37,000	6.14	6.13	?	?	?	?	-370
40,000	4.79	5.81	6.75	6.90	0.15	1.02	40,800
50,000	3.71	3.81	5.46	5.73	0.27	0.10	5,000
60,000	4.13	4.39	4.59	4.92	0.33	0.26	15,600
80,000	3.26	3.60	3.51	3.87	0.36	0.34	27,200
100,000	2.71	3.09	2.82	3.21	0.39	0.38	38,000
150,000	1.94	2.33	1.92	2.28	0.36	0.39	58,500
200,000	1.54	1.91	1.47	1.80	0.33	0.37	74,000
250,000	1.28	1.64	1.17	1.50	0.33	0.36	90,000
315,000	1.06	1.40	0.96	1.23	0.27	0.34	107,100
400,000	0.87	1.19	0.75	1.02	0.27	0.32	128,000
500,000	0.72	1.02	0.60	0.84	0.24	0.30	150,000

A comparison of table 6.2 in chapter 6 and table 8.2b above will immediately reveal the remarkable agreement between the two tables. In the former, TC total costs were lower than those of ORs at the lower size end of up to 30,000 dwt, conceivably due to the specialised management skill required for the management, marketing and distribution of petroleum products and hence product tankers. An area of tanker operation in which the traditional nations with centuries of experience in ship husbandry indisputably excel. The time-charter rates given in table 8.2b, in the same breadth, re-affirm the findings of chapters 5 and 6 by underscoring the fact that open registry operations are subject to diseconomies in the product tanker sector right up to vessels of 37,000 dwt. The cut-off points are indicated by broken lines. With all the U.S. ships included in the regression, table 8.2b provides the global picture. The converted total cost equivalents are given in columns 4 and 5.

For both OR and TC data, columns 2-5 show a symbiotic relationship between costs and freight rates in the long-term in absolute agreement with the

postulate of Bennathan and Walters and all the other works cited in this thesis in this connection, that theoretically and empirically, cost is the 'bedrock' of freight rates in the bulk industry, see figures 8.2 and 8.3. If we compare columns 2 and 4 for ORs, it will be seen that rates are below cost but close to it right up to 100,000 dwt; but from 150,000 dwt as more economies are exploited, operators are seemingly able to cover total costs. The same trend applies to columns 3 and 5 for TCs. This trend goes to prove the abstraction made from the equilibrium price theory that sometimes rates will fall below the long-run cost and at other times rise above it. Our approach to the calculation of the long-run shadow freight rates given in columns 4 and 5 above is certainly redeemed by the fit between these columns and columns 2 and 3. The correlation coefficient (r) for OR costs and rates is 0.987 and 0.992 for TC costs and rates with all r being significant at 1% level.

In columns 6 and 7, cost savings per dwt per month by open registry operators and the differential in rates between them and their traditional counterparts are shown. These two columns also have a remarkable fit and tend to suggest strongly that the savings in cost realised by open registry operations are, according to our data, indeed passed on to consumers by way of lower freight rates as column 8 shows. The column shows that a charterer using an OR tanker of, say, 315,000 dwt can realise savings of up to $107,100 per month.

8.2.3 Freight rate differentials - high rate period

Equation (8.1) was calibrated with its six independent variables but the speed variable was found not to be an important contributor and was therefore eliminated. It is noteworthy, though, to mention that the equation which ensued showed that TC rates were lower up to 30,000 dwt and ORs lower for all sizes of 35,000 dwt and above.

The equations for this period without the speed variable are:

Traditional registries:

$$\ln F_R = \underset{(23.82)}{12.3} - \underset{(-21.82)}{0.910}\ln X_1 - \underset{(-1.54)}{0.0420}\ln X_2 - \underset{(-1.47)}{0.0274}\ln X_3 - \underset{(-5.01)}{0.1410}\ln X_4 + \underset{(2.21)}{0.159}\ln X_6$$

$$R^2 = 0.77; \quad S = 0.4208 \qquad (8.8)$$

Figure 8.2

Open registry costs and freight rates–Low period;Tankers

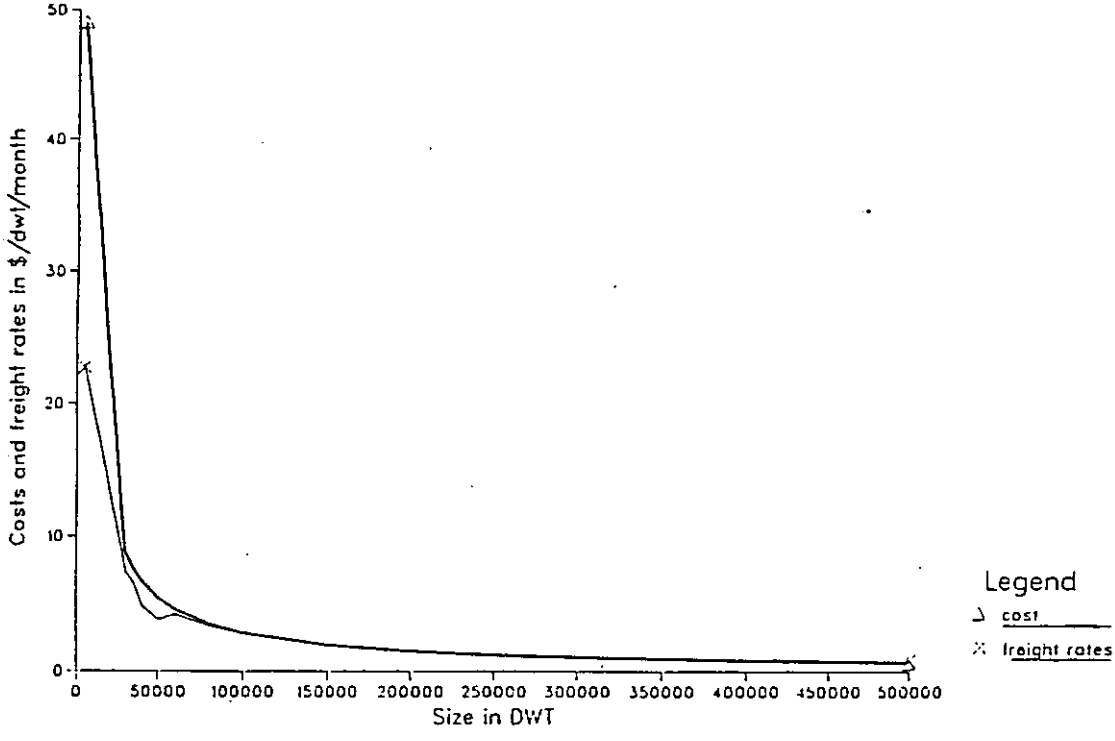
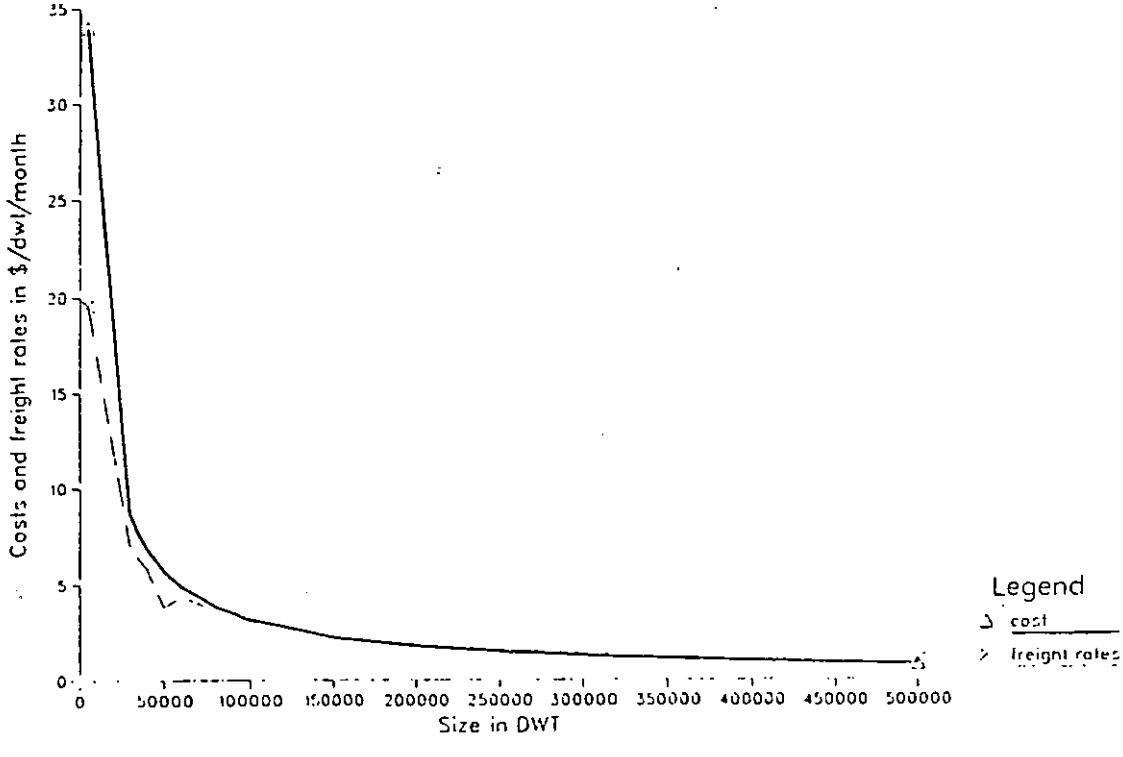


Figure 8.3

Traditional registry costs and freight rates–Low period;Tankers



Open registries:

$$\ln F_R = \underset{(21.27)}{11.6} - \underset{(-20.02)}{0.860}\ln X_1 - \underset{(-0.54)}{0.0176}\ln X_2 - \underset{(-0.37)}{0.0071}\ln X_3 - \underset{(-6.71)}{0.216}\ln X_4 + \underset{(2.31)}{0.205}\ln X_6$$

$$R^2 = 0.81; \quad S = 0.3538 \qquad (8.9)$$

The standardised residuals are shown in figures 8.4 a and b for all flags, TCs and ORs respectively. All the regressors have the correct sign with a lower standard error of estimate, S, indicating a lower level of dispersion and hence a better predictive precision as most of the variations in the data is explained by the fitted model. Table 8.3 shows the results.

Table 8.3 Tanker freight rate differentials - high rate period

Vessel size (dwt)	Rates ($/dwt/month) OR	TC	Differential ($/dwt/month)	Savings/month to consumers
5,000	55.10	69.53	14.43	72,150
30,000	11.80	13.62	1.82	54,600
50,000	7.61	8.55	0.94	47,000
100,000	4.19	4.55	0.36	36,000
150,000	2.96	3.15	0.19	28,500
200,000	2.31	2.42	0.11	22,000
250,000	1.91	1.98	0.07	17,500
315,000	1.56	1.60	0.04	12,600
500,000	1.05	1.05	0.00	0

Table 8.3 shows that less and less savings from scale economies were passed on to consumers of open registry shipping services during the bouyant market period and also that the differential in rates were also relatively smaller than in the low rate period. This much was expected for a period of excess demand when charging 'what the market will bear' would seem to be the rule rather than the exception. Even though their average rates were relatively closer in this period, as would be expected, the table clearly shows that even for this period open registry ships, according to our data, accepted lower freight rates and, ip so facto, benefitted users of their service.

It is obvious that in this period, the kind of close relationship obtained between cost and rates for the low rate period is not to be expected as rates will be far above costs. Rightly, the average of 1973/74 and

Figure 8.4a

Residuals for Traditional Registries – High Rate Period:Tankers

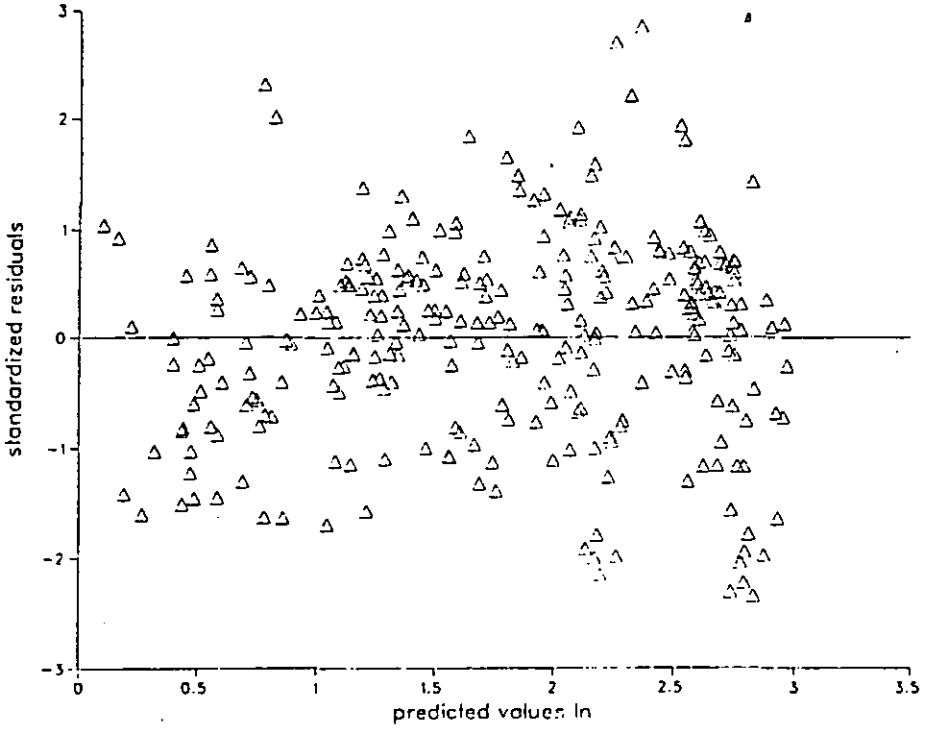
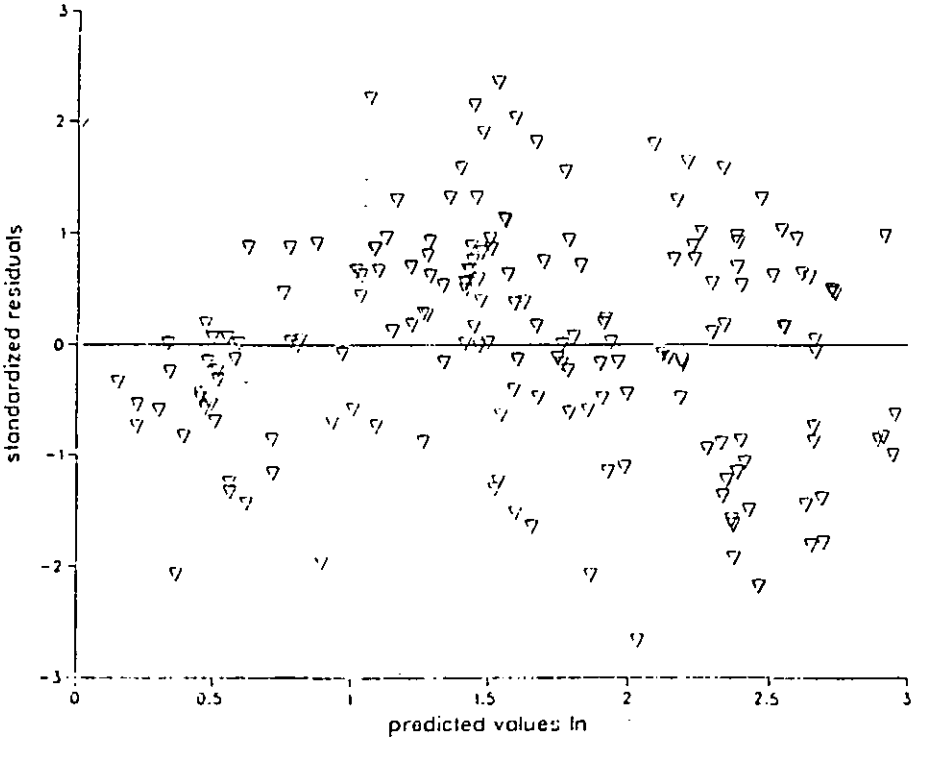


Figure 8.4b

Residuals for Open Registries – High Rate Period;Tankers



1979/80 costs should be used for such comparison. This could be done by using the weighted index of total operating costs for 1982 in appendix D to deflate the relevant total costs given in tables 6.2 and 6.3 to 1973/74, and 1979/80 levels and then take the average. But it is obvious, anyway, that the rates given in table 8.3 will far exceed these shadow freight rates as a casual comparison of these rates to their relevant shadow rates in columns 4 and 5 of table 8.2b will show.

8.3 Results - Bulk Carriers: low-rate period

Equation (8.1) was applied to the bulk carrier data without the speed and dummy variable. The regression equations for the low-freight period are:

Traditional registries:

$$\ln F_R = \underset{(20.79)}{8.66} - \underset{(-17.74)}{0.706}\ln X_1 + \underset{(4.18)}{0.151}\ln X_2 - \underset{(-1.97)}{0.0361}\ln X_3 - \underset{(-1.14)}{0.0282}\ln X_4$$

$$R^2 = 0.52; \quad S = .3919 \qquad (8.10)$$

Open registries:

$$\ln F_R = \underset{(14.38)}{8.43} - \underset{(-12.89)}{0.696}\ln X_1 + \underset{(3.66)}{0.150}\ln X_2 - \underset{(-1.21)}{0.0303}\ln X_3 - \underset{(0.03)}{0.0018}\ln X_4$$

$$R^2 = 0.51; \quad S = 0.3734 \qquad (8.11)$$

Figures 8.5a and b respectively show the residual plots for the TC and OR equations. The figures meet the criteria for a well-behaved regression equation; 93% and 94% of the predicted values fall within the -2, +2 critical range for TC and OR regressions, respectively. As can be seen in table 8.4, our data shows that for the six-year period between 1973 and 1982 for which rates were depressed, open registry operators offered lower time-charter rates than traditional ship operators for all vessel sizes. This finding ties in squarely with table 6.1 which shows that their (OR) bulk carrier costs are also lower right through the size spectrum covered therein. These costs are reproduced in time -charter terms in columns 4 and 5 of table 8.4; and the correlation between costs and rates is 0.999 for both ORs and TCs. Figures 8.6 and 8.7 show the corresponding graphic relationship.

Figure 8.5a

Residuals for Traditional Registries – Low Rate Period:Bulk Carriers

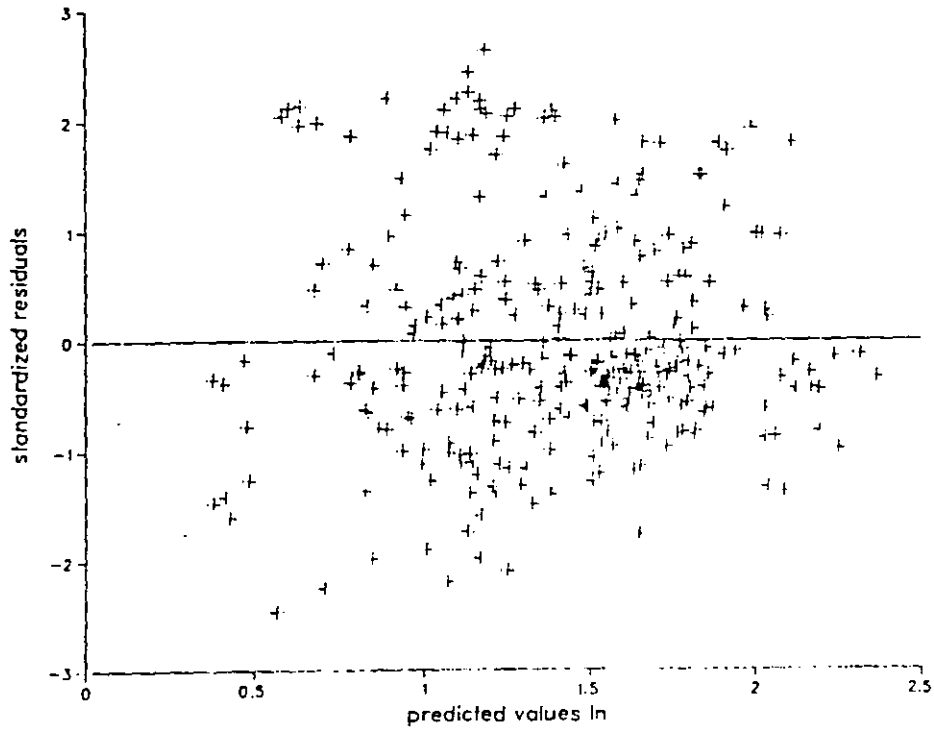


Figure 8.5b

Residuals for Open Registries – Low Rate Period:Bulk Carriers

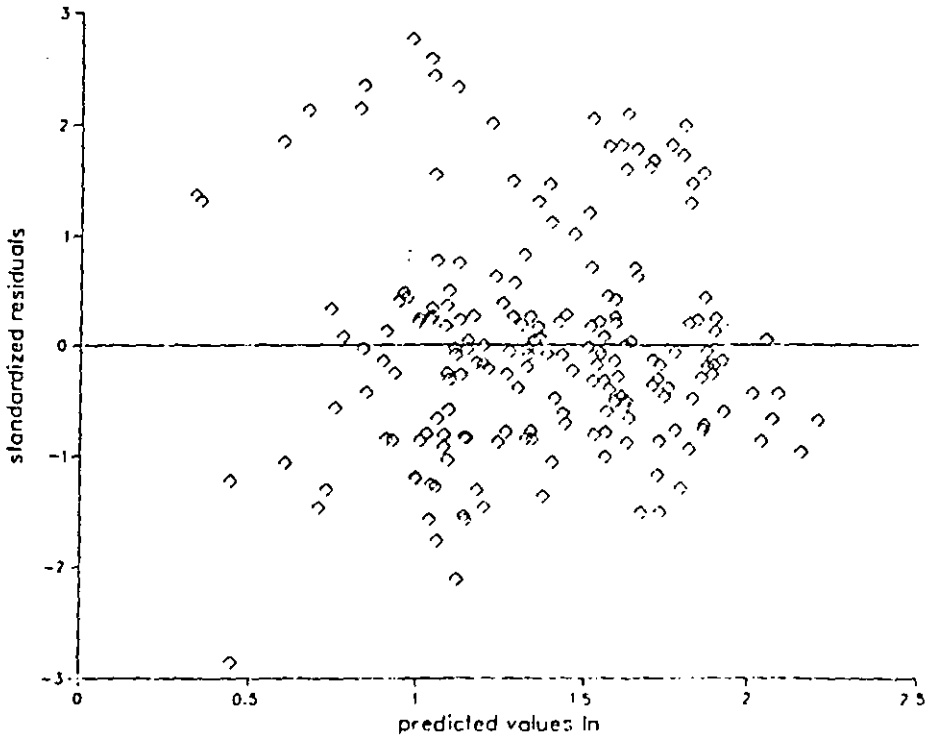


Figure 8.5c

Residuals for Traditional Registries – High Rate period;Bulk Carriers

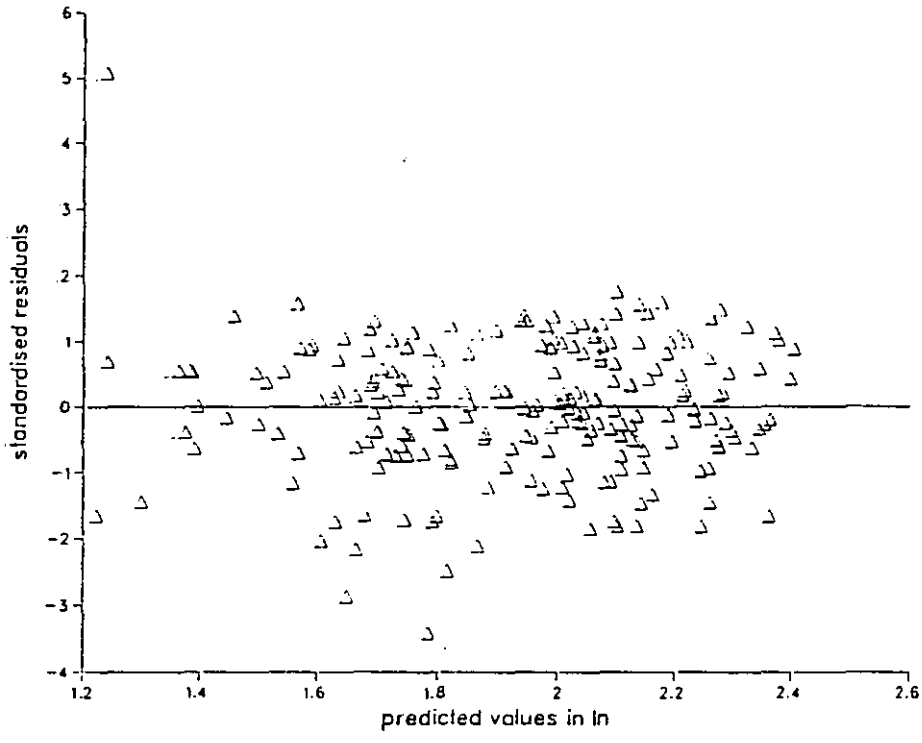


Figure 8.5d

Residuals for Open Registries – High Rate period;Bulk Carriers

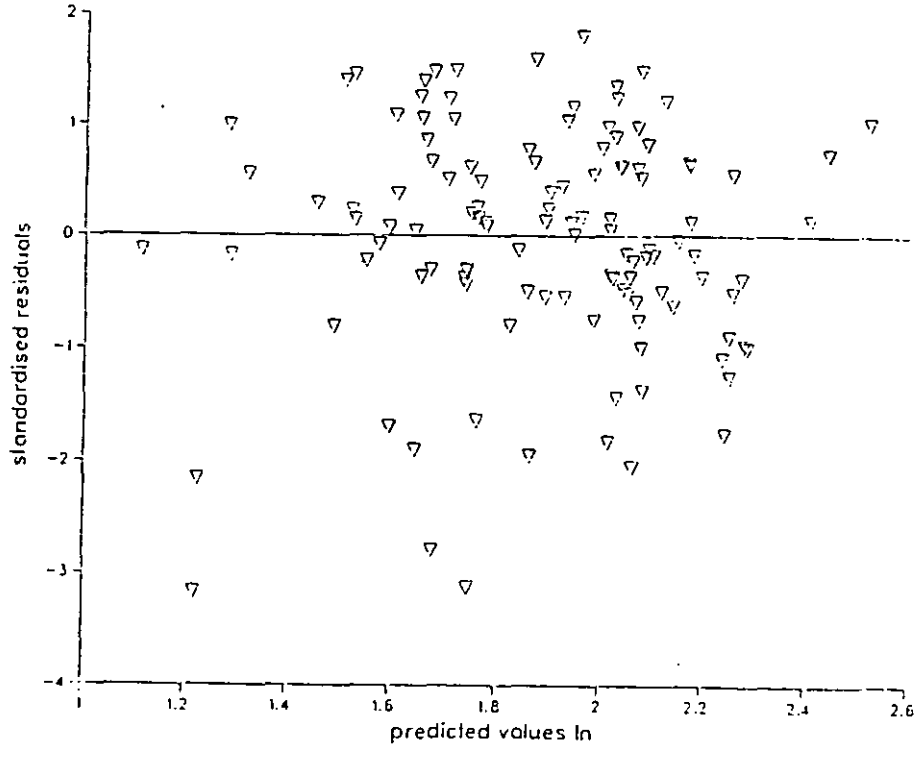


Figure 8.6

Open registry costs and freight rates –Low period;Bulk Carriers

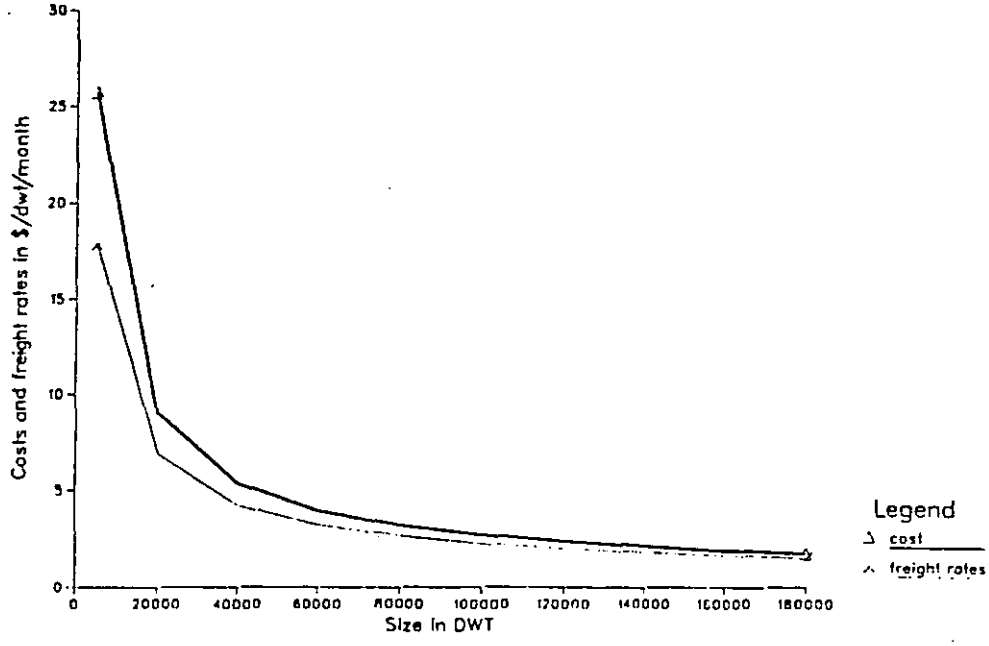


Figure 8.7

Traditional registry costs and freight rates –Low period;Bulk Carriers

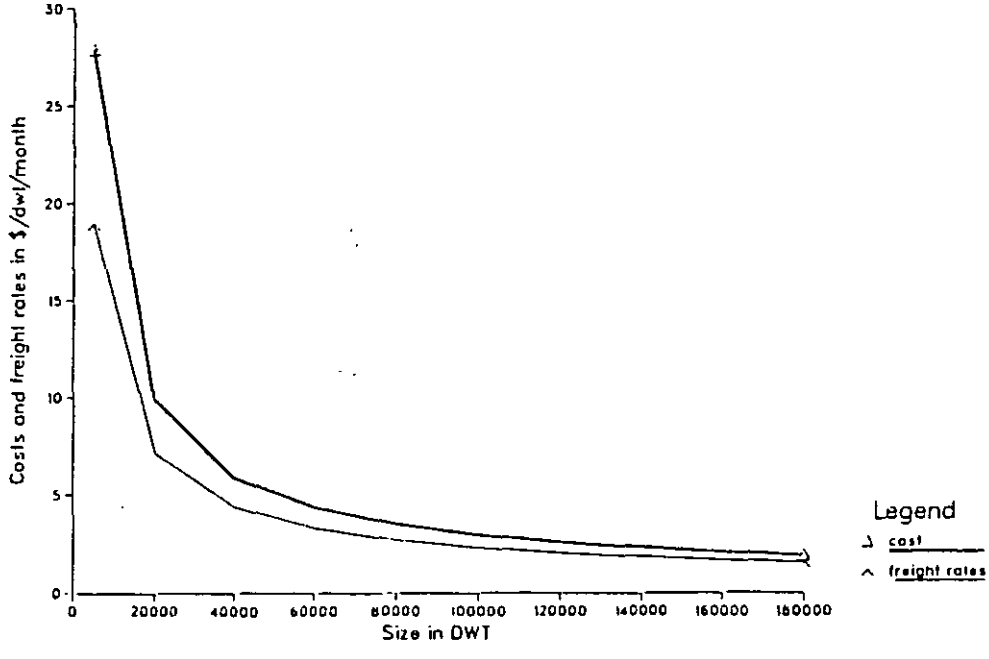


Table 8.4 Bulk Carrier Freight Rate Differential - low-rate period

Vessel size (dwt)	Rates ($/dwt/ /month) OR	TC	Total Cost ($/ dwt/month) OR	TC	Cost Savings ($/ dwt/month)	Rate diff. $/dwt/month	Savings/month to consumers
5,000	17.81	18.90	25.71	27.90	2.19	1.09	5,450
20,000	6.79	7.10	9.00	9.87	0.87	0.31	6,200
40,000	4.19	4.35	5.34	5.88	0.54	0.16	6,400
60,000	3.16	3.27	3.93	4.35	0.42	0.11	6,600
80,000	2.59	2.67	3.15	3.51	0.36	0.08	6,400
100,000	2.21	2.28	2.67	2.97	0.30	0.07	7,000
120,000	1.95	2.00	2.34	2.58	0.24	0.05	6,000
140,000	1.75	1.80	2.07	2.31	0.24	0.05	7,000
160,000	1.60	1.64	1.86	2.07	0.21	0.04	6,400
180,000	1.47	1.51	1.71	1.89	0.18	0.04	7,200

In the discussion of the results of the preliminary cost analysis of chapter 5 in section 5.6, it was noted that the results showed that open registry tanker operations yield larger savings at the large end of the size distribution because of their seeming higher economies of scale. The extent to which those scale economies have been exploited by operators was revealed in chapter 7. A comparison of tables 6.1 and 6.2-3 will reveal that OR tanker savings are bigger than those of their bulk carriers. This higher tanker cost savings, as our data suggests, appear to have brought about a relatively higher differential in freight rates and thus larger savings to the consumers of OR tankers at the large size end.

Thus in summing up the findings of the low rate period, it can be deduced from tables 8.2b and 8.4 that open registry operations have reduced costs in the bulk shipping industry and thus lowered freight rates. Comparing the differences between OR costs and their relevant freight rates, it will be seen that for both tankers and bulk carriers in the low-rate period, the differences are smaller than those between TC costs and their relevant rates (Cf. figures 8.6 and 8.7). It follows that since TC rates seem to have been 'forced' by competition to be very close to those of ORs (a situation very pronounced in the bulk carrier case - table 8.4, column 7) for the depressed period, it is very probable that OR operations have reduced freight levels and by so doing benefitted the consumers of bulk shipping services generally.

If this logic is not quite clear, tables 8.2b and 8.4 clearly provide evidence hitherto lacking, to satisfy UNCTAD's (1979) doubt about the fact that "there is no evidence to suggest that savings which owners of high-cost countries achieve by operating under open registry flags have ever been passed on to users." Although, UNCTAD, which is the chief proponent of the open registry phasing out debate, is uncertain about the extent of cost savings that may have been passed on to the users of open registry shipping services, it, unequivocally, believes that, owing to the ability of ORs to reduce their operating costs, it is possible that "In the bulk trades these lower costs might have reduced freight levels during periods of over-supply of shipping tonnage." (UNCTAD, 1977, p. 73, paragraph 228) - Cf. tables 8.2 and 8.4.

8.3.1 Bulk Carrier Freight Rate Differentials: high-rate period

The relevant equations for this period are:

Traditional registries:

$$\ln F_R = \underset{(24.31)}{6.94} - \underset{(-16.65)}{0.4491}\ln X_1 - \underset{(-3.66)}{0.0719}\ln X_2 - \underset{(-0.23)}{0.0017}\ln X_3 - \underset{(-3.20)}{0.0642}\ln X_4$$

$$R^2 = 0.60; \quad S = 0.2190 \qquad (8.12)$$

Open registries:

$$\ln F_R = \underset{(18.60)}{7.50} - \underset{(-13.42)}{0.5031}\ln X_1 - \underset{(-3.02)}{0.0876}\ln X_2 - \underset{(-0.34)}{0.0067}\ln X_3 - \underset{(-1.29)}{0.0304}\ln X_4$$

$$R^2 = 0.63; \quad S = 0.2102 \qquad (8.13)$$

Both the intercept and coefficients are very significant. Even though delivery lead time is not significant in both cases, it emerged with the right sign. During periods of rising rates, prompt or quick delivery attracts a premium and late delivery a penalty. The residuals are given in figures 8.5c and d for TCs and ORs respectively. The very pronounced horizontal spread of the TC residuals leaves us in no doubt, as would normally be expected, that there are not as many conflicting forces during periods of excess demand as there are in times of excess supply when uncertainties and future expectations affect the impact of some of the determinants of rates. Not surprisingly, for both TC and OR observations, 97% and 96%, respectively, of the predicted values fall within the -2, +2 band with, correspondingly, only 7 and 5 outliers. The differentials are

given in table 8.5 below.

Table 8.5 Bulk Carrier Rate Differentials for the high-rate period

Vessel Size (dwt)	Rates ($/dwt/month) OR	TC	Differential ($/dwt/month)	Savings per month to consumers ($)
5,000	17.20	15.39	-1.81	-9,050
20,000	8.56	8.26	-0.30	-6,000
40,000	6.04	6.05	-0.01	- 400
60,000	4.93	5.04	0.11	6,600
80,000	4.26	4.43	0.17	13,600
100,000	3.81	4.01	0.20	20,000
120,000	3.48	3.69	0.21	25,000
140,000	3.22	3.45	0.23	32,200
160,000	3.01	3.25	0.24	38,400
180,000	2.84	3.08	0.24	43,200

Even for this period the table shows that OR ships accepted lower rates for bulk carriers larger than 40,000 dwt whilst TCs sold cheaper services for smaller sized vessels up to and including 40,000 dwt. The interest of this thesis is not so much in the high-rate period, when excess demand may tend to obscure the relationship between cost and price, as it is in the low-rate period. But the results of this chapter have shown that for both TC and OR operations there is a close relationship between costs and rates in depressed market conditions.

In this regard additional tests (t-tests) were conducted to find whether the difference between the means of the cost and rates observations, as represented by the above tables, are significantly different from each other. The result is that for both TCs and ORs, the null hypothesis of the two means being equal was accepted with 99% confidence level (see Yamane (1973) p. 659 et. seq. for tests concerning the difference between two means from different populations). It follows that, given the fact that the freight rates accepted by each group is a reflection of its cost profile, and that the TC cost profile (and thus their rate profile) would have been higher if there were no OR operations, the results of this chapter provide strong evidence to support Sturmey's (1984) argument that "the thesis that lower shipping costs have not reduced freight rates ... is antithesis".

It must be noted, however, that the relatively low R^2 values obtained might have been due to other variables such as type of propulsion, commodity carried and trading area not forming part of the independent variables. Thus, in view of these relatively low explanatory powers of the regressions, the predicted freight rates should be treated with some caution.

Even though the main hypothesis of this thesis that 'lower costs breed lower freight rates' has been proved and some measure of the extent of such lower rates in terms of consumer savings indicated, it is questionable whether the freight rate differential is the right index for measuring consumer surplus. The questionable nature of this index is caused by the fact that it is well known that in depressed market conditions some operators operate in the market at negative quasi-rents and below operating costs (see table 8.2a) in the expectation that the market conditions will improve in the near future. Also in some cases competition is more imperfect than perfect, as some shipowners who use ship operations as a complementary business to their main business can afford, by cross-subsidisation from their more profitable concerns, to keep a ship trading far below its cost of operation while they expect an upturn in rates. Although J.S. Mill whom Kojima cites, rightly maintains that "capitalist will not go on permanently producing at a loss", Kojima himself contends that more often than not shipowners operate at below quasi-rents. For these sub-optimal reasons, and the fact, as proven in this chapter, that freight rates approach the long-run cost from below during low-rate periods, or roughly equal to it and above it at high rates, coupled with the more important fact of its long-run cost representation of the long-run opportunity cost of capital, a methodology based on the long-run cost is recommended in the following concluding chapter.

CHAPTER 9

SUMMARIES AND CONCLUSIONS

The preceding eight chapters have investigated the nature of open registries, their cost structures and the relationship with freight rates offered by ships which operate under these registries, vis a vis those of traditional maritime registries. In this final chapter, the many strands of the wide-ranging issues raised in those chapters are drawn together by way of summaries, conclusions and suggestions for further research.

9.1 Chapter summaries

In the first three chapters of the thesis the definition of open registries, their evolution, fleet development and characteristics, the conditions of ship registration, and their performance with regard to marine casualties were undertaken. In defining an open registry in chapter 1 it was made clear that the study was concerned only with those registries with an avowed policy of open ship registration as defined by the Rochdale Committee on shipping. It was recognised in that chapter that an open registry is an extreme form of a flag of convenience, even though the thesis accepts the two terms as inter-changeable because it takes the view that whilst all open registries are undoubtedly convenient, not all convenient registries are open. Thus the Rochdale definition of an open registry was adopted by the thesis because it contains all the salient features of the system. Whilst recognising that not all the features of the Committee's definition may apply today to open registries because of some changes made by these registries, for example, in respect of vessel inspection, the study takes the view that these changes notwithstanding, the conditions for operating ships under these registries are still far less stringent than those that obtain under regulated traditional registries.

Chapter 2, in reviewing the nature of open registries, provides evidence to the effect that open registry shipping is not a novel historical phenomenon but that maritime history abounds with evidence of its early existence well before the advent of the modern open registry states.

Five antecedents to the evolution of the modern open registries are traced; and the legal background of the prerogative of states to prescribe the conditions for registering ships under their flags outlined, followed by an international comparison of conditions for ship registrations. The absence of a genuine link between ship and flag of registry as implied by national equity participation and/or requirement for national involvement in the crewing and management of ships is very pronounced in the case of open registry conditions for ship registration. The growth of the fleet in the 1980's is not characterised by the sort of spectacular growth of the 1970's, but this is more a reflection of the generally depressed conditions of the shipping industry rather than a move away from these registries.

Open registry marine casualty performance was examined in chapter 3. The analysis of that chapter revealed that the opprobium which open registry operators have earned with respect to poor marine casualty records is not without foundation. Casualty analyses over several years have consistently shown that open registry ships on all bases of comparison have had poor marine accident records over the years, although individually some open registries have better records than others. On this score, it is thought that the measures being taken by open registries, with respect to vessel inspection services are aimed, idealised as they seem to be, at the effect of lack of jurisdiction and control over their vessels rather than the real problem - absence of a genuine link between vessel and registry. The chapter recognises that even though the international maritime community (eg. IMO) have conventions which are aimed at reducing sub-standard operations, it is the responsibility of each individual state to ensure their enforcement. The very nature of open registration which guarantees anonymity, ip so facto, makes accountability and hence enforcement of Conventions by the flag State almost impossible.

Since the thesis is concerned only with the bulk shipping sector, it was necessary to undertake an overview of the general characteristics of the bulk freight markets and the mechanics of rate determination. These are the matters dealt with in chapter 4. The chapter produces evidence from the literature to support the fact that the bulk trades

are approximately perfectly competitive; and that freight rates in these markets are determined by the inter-play of demand and supply and more significantly by the cost of production in agreement with the equilibrium price theory. Because cost is a major determinant of rates both in the short and long runs, the appendix to this chapter (appendix C.2) undertook a detailed discussion of the determinants of the major shipping cost elements, thus giving reasons why costs for the same vessel size vary.

In chapters 5 and 6, which draw heavily from the discussion of costs in appendix C.2, cost analyses based on cost survey data were undertaken. Using single equation regression models, chapter 5 analysed the cost differentials of open and traditional registries for all the five components of operating costs for tankers and bulk carriers. It was found that for bulk carriers, open registry manning, and repairs and maintenance costs were lower than those of traditional registries for all vessel sizes; whilst for stores and provisions, insurance and administration costs, the latter's were lower. The lower costs of the traditional registries in respect of administration and stores and provisions costs are attributed to their centuries of experience in ship husbandry and thus better management skills in buying and managing stores. Analysis of insurance costs showed that in practice considerations other than objective ones such as hull value of vessels appear to have influenced open registry insurance costs since insurance premia are also a function of the reputation of the operator and their claims record. In view of the poor accident records of open registry vessels, therefore it is not surprising that their insurance costs are higher. This finding runs counter to the claim made in an earlier study (Metaxas and Doganis, op. cit) that open registry bulk carrier insurance costs are subsidised by the insurance payments of the traditional operators. For tankers the finding is very much the same, except that insurance costs are lower for open registry ships at the large size category due to the cheapness of insurance premia for VLCC/ULCC vessels as a result of their falling hull values. For all vessel types and sizes, open registry total operating costs were found to be lower than those of traditional registry ships.

Capital cost estimation was undertaken in chapter 6 where the relationship between secondhand values, size, age, engine type, design speed and charter rates was used to derive the market values of the ships of the operating cost data. The regression model showed a very good fit. Annual capital costs were derived by using the economists' approach of opportunity cost of capital. Adding annual capital costs so derived to total operating costs, it was found that open registry total shipping costs for bulk carriers were lower for all vessel sizes within the range of the data. For tankers, traditional maritime nation's costs were lower for product carriers and higher otherwise.

In chapter 7 transcendental logarithmic cost functions are estimated for the first time for the tanker and bulk carrier sectors based on the flag dichotomy of this thesis. In this way an appropriately unrestricted cost function is reflected and the estimation provides evidence of the production technology of the shipping industry and for the flag dichotomy. This provides further evidence of scale economies associated with shipping operations and the extent to which they have been exploited, in addition to patterns of substitution possibilities, along with own-price and cross-price elasticities of factor demand. It is found that tanker operations are generally subject to greater scale economies than bulk carrier operations with open registry operations showing evidence of greater exploitation of scale potential for both vessel types. Tanker operations are also found to have higher factor substitutability. The production structure of shipping technology is found to be non-homothetic, non-separable and not subject to constant returns to scale, hence the different patterns of substitution and complementarity found.

It is also found that there is a remarkable flexibility in the use of labour and hence a consistently higher degree of substitution found between the manning and repair cost elements for open registries. These detailed and rigorous cost analyses also show that on average open registry costs are lower than those of traditional vessels for the two vessel types examined and that the manning cost element is the main contributor to the differential. It is concluded that the liberal registration conditions offered by open registry countries have ensured greater factor substitution flexibility and thus lower operating costs.

In chapter 8 empirical evidence is provided to support the theoretical postulation of the relationship between cost and freight rates in the long-run. Using time-charter rates over a ten-year and nine-year period for tankers and bulk carriers respectively, it was found that first, there is a symbiotic relationship between tanker and bulk carrier costs and time-charter rates, thereby adducing evidence to support the thesis that in the bulk trades freight rates are determined by cost of operation especially during periods of excess supply of tonnage. Secondly, it was found, ip so facto, that open registry freight rates for both periods of excess supply and excess demand covered by the study were lower than those offered by traditional registry operators. In agreement with the cost analyses of chapters 5 and 6, it was found that for tankers open registry time-charter rates were also higher for product tankers. It is thus concluded that the freight rate analysis yields evidence supporting the hypothesis hitherto, that the savings from open registry lower cost operations are passed on to the consumers of bulk shipping services by way of lower freight rates.

9.2 Conclusions

The primary aim of this thesis has been to investigate the relationship between the cost structure of open registry shipping and the freight rates accepted by these registries with a view to contributing a quantitative dimension to the hitherto largely unquantified issues of the open registry phasing out controversy. In so doing, the study has produced evidence which was until now lacking to the effect that the abolition of open registries despite their negative aspects could have serious repercussions for international trade because of the probable higher cost of sea transport which may ensue. It may mean that "the very substantial involvement of the open registers in the external trade of a number of OECD countries particularly the U.S., Japan, Australia and Canada will mean that any move to curtail their activities ... could have serious consequences upon the availability and cost of bulk exports and imports of these countries" (OECD, 1984, p. 61). For the U.S., whose 30% of exports and 50% of imports are transported in open registry ships; the impact of abolition will be considerable and so will it be for the OECD as a whole since over one-third of its foreign trade move in open registry vessels. The impact of abolition of the open registry system will therefore depend on how much of a country's foreign trade is carried in open registry

vessels and the differential between open registry costs and those of national flags.

Whilst the realisation of the objective of this study has identified an important positive aspect of open registry shipping, such a finding of itself does not justify the existence of open registration. The negative aspects must thus be set against this benefit in order to have a balanced picture of the costs and benefits of the system. For this reason the positive and negative aspects of open registry shipping have been outlined in table 3.7. From the potential costs and benefits given there, it is clear that the costs and benefits of the system are widespread with both the countries of registry and those of traditional maritime nations benefitting from them. Equally all countries suffer from the externalities. These countries experience different degrees of costs and benefits, therefore, it is not enough to study the effects of the system on one or two communities or even on a global basis, because the level of welfare distribution experienced by each country is different from the other. Therefore it is necessary that each country study its relationship to the open registry system on a cost-benefit scale to find out the extent to which the existence or abolition of the system will affect its welfare position. Without such an ad hoc approach, the full picture of costs and benefits of the institution will not be easily discernible, and thus the economic rationality for abolition or 'phasing out' will be difficult to justify.

Finally, this study has demonstrated that if providing a given service in one way uses less resources, or uses resources the opportunity costs of which are lower than would be used in providing the same service in another way, then from the resource allocation standpoint, the first way is cheaper, and that in a competitive market such as the bulk freight markets the price of the latter will also be cheaper.

9.3 Suggestions for further work

The background for further research has been laid out above. Individual country by country study is essential as earlier remarked in order to identify the net benefit of the retention of the system. To do this such ad hoc studies will need to draw up costs and benefits on the lines of table 3.7.

But it can be seen from that table that quantification of some of the benefits and costs may be extremely difficult and in some cases impossible. But this hardly argues against the use of cost benefit techniques as an aid to the decision-making process.

One benefit that can be quantified in monetary terms is the impact of lower costs on freight rates, and for this work a methodology is suggested here. The essential postulation of this methodology, which was first proposed in a paper presented to the Universities Transport Research Group (UTSG) in 1984 (Tolofari, 1984), is that in a freely competitive market, when the effects of any cost reductions induced by lower operating costs on the part of open registry operations are passed on in the form of lower freight rates, the ultimate beneficiaries will be the producers and consumers of exports and imports, through the effects of such reductions on their f.o.b. and c.i.f. prices. The size of the final benefit is determined by the extent to which the initial reduction in freight rate is actually converted into higher f.o.b. prices for exporters and lower c.i.f. prices for importers. This invariably depends on the elasticities of demand and supply with respect to transport costs (cf. chapter 4).

This impact can be determined by establishing initial equilibrium conditions as follows:

$D_m = Q_m P_m$ = demand function of the importing country (9.1)

P_m = demand price or c.i.f.

$S_x = Q_x P_x$ = exporters supply function (9.2)

P_x = f.o.b. price of exports

$P_m - P_x = t$ = transport cost or unit freight rate (9.3)

So that: $P_m = P_x + t$ (9.4)

If $S_x - D_m = 0$ = market equilibrium (9.5)

Equations (9.1) and (9.2) can be differentiated with respect to (9.3) on the basis of the equilibrium condition set at (9.5) to obtain the effect of a change in t on P_m and P_x.

Thus for exports a change in f.o.b. can be determined as:

$$\Delta Fp_i = \frac{\dfrac{-dQm_1}{dPm_1}}{\dfrac{dQm_1}{dPm_1} + \dfrac{dQm_2}{dPm_2} - \dfrac{dQx}{dPx}} \; dt_i \qquad (9.6)$$

The whole equation can be rewritten in elasticity form as:

$$\Delta Fp = \frac{-aem_i}{Em_i - T.e_x} \cdot dt_i \qquad (9.7)$$

where: ΔFp = change in the f.o.b. price of commodity i brought about by a unit change in the cost of transport,

a = proportion of the seaborne trade of country K in respect of commodity i transported in open registry ships,

em_i = elasticity of demand for commodity i in the Kth market for exports carried in open registry ships,

Em_i = total elasticity of demand for commodity i in the Kth importing country,

e_x = domestic elasticity of supply of commodity i in the jth exporting country,

T = the derived demand for transport

dt_i = difference in unit freight cost between OR and TC/national fleet.

Equation (9.7) provides the link between the change in unit transport costs and the change in the f.o.b. prices of exports in terms of the elasticities of demand and supply and the proportion of commodity i from country j to K carried in open registry ships. A good approximation to the total benefit from exports will be to multiply the initial volume of exports, S_x, by the change in f.o.b. prices ΔFp. But because we are interested more in the share of exports handled by open registries, 'a', the benefit can be calculated as:

$$(Dm_1 \times dt_1) \cdot \frac{\Delta Fp}{(A \times dt_1)} \qquad (9.8)$$

(See Vanags, 1982, for an application of this model to the costs and benefits of navigational aids)

To illustrate the use of (9.8) let us use the export of commodity i from the U.S. to country K. Let us assume that exports for a given year were worth £400m and that this was only a proportion of U.S. exports of this commodity, say 10%. Let us assume further that the transport cost for carrying this equivalence of cargo in a national flag ship is £40m. If it is assumed further that open registry ships can carry this commodity for a freight rate 0.4% lower, because of their lower shipping costs, then transport costs on the tonnage carried in open registry ships are relatively cheaper by £40m x 0.004, that is £160,000 for the given year. The value £160,000 represents the left hand side of (9.8) and is termed the 'impact effect'. The right hand side of (9.8) represents a 'conversion factor' needed to convert the 'impact effect' of the use of open registry ships into total benefits on exports. The values of the conversion factors depend on the value of 'T' - the share of transport cost in delivered price - and the respective elasticities for the commodity in question.

Assuming that 'T' represents 10% of the final price of one ton of commodity i and that the elasticity of demand for the share of this commodity carried by open registry ships is the same in the U.S. as the total elasticity of demand for all exports of commodity i, then

$$em_1 = em_2 = E.$$

Since both em and E are equal, we assume elasticity of demand to be - 2 and that for supply to be 2. We would then get a conversion factor of 0.48 based on the right hand side of equation 9.8, ie.

$$\frac{-em}{E.T.e_x} \qquad (9.9)$$

Applying this conversion factor to the initial reduction in transport costs, the annual benefit on exports of commodity i in open registry ships becomes £160,000 x 0.48 = £75,800.

The same process can be repeated for the assessment of total benefits on imports to find what change a lower freight rate makes on the c.i.f. prices of imports.

The term dt (difference in unit transport cost) should not be taken as the differential in freight rates between the national flag and open registry ships because as Mishan (1976, p.25) points out "for all except marginal changes in the amount of a good, the market price prevailing in a perfectly competitive setting is an inadequate index of the value of the good." It means that the appropriate measure of dt should be the cost difference or cost savings in consumer surplus terms (Mishan, ibid, pp. 28 et. seq). The theoretical justification for using the shadow freight rate as enunciated in this thesis as a basis for measuring the consumer surplus with respect to sea transport is well supported in the literature. Thus dt should be the differential in the long-run equilibrium cost as calculated in chapters 5 and 6.

The value of 'a' can be easily obtained from OECD's annual publication - 'Maritime Transport', where the proportions of bulk and liner cargoes carried in open and national registry vessels are published annually for all OECD countries. Also the volume of exports and imports, and f.o.b. and c.i.f. prices can be obtained from U.N.'s international trade publications.

All in all, the impact of abolishing open registries in terms of freight rates, will be the opportunity cost of carrying 'a' in national flag ships. The net difference in social benefits thus serves as a measure of the economic value of abolishing the system to the countries concerned. This thesis is a contribution to that wider cost-benefit calculus.

APPENDIX A

STATISTICS ON THE NATURE & DEVELOPMENT OF THE OPEN REGISTRY FLEET

Table 2.2 Growth of the Major Open Registries Fleets, 1924-1984 (vessels of 100 grt and over in million grt)

Year	Liberia		Panama		Honduras		Cost Rica		Lebanon		Cyprus		Somalia		Singapore		Bermuda		Bahamas		FOC Total	World Total	FOC % of World
	No.	GRT	No.	GRT	No.	GRT	No.	GRT	No.	GRT	No.	GRT	No.	GRT	No.	GRT	No.	GRT	No.	GRT	GRT	GRT	
1924		-	14	0.084																		61.51	-
1939	-	-	159	0.72	32	0.08															0.80	68.51	1.2
1948	2	772	515	2.72	93	0.32															3.04	80.29	3.8
1950	22	0.24	573	3.40	142	0.52															4.10	84.58	4.9
1951	69	0.59	607	3.61	152	0.51															4.71	87.25	5.4
1952	105	0.90	606	3.74	145	0.47															5.11	90.18	5.7
1953	158	1.43	593	3.91	146	0.47	50	0.15													5.96	93.35	6.4
1954	245	2.38	595	4.09	130	0.44	70	0.20													7.11	97.42	7.3
1955	436	4.00	555	3.92	117	0.43	114	0.34													8.69	100.57	8.6
1956	582	5.58	556	3.92	106	0.39	152	0.51													10.40	105.20	9.9
1957	743	7.47	580	4.13	94	0.37	152	0.52													12.49	110.25	11.3
1958	975	10.08	602	4.26	89	0.34	144	0.51													15.27	118.03	12.9
1959	1085	11.94	639	4.58	78	0.20	91	0.29													17.01	124.94	13.6
1960	977	11.28	607	4.23	59	0.15	44	0.09	74	0.26											16.01	129.77	12.3
1961	903	10.93	601	4.05	58	0.12			131	0.55											15.65	135.92	11.5
1962	853	10.57	592	3.85	54	0.11			164	0.75											15.28	139.98	10.9
1963	893	11.39	619	3.89	49	0.10			190	0.91											16.29	145.86	11.2
1964	1117	14.55	691	4.27	46	0.09			174	0.85											19.76	153.00	12.9
1965	1287	17.54	692	4.46	47	0.08			157	0.78											22.86	160.39	14.3
1966	1436	20.60	702	4.54	43	0.07			149	0.74	35	0.18									26.13	171.13	15.3
1967	1513	22.60	757	4.76	45	0.07			139	0.60	60	0.36									28.39	182.10	15.6
1968	1613	25.72	798	5.10	45	0.07			122	0.44	109	0.65	15	0.06	73	0.13					32.17	194.15	16.6
1969	1731	29.22	823	5.37	51	0.07			95	0.30	134	0.77	58	0.20	112	0.23					36.25	211.66	17.1
1970	1869	33.30	886	5.64	52	0.06			79	0.18	207	1.14	79	0.37	153	0.42					41.11	227.49	18.1
1971	2060	38.55	1031	6.26	54	0.07			65	0.13	277	1.50	109	0.59	185	0.58					47.68	247.20	19.3
1972	2234	44.44	1337	7.79	58	0.07			70	0.12	394	2.01	148	0.87	281	0.87					56.17	268.34	20.9
1973	2289	49.90	1692	9.57	57	0.07			81	0.12	589	2.94	239	1.69	387	2.00					66.29	289.93	22.9
1974	2332	55.32	1962	11.00	56	0.07			88	0.12	722	3.39	276	1.92	511	2.88					74.70	311.32	24.0
1975	2520	65.82	2418	13.67	60	0.07			123	0.17	735	3.22	273	1.81	610	3.89					85.75	342.16	25.1
1976	2600	73.48	2680	15.63	57	0.07			136	0.21	765	3.11	255	1.79	722	5.48			119	0.15	99.92	372.00	26.9
1977	2617	79.98	3276	19.46	63	0.10			163	0.23	800	2.79	31	0.16	872	6.79	88	1.75	424	1.37	112.63	393.68	28.6
1978	2523	80.19	3640	21.75	70	0.10			189	0.30	793	2.60			954	7.49	99	1.81	93	0.08	113.39	406.00	27.9
1979	2466	81.53	3803	22.32	99	0.20			185	0.30	762	2.36			1031	7.87	112	1.73	91	0.12	116.49	413.02	28.2
1980	2401	80.29	4090	24.19	124	0.21			203	0.27	688	2.09			988	7.66	114	1.72	91	0.09	116.57	419.91	27.8
1981	2281	74.91	4461	27.66	143	0.20			230	0.32	588	1.82			828	6.89	75	0.50	106	0.20	112.50	420.83	26.7
1982	2189	70.72	5032	32.60	172	0.23			240	0.37	587	2.15					68	0.47	96	0.43	106.97	424.74	25.2
1983	2062	67.56	5316	34.67						0.50		3.50						0.82		0.86	107.91	422.59	25.5
1984	1934	62.02	5499	37.24	238	0.28			251	0.50	737	6.73					76	0.82	163	3.19	110.78	418.68	26.5

Table 2.3 Fleet Development in the Traditional Maritime Countries*, 1939 - 1984

	1939	%	1950	%	1960	%	1970	%	1980	%	1982	%	1984
U.K.	17,891	26.1	18,219	21.5	21,131	16.3	25,825	11.4	27,135	6.5	22,505	5.3	15,874
U.S.A.	11,362	16.6	27,513	32.5	24,837	19.1	18,463	8.1	18,464	4.4	19,111	4.5	19,292
Japan	5,630	8.2	1,871	2.2	6,931	5.3	27,004	11.9	40,960	9.6	41,594	9.8	40,358
Norway	4,834	7.1	5,456	6.4	11,203	8.6	19,347	8.5	22,007	5.2	21,862	5.1	17,663
Germany	4,483	6.5	460	0.5	4,537	3.5	7,881	3.5	8,356	2.0	7,707	1.8	6,242
Italy	3,425	5.0	2,580	3.0	5,122	4.0	7,448	3.3	11,096	2.6	10,375	2.4	9,158
Netherlands	2,970	4.3	3,109	3.7	4,884	3.8	5,207	2.3	5,724	1.4	5,393	1.3	4,586
France	2,934	4.2	3,207	3.8	4,809	3.7	6,458	2.8	11,925	2.8	10,770	2.5	8,945
Greece	1,781	2.6	1,349	1.6	4,529	3.5	10,952	1.8	39,472	9.4	40,035	9.4	35,059
Sweden	1,577	2.3	2,048	2.4	3,747	2.9	4,921	2.2	4,234	1.0	3,788	0.9	3,520
U.S.S.R.	1,306	1.9	2,125	2.5	3,429	2.6	14,832	6.5	23,444	5.6	23.789	5.6	24,492
Denmark	1,175	1.7	1,269	1.5	2,270	1.8	3,314	1.5	5,390	1.3	5,214	1.2	5,211
Total	59.26	86.5	69.2	81.6	97.5	75.1	152.0	66.8	218.0	51.8	212.0	49.1	186.88
World Total	68,509	100	84,583	100	129,770	100	227,490	100	419,911	100	424,742	100	418,682
													(44.64%)

* Countries with over 10^6 GRT before 1939 - GRT and % of World Fleet

Source: Lloyds Register of Shipping - Statistical Tables

Table 2.4 Comparison of individual fleet growth rates in grt terms (%)

1980-1984	1983-1984		1950-1960	1960-1970	1970-1980	1980-1981	1981-1982	1982-1983
-6.25	-8.20	Liberia	46.96	11.43	9.20	-6.70	-5.59	-4.47
11.39	7.41	Panama	2.21	2.92	15.67	14.34	17.86	6.35
33.96	9.23	Cyprus	-	58.64	6.25	-12.92	18.13	62.79
-	-	Singapore	-	79.74	33.69	-10.05	4.21	-
144.00	271.00	Bahamas	-	-	-59.65	122.22	115.00	100.00
-16.91	0	Bermuda	-	-	9.72	-70.93	-6.00	74.47
-0.84	1.88	Denmark	6.00	3.86	4.98	-7.05	4.07	-1.90
-6.94	-9.35	France	4.13	3.00	6.33	-3.56	-6.35	-8.38
-7.03	-9.50	Germany (FR)	25.72	5.68	0.59	-7.73	-0.04	-10.51
-2.92	-6.45	Greece	12.88	9.23	13.68	6.40	-4.68	-6.39
-4.69	-8.56	Italy	7.10	3.81	4.07	-4.11	-2.49	-3.47
-0.37	-0.97	Japan	14.00	14.57	4.25	-0.29	1.85	-2.02
-5.39	-7.17	Netherlands	4.62	0.64	0.95	-4.44	-1.41	-8.40
-5.35	-8.15	Norway	7.46	5.62	1.30	-1.53	0.89	-12.04
-4.51	2.53	Sweden	6.23	2.76	-1.49	-4.82	-6.00	-9.37
-12.54	0.17	U.K.	1.49	2.03	0.50	-6.32	-11.47	-15.03
1.10	-0.35	U.S.A.	-1.02	-2.92	0	2.42	1.06	1.30

Table 2.5 Annual % growth rates of open registry, traditional and world fleets in grt terms.

Period	Open Registries (OR)	Traditional Countries (TC)	World
1939-1950	16.02	1.42	1.93
1950-1960	14.60	3.49	4.37
1960-1970	9.90	4.54	5.77
1970-1980	10.98	3.67	6.32
1980-1981	-3.49	-0.60	0.22
1981-1982	-4.92	-2. 17	0.93
1982-1983	0.88	-5.28	-0.51
1983-1984	2.66	-6.93	-0.92
1980-1984	-1.27	-3.78	-0.07
1950-1984	10.18	2.97	4.82

Table 2.6 Percentage structure of vessel types in the open registry fleets and traditional shipping fleets - 1984 (GRT)

Flag	Oil Tankers	Ore & Bulk Carriers	Combined Carriers	Chemical Tankers	General Cargo	Container-ships	Miscel.	Total %	Total Mil. GRT
Liberia	53.9	24.2	10.6	2.3	4.1	0.8	4.1	100	62.0
Panama	21.2	35.0	4.0	1.6	27.1	3.2	7.9	100	37.2
Cyprus	47.2	24.0	2.2	0.5	25.4	0.4	0.3	100	6.7
Bahamas	80.8	3.3	3.9	2.6	3.1	0.1	6.2	100	3.2
Bermuda	25.0	40.0	1.3	-	22.6	0.6	10.5	100	0.8
Total OR	43.0	27.3	7.6	1.9	13.3	1.6	5.3	100	110.0
Denmark	44.2	8.6	-	1.9	14.6	19.2	11.5	100	5.2
France	53.7	12.4	5.4	0.7	11.2	7.2	9.4	100	8.9
Germany(FR)	24.2	12.1	1.5	2.6	25.8	24.2	9.6	100	6.2
Greece	30.8	39.9	6.8	0.3	19.1	0.6	2.5	100	35.1
Italy	38.0	23.9	13.0	1.2	9.8	2.2	11.9	100	9.2
Japan	37.1	27.7	5.0	1.2	9.2	4.7	15.1	100	40.4
Netherlands	21.7	17.4	-	4.3	28.3	13.0	15.3	100	4.6
Norway	49.2	15.3	13.0	4.5	5.6	0.3	12.1	100	17.7
Sweden	34.3	8.6	2.9	5.7	25.7	2.9	19.9	100	3.5
U.K.	40.3	15.1	6.3	2.5	9.4	9.4	17.0	100	15.9
U.S.A.	38.9	9.8	1.0	2.6	16.6	15.0	16.1	100	19.3
U.S.S.R.	19.2	8.6	2.9	0.01	32.2	2.4	34.7	100	24.5
Total IC	35.4	20.9	5.5	1.6	16.0	5.9	14.7	100	190.5
Total World Fleet	34.5	24.8	5.9	1.6	18.2	4.0	11.0	100	418.7
% of World Under OR	32.8	30.0	34.2		19.0	10.0			
World Nos. %	6,288	4,829	400	1,216	21,608	940	40,787	76,068	

NOTE: Containerships include Lighter Carriers, and miscellaneous vessels include: passenger/cargo ships, liquefied gas carriers and miscellaneous tankers, vehicle carriers, fishing vessels, supply ships, tugs and dredgers, livestock carriers, etc. Chemical tankers include oil/chemical tankers.

Table 2.7 The flag structure of open registry fleets, 1984 (% of GRT) (% of OR fleet by each flag)

Flag / Vessel Type	Tankers No.	Tankers GRT	Bulk Carriers No.	Bulk Carriers GRT	Combined Carriers No.	Combined Carriers GRT	General Cargo No.	General Cargo GRT	Containers No.	Containers GRT	Total OR No.	Total OR GRT
Liberia	46.4	70.6	46.8	56.3	78.6	78.4	10.0	17.4	22.0	28.2	23.0	56.4
Panama	44.4	17.0	46.0	37.8	17.9	18.2	73.3	68.9	67.7	67.6	65.4	33.8
Cyprus	5.8	6.6	5.8	4.5	1.4	1.8	14.5	11.6	7.3	1.5	8.8	6.1
Bahamas	2.8	5.4	0.5	0.6	1.4	1.5	1.5	0.7	1.2	0.2	1.0	.9
Bermuda	0.6	0.4	0.9	0.8	0.7	0.1	0.9	1.2	1.8	0.3	0.9	0.8
Total	100	100	100	100	100	100	100	100	100	100	100	100
	1182	48.31	1627	38.47	145	8.44	3425	16.25	164		8409	110.0
% of World	17.8	32.8	31.1	30.0	36.3	34.2	15.9	17.4				

Table 2.8 Percentage distribution of the age of all vessels under open registry and traditional maritime countries - 1984

Flag		Age (years) 0-4	5-9	10-14	15-19	20-24	25-29	30+	Total (No. of vessels & million grt)
Liberia	No.	16.1	33.5	31.5	14.6	2.9	1.0	0.4	1934
	GRT	11.8	38.7	38.2	9.5	1.3	0.5	0.1	62.0
Panama	No.	16.2	16.4	18.3	18.9	12.0	8.4	9.7	5499
	GRT	22.1	24.3	20.6	17.7	8.7	4.1	2.5	37.2
Cyprus	No.	2.0	9.6	25.2	30.7	13.2	7.5	11.8	737
	GRT	2.4	20.9	35.8	31.3	6.0	2.1	2.5	6.7
Bahamas	No.	19.6	26.4	19.6	10.4	9.8	6.7	7.4	163
	GRT	15.6	53.1	31.3	0.9	0.2	1.3	0.2	3.2
Total open registries	No.	15.0	20.0	22.0	18.8	10.0	6.6	7.6	8333
	GRT	14.8	33.2	31.9	13.4	4.0	1.8	0.9	109.1
Denmark	No.	13.8	24.3	15.9	19.3	12.0	5.3	9.5	1101
	GRT	23.1	46.2	22.1	5.8	1.8	0.8	0.8	5.2
France	No.	11.1	18.7	20.5	13.5	15.2	12.5	8.5	1174
	GRT	11.2	48.3	33.7	4.5	2.2	0.9		8.9
Germany(FR)	No.	21.1	21.6	14.3	14.8	8.8	6.7	12.7	1813
	GRT	29.0	33.9	24.2	9.7	1.5	0.8	0.9	6.2
Greece	No.	5.6	14.6	20.6	19.8	13.7	10.8	14.9	2904
	GRT	8.8	21.9	29.3	25.6	8.8	3.7	1.9	35.1
Italy	No.	9.9	11.9	19.8	16.9	13.5	10.2	17.8	1590
	GRT	7.6	34.8	26.1	13.0	8.7	5.4	4.4	9.2
Japan	No.	25.1	26.4	27.4	15.1	4.8	0.8	0.4	10425
	GRT	30.0	28.0	35.9	5.0	0.7	0.2	0.2	40.4
Netherlands	No.	25.5	26.3	20.9	12.7	7.9	3.7	3.0	1337
	GRT	30.4	28.3	23.9	10.9	4.3	2.2	-	4.6
Norway	No.	13.5	23.6	16.2	15.2	6.1	7.7	17.7	2271
	GRT	20.3	44.1	30.5	2.8	1.1	0.4	0.8	17.7
Sweden	No.	13.1	20.2	14.9	18.0	9.9	4.0	19.0	679
	GRT	20.0	51.4	17.1	5.7	1.4	0.3	4.1	3.5
U.K.	No.	12.2	19.0	18.3	15.8	15.0	8.8	10.9	2468
	GRT	15.1	34.0	34.6	10.7	4.4	0.9	0.3	15.9
U.S.A.	No.	15.2	28.7	16.1	13.3	4.1	3.4	19.2	6254
	GRT	11.9	26.7	18.8	8.5	9.7	5.7	18.7	17.6
U.S.S.R.	No.	14.1	16.8	19.4	22.5	14.6	10.3	2.3	7095
	GRT	15.1	22.4	18.4	24.1	15.5	3.7	0.8	24.5
Total Traditional Countries	No.	16.8	22.3	20.5	12.6	9.1	5.9	12.8	39115
	GRT	17.8	30.5	28.2	12.6	5.9	2.3	2.7	188.8
Total World Fleet	No.	15.3	20.6	20.1	17.7	10.1	6.4	9.8	76068
	GRT	17.5	30.	27.5	13.4	5.9	2.6	2.5	418.7

Source: Lloyds Register of Shipping: Statistical Tables, 1984

Table 2.9 Percentage distribution of the age of the tanker fleet under open registry and traditional maritime flags - 1984

Flag		Age (years) 0-4	5-9	10-14	15-19	20-24	25-29	30+	Total No/mill.grt
Liberia	No.	17.5	37.2	33.0	8.2	2.4	0.9	0.7	548
	GRT	7.6	45.5	41.3	4.1	2.6	0.6	0.2	34.1
Panama	No.	14.9	17.3	16.4	24.8	14.7	6.1	6.0	525
	GRT	13.4	40.2	20.7	14.6	7.3	2.4	1.2	8.2
Cyprus	No.	8.7	18.8	33.3	27.5	10.1	1.5	-	69
	GRT	3.1	34.4	34.4	25.0	3.1	0.6	-	3.2
Bahamas	No.	24.2	36.4	33.3	-	-	3.0	3.0	33
	GRT	14.7	52.9	32.4	-	-	0	0.02	2.6
Total open registries	No.	16.0	27.2	25.6	16.5	8.3	4.0	2.4	1175
	GRT	8.7	44.3	36.8	7.1	2.1	0.9	0.1	48.1
Denmark	No.	18.0	42.6	19.7	8.2	4.9	3.3	3.3	61
	GRT	12.5	58.3	29.2	0.1	0.8	0.03	0.02	2.4
France	No.	5.3	30.7	34.7	14.7	10.7	4.0	-	75
	GRT	1.5	54.2	39.6	2.1	2.1	0.2	-	4.8
Germany(FR)	No.	18.7	16.5	18.7	26.4	12.1	2.2	5.5	91
	GRT	6.3	43.8	31.3	12.5	0.1	0.02	0.7	1.6
Greece	No.	6.1	11.0	18.0	23.5	15.5	11.6	14.4	362
	GRT	6.4	24.8	30.3	28.4	6.4	3.7	0.9	10.9
Italy	No.	5.5	12.3	16.4	14.1	16.4	13.6	21.8	220
	GRT	2.6	48.6	25.7	8.6	5.7	5.7	2.6	3.5
Japan	No.	27.1	41.8	20.7	6.6	2.7	0.7	0.3	1355
	GRT	19.1	36.2	43.4	1.3	0.07	0.02	0.02	15.2
Netherlands	No.	28.1	3.5	15.8	19.3	17.5	12.3	3.5	547
	GRT	16.7	13.2	36.0	15.8	13.2	5.2	0	1.1
Norway	No.	26.6	34.5	23.0	8.6	5.0	0.7	1.4	139
	GRT	14.8	50.0	34.1	1.1	0.7	0.7	1.4	8.8
Sweden	No.	15.2	16.5	17.7	20.3	7.6	3.8	19.0	79
	GRT	7.1	78.6	3.6	1.4	0.4	0.06	0.2	1.4
U.K.	No.	13.9	17.0	24.8	20.7	13.6	6.1	3.7	294
	GRT	10.4	40.3	31.3	10.4	4.5	0.8	0.2	6.7
U.S.A.	No.	7.2	18.0	12.4	5.9	9.2	16.3	31.0	306
	GRT	6.4	37.2	17.9	5.1	9.0	11.5	12.8	7.8
U.S.S.R.	No.	11.4	14.9	12.8	24.9	21.1	13.0	1.9	422
	GRT	10.6	27.7	6.4	25.5	25.5	4.3	0.2	4.7
Total Traditional Countries	No.	17.4	26.8	19.0	13.6	9.6	6.4	7.0	3461
	GRT	10.8	39.4	30.7	9.4	5.0	2.6	2.1	68.9
Total World Fleet	No.	15.6	24.6	20.9	16.0	10.1	5.5	7.4	6647
	GRT	11.3	41.1	31.7	8.9	3.9	1.9	1.2	147.5m

Table 2.10 Percentage distribution of the age of the dry bulk fleet under open registry and traditional maritime flags - 1984

Flag		Age (years) 0-4	5-9	10-14	15-19	20-24	25-29	30+	Total
Liberia	No.	17.1	30.0	31.1	19.3	2.5	-	-	761
	GRT	17.1	27.2	36.9	17.1	1.4	-	-	21.7
Panama	No.	30.0	23.0	17.0	20.0	8.4	1.6	0.3	749
	GRT	30.8	17.8	22.6	21.2	6.2	0.7	0.1	14.6
Cyprus	No.	2.1	7.4	36.8	49.5	3.2	1.1	-	95
	GRT	1.2	5.9	41.2	47.1	2.4	0.6	-	1.7
Total open registries	No.	22.2	25.4	24.9	21.4	5.3	0.8	0.1	1605
	GRT	21.6	22.6	31.6	20.0	3.3	0.3	0.05	38.0
France	No.	23.8	38.1	26.2	9.5	-	2.4	-	42
	GRT	30.6	31.3	35.0	3.1	-	0.4	-	1.6
Germany	No.	48.0	28.0	16.0	8.0	-	-	-	25
	GRT	36.3	25.0	32.5	11.3	-	-	-	0.8
Greece	No.	9.9	21.7	28.8	26.9	10.8	1.7	0.2	808
	GRT	11.6	21.3	32.3	26.8	7.3	1.2	0.01	16.4
Italy	No.	7.7	21.2	23.1	19.2	17.3	10.6	1.0	104
	GRT	7.6	29.4	29.4	17.6	10.6	2.9	2.5	3.4
Japan	No.	39.8	29.0	25.7	4.7	0.6	0.3	-	362
	GRT	37.9	23.9	33.8	4.5	0.1	0.07	-	13.2
Netherlands	No.	42.9	28.6	17.0	10.7	-	-	-	28
	GRT	45.0	25.0	18.8	8.8	-	-	-	0.8
Norway	No.	27.9	38.5	27.9	5.7	-	-	-	122
	GRT	26.0	36.0	34.0	4.0	-	-	-	5.0
U.K.	No.	26.7	34.4	33.3	3.3	1.1	1.1	-	90
	GRT	21.8	29.4	42.6	4.4	0.2	0.2	-	3.4
U.S.A.	No.	10.7	10.0	7.9	0.7	2.1	3.6	65.0	140
	GRT	23.8	16.7	11.0	1.2	2.0	3.4	42.9	2.1
U.S.S.R.	No.	23.0	38.8	19.1	8.6	9.2	1.3	-	152
	GRT	23.7	48.1	17.0	7.8	3.5	0.8	-	2.7
Total Traditional Countries	No.	20.0	25.8	23.3	15.3	6.7	1.9	5.0	1873
	GRT	23.1	26.7	31.5	12.8	3.5	0.8	1.9	49.4
Total World Fleet	No.	20.8	25.7	24.3	18.6	6.4	1.5	2.7	5229
	GRT	23.4	24.8	29.8	16.4	3.9	0.7	1.1	128.3

Table 2.11 Percentage distribution of open registry bulk fleets by vessel size - 1984 (GRT)

Flag	Vessel Type	Under 10,000	10,000 - 19,999	20,000 - 39,999	40,000 - 59,999	60,000 - 79,999	80,000 - 99,999	100,000 - 119,999	120,000 - 139,999	140,000 + above	Total No.	Total GRT	Average Size GRT	Average Size DWT
Liberia	Tankers	0.2	5.8	9.4	10.0	10.0	2.5	26.0	22.4	13.6	548	34.11	62,245	131,368
	Bulk Carriers	1.2	23.3	40.7	12.9	10.0	6.7	2.1	3.1	-	761	21.65	28,451	54,090
Panama	Tankers	7.9	12.6	15.9	18.8	7.8	-	11.6	15.6	9.7	525	8.21	15,638	30,683
	Bulk Carriers	5.3	40.7	40.9	6.6	2.9	1.9	0.8	-	1.0	749	14.56	19,437	34,576
Cyprus	Tankers	0.7	11.4	10.4	8.1	5.0	13.8	7.3	8.1	35.2	69	3.18	46,089	89,991
	Bulk Carriers	6.9	49.6	33.9	2.5	-	-	-	7.1	-	95	1.71	18,000	30,641
Bahamas	Tankers	0.2	2.2	1.7	21.4	2.4	-	4.0	10.3	57.8	33	2.59	78,485	149,686
	Bulk Carriers	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	8	0.23	29,103	51,251
Total OR*	Tankers	1.6	7.1	10.1	12.0	8.9	2.7	21.1	19.7	16.8	1,175	48.09	40,928	
	Bulk Carriers	3.0	31.2	40.5	10.0	6.8	4.6	1.5	2.1	0.4	1,605	37.92	23,626	
World Fleet	Tankers	4.2	9.4	12.7	12.5	9.6	3.5	14.2	17.6	16.3	6,647	147.46	22,185	
	Bulk Carriers	3.0	29.5	35.3	10.9	12.8	5.3	1.5	1.4	0.3	5,229	128.33	24,543	

*Note: Total bulk fleets does not include the bulk carrier fleet of Bahamas

Source: Lloyds Register of Shipping: Statistical Tables, 1984

Table 2.12 True Managers and Beneficial Owners of open-registry fleets 1982 (Number of vessels and dwt)

Home Country or territory	True Managers Number	True Managers DWT ('000)	True Managers % of total DWT	Beneficial Owners Number	Beneficial Owners DWT ('000)	Beneficial Owners % of total DWT	Rank
U.S.A.	761	51,854	26.3	835	58,671	29.7	1
Hong Kong	1,222	46,393	23.5	989	40,866	20.7	2
Greece	579	13,901	7.0	718	22,846	11.6	3
Japan	851	19,264	9.8	907	20,977	10.6	4
Unspecified	247	4,961	2.5	284	6,486	3.3	5
Norway	125	3,773	1.9	164	5,940	3.0	6
Germany,West	317	5,379	2.7	327	5,720	2.9	7
Switzerland	140	5,064	2.6	130	4,964	2.5	8
U.K.	297	11,834	6.0	148	3,365	1.7	9
China	10	123	-	131	2,998	1.5	10
Italy	70	1,883	0.9	90	2,461	1.2	11
Netherlands	113	2,168	1.1	113	2,199	1.1	12
South Korea	98	2,406	1.2	88	1,970	1.0	13
Israel	23	1,216	0.6	32	1,456	0.7	14
Monaco	95	8,920	4.5	25	1,439	0.7	15
Indonesia	74	1,078	0.5	75	1,111	0.6	16
Singapore	170	1,923	1.0	145	1,078	0.5	17
France	37	789	0.4	35	1,005	0.5	18
Canada	27	1,092	0.6	31	1,003	0.5	19
Saudi Arabia	4	52	-	13	1,000	0.5	20
Others*	540	10,955**	5.6	520	7,473	3.8	na
Unidentified	318	2,225	1.1	318	2,225	1.1	na
Total OR Fleet	6,118	197,253	100.0	6,118	197,253	100.0	

SOURCE: UNCTAD (1982) Beneficial ownership of open registry fleets, report TD/B/C.4/255.

Note: * others are countries, entities or territories, each owning less than 0.5%

**this figure includes mainly tonnage owned by U.K. based Greek shipowners (5 million tons) and U.S. based Greek owners (1.2m)

APPENDIX B

MARINE CASUALTIES STATISTICS

Table 3.1 Tonnage (GRT) lost by major open registry (fleets) and (major) regulated fleets as % of world tonnage lost 1975-1983

World '000 GRT	OR	Year	Liberia	Panama	Singapore	Cyprus	Greece	U.K.	Norway	Japan
995	47.00	1975	25.03	15.51	3.45	3.00	14.68	6.30	0.62	6.70
1,156	57.74	1976	30.51	18.78	1.68	6.77	11.00	0.36	0.92	6.97
1,073	53.48	1977	27.18	18.54	3.78	3.98	13.47	3.76	8.22	5.95
1,711	31.26	1978	12.01	13.10	1.27	4.88	45.73	0.67	0.98	2.25
2,210	47.84	1979	31.39	12.34	1.61	2.50	23.14	0.34	0.13	2.87
1,804	39.86	1980	28.63	7.88	1.07	2.28	18.14	6.07	0.30	3.08
1,238	30.24	1981	11.23	16.10	1.96	0.95	33.28	1.00	0.24	3.01
1,632	36.89	1982	9.56	22.07	-	5.26	23.53	0.69	0.80	0.27
1,473	37.75	1983	11.85	23.21	-	2.69	28.40	0.70	1.10	0.67
1,477	42.45	Average	20.82	16.39	2.12	3.59	23.44	2.21	1.48	3.53

Number of totally

Table 3.2 Vessels lost as % of world vessel losses 1975 - 1983

OR	Year	Liberia	Panama	Singapore	Cyprus	Greece	U.K.	Norway	Japan	World
21	1975	4.76	12.50	1.19	2.38	5.36	5.65	4.17	16.37	336
26.1	1976	4.93	14.49	1.16	5.51	6.67	2.61	3.77	15.07	345
28	1977	3.57	16.07	2.38	5.95	7.44	4.46	5.06	10.71	336
23	1978	1.69	13.11	1.27	6.55	18.39	3.38	3.59	12.05	473
28	1979	3.44	16.99	1.51	6.02	14.41	2.58	2.37	4.73	465
20.2	1980	3.10	11.89	0.78	4.39	10.08	2.33	2.84	11.89	387
24.24	1981	1.95	18.11	1.67	2.51	15.32	2.51	2.79	8.08	359
23.4	1982	1.49	17.41	-	4.48	12.19	2.49	1.74	10.45	402
23.24	1983	2.06	18.53	-	2.65	11.18	2.65	2.94	7.65	340
24.13%	Avge.75-83	3.00	15.46	1.42	4.49	11.23	3.18	3.25	10.78	383

Table 3.3 Vessels and tonnage lost as % of composite fleet, 1970-83

Year	Open Registries[1] No.	Open Registries[1] GRT	Regulated Fleets[2] No.	Regulated Fleets[2] GRT	Regulated Fleets[3] No.	Regulated Fleets[3] GRT	World Average No.	World Average GRT
1970	1.4	0.51	0.53	0.19	0.51	0.16	0.70	0.27
1971	2.0	0.80	0.50	0.31	0.45	0.23	0.70	0.42
1972	1.5	0.62	0.45	0.14	0.44	0.08	0.70	0.35
1973	1.3	0.71	0.45	0.14	0.40	0.11	0.60	0.32
1974	1.1	0. 43	0.35	0.23	0.33	0.19	0.50	0.28
1975	1.0	0.48	0.37	0.19	0.35	0.13	0.50	0.29
1976	1.3	0.67	0.35	0.12	0.32	0.07	0.50	0.31
1977	1.2	0.53	0.32	0.17	0.29	0.11	0.50	0.27
1978	1.4	0.49	0.59	0.44	0.41	0.09	0.70	0.42
1979	1.6	0.93	0.45	0.34	0.31	0.13	0.70	0.54
1980	1.0	0.63	0.38	0.28	0.31	0.15	0.50	0.43
1981	1.1	0.34	0.36	0.26	0.24	0.09	0.50	0.29
1982	1.2	0.55	0.40	0.25	0.30	0.11	0.50	0.38
1983	1.3	0.53	0.35	0.25	0.27	0.06	0.50	0.35
Average	1.31	0.59	0.42	0.29	0.35	0.12	0.58	0.35

Note 1: major fleets

[2]: regulated fleets including Greece

[3]: regulated fleets excluding Greece

Table 3.4 Vessels and tonnage lost as % of fleet in the major open registry and regulated fleets, 1970-1983

	Liberia		Panama		Singapore		Cyprus		Greece		U.K.		Norway		Japan		World Av.	
Year	No.	GRT	No.	GRT	No.	GRT	No.	GRT	No.	GRT	No.	GRT	No.	GRT	No.	GRT	No.	GRT
1970	0.64	0.28	2.26	1.44	2.61	2.11	2.41	1.22	0.86	0.64	0.24	0.19	0.57	0.19	1.06	0.31	0.67	0.27
1971	1.02	0.51	2.81	1.49	3.24	6.50	3.25	2.16	1.46	1.12	0.24	0.10	0.68	0.54	0.88	0.19	0.68	0.42
1972	0.90	0.45	1.94	1.18	0.71	0.58	2.80	1.22	0.67	0.78	0.22	0.06	0.60	0.02	0.80	0.11	0.65	0.35
1973	0.74	0.56	1.04	0.37	1.29	0.79	4.41	3.64	1.18	0.41	0.52	0.12	0.51	0.13	0.46	0.05	0.61	0.32
1974	0.43	0.19	1.43	0.96	1.37	1.42	2.49	1.53	0.72	0.55	0.42	0.08	0.48	0.21	0.47	0.20	0.51	0.28
1975	0.64	0.38	1.74	1.13	0.66	0.88	1.09	0.93	0.66	0.65	0.53	0.19	0.52	0.02	0.55	0.17	0.53	0.29
1976	0.65	0.48	1.87	1.39	0.55	0.35	2.48	2.51	0.79	0.51	0.25	0.01	0.47	0.04	0.53	0.19	0.52	0.31
1977	0.50	0.36	1.65	1.02	0.92	0.60	2.50	1.53	0.75	0.49	0.44	0.13	0.62	0.32	0.37	0.16	0.49	0.27
1978	0.32	0.26	1.70	1.08	0.63	0.29	3.91	3.21	2.37	2.30	0.48	0.04	0.64	0.06	0.61	0.10	0.69	0.42
1979	0.65	0.85	2.08	1.22	0.68	0.45	3.67	2.34	1.75	1.37	0.37	0.03	0.43	0.01	0.22	0.16	0.65	0.54
1980	0.50	0.64	1.12	0.59	0.30	0.25	2.47	1.96	0.99	0.83	0.28	0.40	0.43	0.02	0.44	0.14	0.52	0.43
1981	0.31	0.19	1.46	0.72	0.72	0.35	1.53	0.65	1.48	0.98	0.30	0.05	0.42	0.01	0.28	0.09	0.49	0.29
1982	0.27	0.30	1.39	0.90	-	-	3.07	3.62	1.40	0.88	0.35	0.11	0.29	0.06	0.39	0.04	0.53	0.38
1983	0.34	0.26	1.19	0.99	-	-	-	1.15	0.97	1.12	0.36	0.05	0.44	0.08	0.25	0.02	0.45	0.35
Avge.	0.57	0.41	1.69	1.03	1.14	1.21	2.78	1.98	1.15	0.90	0.36	0.11	0.51	0.12	0.52	0.14	0.87	0.33

Table 3.5 Total losses of major tanker fleets as % of GRT, 1970-1978

Year	Liberia	Panama	Other OR	Greece	U.K.	Norway	Japan	Rest of World	World Average
1970	0.30	0.88	--	0.58	0.24	0.12	--	0.07	0.20
1971	0.46	0.71	1.60	0.65	--	0.94	--	0.17	0.33
1972	0.49	0.35	--	1.10	--	--	--	0.42	0.31
1973	0.74	0.28	0.99	--	0.08	--	--	0.17	0.27
1974	0.11	--	1.10	0.84	--	0.11	0.26	0.08	0.16
1975	0.20	0.64	0.95	1.13	0.25	--	0.24	0.12	0.25
1976	0.58	0.63	0.37	0.56	--	--	0.26	0.23	0.32
1977	0.38	0.81	--	0.26	0.20	--	0.26	0.02	0.21
1978	0.35	0.61	0.06	3.62	--	--	0.01	0.14	0.39
Avge.	0.40	0.55	0.56	0.97	0.09	0.13	0.11	0.16	0.27

Source: Drewry (Shipping Consultants, 1980), performance of open registry bulk fleets, London.
Note: Rest of World comprises mainly developing countries

Table 3.6 Total losses of major dry bulk carrier fleet as % of GRT, 1970-1978

Year	Liberia	Panama	Other OR	Greece	U.K.	Norway	Japan	Rest of World	World Average
1970	0.21	--	--	--	0.45	--	0.75	0.16	0.26
1971	0.30	3.55	--	--	--	--	--	0.08	0.14
1972	0.13	1.19	--	--	--	--	--	0.05	0.06
1973	--	--	1.02	0.46	--	0.43	--	0.73	0.33
1974	0.09	--	--	--	--	0.55	--	0.09	0.10
1975	--	1.59	0.07	1.18	--	--	--	0.28	0.18
1976	0.33	1.80	--	--	--	--	--	0.11	0.18
1977	0.21	0.30	0.57	0.24	--	--	--	--	0.10
1978	--	0.41	--	0.95	0.18	--	--	0.20	0.23
Avge.	0.14	0.98	0.18	0.20	0.07	0.11	0.08	0.19	0.18

Source: Drewry (1980) ibid.

APPENDIX C.1

DEFINITIONS OF TYPES OF CHARTER

APPENDIX C.1

DEFINITIONS OF TYPES OF CHARTER

There are six main types of charter agreement that can be entered into by charterers and shipowners namely: spot or single voyage charter; consecutive voyage charter; trip charter; time charter; contract of affreightment; and demise or bareboat charter.

C.1.1 Spot or single voyage charter

As the name implies, this type of charter is one in which an owner undertakes to use a specific vessel, according to the charterer's requirements, to transport a fixed quantity of cargo from a specified loading port(s) to a specified port(s) of discharge for an agreed rate per ton of cargo carried. All costs (fixed, operating and voyage) associated with such a voyage are borne by the shipowner not the charterer.

C.1.2 Consecutive voyage charter

Under this type of charter, which is a variant of the single voyage charter, an owner agrees with the charterer to supply a specified vessel to carry a fixed quantity of cargo on a series of single voyages, ie. on a repeat voyage basis, either specifying the number of voyages between a designated port(s) of loading and discharge, or a period of time during which repeat voyages are to be undertaken. Like single voyages, consecutive charters are paid at agreed rates per ton of cargo, and all vessel costs are for the account of the shipowner.

C.1.3 Trip charter

Under a trip charter, a vessel is chartered for a specific movement of cargo on a daily rate (either per dwt or as a lump sum) without reference to the quantity or nature of the cargo. This type of charter which is an alternative to the single voyage charter, allows the charterer to specify the vessel, the delivery and redelivery areas in contrast to the single voyage charter in which the charterer only specifies the cargo, when and where it is to be loaded and discharged, leaving the shipowner to choose the appropriate vessel for the cargo. All costs are also borne by the shipowner.

C.1.4 Time or period charter

By this arrangement a specific vessel is chartered for a specific period of time which can vary between a few weeks, months, several years or extend over the entire trading life of the vessel. Unlike the other types of charter above, the time charter rate is based not on the cargo ton but on a ship's dwt capacity per month - usually expressed as U.S.$/dwt/month. Also a time-charter does not specifiy the freight to be carried nor the ports of loading and discharge, rather the deployment of the vessel is determined by the charterer for whatever legitimate cargo that suits his purpose. The shipowner is thus responsible to supply a seaworthy vessel for which he undertakes to meet all capital and operating costs; whilst the charterer bears all voyage costs.

C.1.5 Contract of affreightment

For this type of charter a shipowner contracts to supply a specific tonnage capacity for a specified period into the future between specified loading and discharging areas, without a particular vessel being designated. Like spot and consecutive charters, the hire rate is fixed on a per ton of cargo basis and the shipowner remains directly responsible for the fixed and variable costs of the vessel.

C.1.6 Bareboat or demise charter

Here the vessel is chartered for a specified period of time on a daily or monthly rate per dwt or grt, with the charterer responsible for the provision and payment for manning, repair and maintenance, insurance, stores and provisions of the vessel plus all voyage costs. Whereas on the previous forms of charter outlined above, the shipowner retains legal control of the vessel with the master and crew under his employment and the charterer only designating the employment of the vessel; in a bareboat charter the charterer takes temporary ownership of the vessel for the period of the charter. In which case the shipowner is only legally required to provide a 'bareboat' without any crew.

APPENDIX C.2

DEFINITIONS OF SHIP OPERATING COSTS

APPENDIX C.2

SHIP OPERATING COSTS - DEFINITION

C.2.1 Introduction

Because of the relationship between costs and freight rates, both in the short and long term, a good knowledge of the components of shipping costs is important not only to the shipowner, to whom accurate knowledge of operating costs is important for the efficient management of vessels, but also to the charterers as they may have to negotiate escalation clauses in charter parties. Equally important is the structure of costs which is central to the purpose of this study and thus requires a definition of the different components of a ship's costs.

Shipping costs are traditionally categorised into three main elements: capital, operating and voyage costs. A ship's capital costs refer to the cost of vessel ownership, that is, the costs of acquiring the vessel and armortising its initial cost over its economic life, ie. by such capital charges as depreciation and interest payments on loans. Operating costs comprise all the costs and expenses incurred in the day-to-day operation of the vessel at sea and in port. These costs, which are sometimes referred to as running costs, are the costs associated with manning, maintaining, husbanding (supplying) and insuring a vessel. Voyage costs are those variable costs incurred in undertaking a particular voyage and are composed of such cost elements as fuel (bunker) costs, port charges, cargo-handling costs, canal dues (where necessary) and agency fees. The level of voyage costs naturally varies from vessel to vessel not only because of the differences in the technical characteristics of vessels but also due to variations in voyage distances, fuel prices and port charges, which vary according to the trading pattern of a vessel with the latter two elements varying between geographical areas, ie. location where fuel is purchased.

These three categories make up a ship's total cost. However, it is not unusual to find in the shipping literature some confusion in the use of the terminology of costs, for sometimes one finds operating costs, as defined above, being confused with total cost or operating cost -

used as a composite cost embracing voyage costs. These variations in the use of the term 'operating cost' can be seen in some of the references already cited. See Heaver (1985) for the various definitions that are used in the shipping literature to denote operating costs. Operating costs are simply the actual daily expenditure incurred in running the vessel, with specific provisions for meeting contingencies and periodic expenses such as drydocking and classification; and so involve a miscellany of expenses covering salaries and wages, travelling, ship supplies and stores, repairs and maintenance, surveys and management overheads. As would be expected, these costs can be extremely varied in nature. Conventionally, they are classified into five main categories which reflect the principal functions of ship management: manning, repairs and maintenance, stores, lubricating oil and ship supplies or provisions, insurance and administration costs.

C.2.2 Manning Costs

Manning or crewing costs are the direct and indirect costs of crewing a vessel and as such consist of: basic pay, overtime payments, supplementary payments - bonuses, efficient service and certificate payments, special work payments, etc, leave pay, leave subsistence, medical expenses and sick-leave pay, personal and national insurance contributions, pensions, victualling, travelling and repatriation expenses, training and maintenance allowances with study leave pay, standby pay, union payments, cadet training, etc. The basic pay component is usually the largest single component of crew costs. The elements of manning costs vary with the registry of a ship and are primarily determined by three factors: the manning scales - the size and composition of the crew, the conditions of service and crew nationality.

(a) The size and composition of the crew

Manning levels, which determine the numbers of crew required for the manning of different type and sizes of vessels and the composition of the crew in terms of number of officers and ratings in the different departments of a ship, are determined by national regulations which stipulate minimum manning levels for domestic flagships. These scales are based on estimates

of the minimum number of suitably qualified ship personnel necessary for the safe operation of the vessel and safety of life at sea. More often, additional requirements regarding the size and composition of the crew are agreed between shipowners and national seamen's unions since the recommended government scales may fall short of the level of manning deemed appropriate for the type and size of ship by the union.

Under traditional flags, minimum manning scales and qualifications required are usually specified for various types and sizes of vessels, according to trading patterns. Additionally, the shipowner is under pressure from government agencies and other national and international organisations such as seamen's unions to adhere to these regulations. Under open registries such regulations are generally not laid down and where they exist may be subject to wide interpretations. For instance, Liberian regulations stipulate minimum manning scale for officers only leaving the rating structure to the shipowner's discretion (Gailbraith, 1979); whilst Somalia, which ceased to be an open registry in 1978, during its time as an open registry had it stated in its regulations that a vessel of its registry should have sufficient officers and ratings to ensure safe navigation. Such vagueness obviously, offers the operator a wide flexibility in reducing manning levels to the barest minimum appropriate for the safe operation of the vessel should there be need to cut down crew costs. Generally, however, because of the relatively higher freedom of choice with respect to the employment of crew from different nationalities, open registry ships employ more crew than their traditional counterparts, but this trend seems to be changing under the pressures of inflationary cost tendencies of the 1980's.

(b) <u>The nationality of the crew</u>

The nationality of a ship's crew can be extremely varied and it is this more than anything else which accounts for the wide disparities in wages. Wages are generally established by agreement with maritime unions and shipowners' associations or by government regulations. The wide differences in wage levels amongst various countries are reflections of the differences in economic development and the cost of living in the crew's home country

because seamen's wage rates are in most cases those paid by domestic flags for national crew. These rates, are of necessity dictated by the flag of registry which also determines the levels of manning, conditions of service and the nationality of the crew. Whilst in traditional shipping registries freedom of employment as regards crew nationality is restricted, the open registry operators enjoy a high latitude in their choice of crew nationality, as table 2.1 shows.

As manning costs can sometimes represent more than 50% of a ship's operating costs, there is an obvious advantage in employing crews from countries with relatively low wage levels. Not surprisingly, the Liberian fleet was made up of crews from 107 countries as at June 1984; 65% of whom are from developing countries with six developing countries (Taiwan, Hong Kong, India, Indonesia, South Korea and the Philippines - the latter and Taiwan are the largest single labour supplying countries to the fleet with 17,160 and 17,000 crew respectively) accounting for almost 60% of the total or 91% of all developing countries' crews, Taiwan, South Korea, the Philippines, India and Hong Kong contributing 46% of officers on the fleet with the first three representing the largest single sources of officers (Wiswall, 1984). The relative cheapness of crews from less developed countries and hence the cost savings which can be made therefrom, is the principal factor underlying the economic gravitation towards open registries in as much as manning costs remain the deciding element in the cost competitiveness of any flag.

(c) <u>The conditions of service</u>

Conditions of service are normally determined by government regulations and union agreements. They cover such aspects of manning costs as rates of pay, leave allowance, contribution to social insurance and/or national pension schemes, overtime, shiftwork, hours of duty, sick pay, subsistence allowances, and other fringe benefits mentioned above. These conditions determine mostly the indirect cost of manning a ship and they do vary considerably amongst different countries and crew nationalities and individual operators under the same registry. Since government regulations vary from country to country, as table 2.1 tells us, and the degree of adherence

can also vary amongst companies operating under the same flag, this determinant significantly affects the level of crewing cost under different registries.

In most maritime nations, the conditions of service are set out in maritime laws - ie. The Merchant Shipping Act of 1970 in the U.K. - and the contract of employment between the crew and the shipowner is usually covered by the Articles of Agreement. For open registry ships these conditions are largely controlled by the ITF through its 'collective agreements'. It is however noted that many owners of open registry vessels paying ITF rates do not incur some indirect costs such as training, repatriation and other fringe benefit costs (Moreby, 1985). It has already been said that it would be misleading to generalise that wage rates on open registry ships do not match those paid on traditional vessels, but much as it is recognised that some companies pay well and have equivalent conditions of service in open registry ships, the fact that an owner is not legally bound by virtue of his registration to ensure certain minimum conditions of employment gives the owner freedom to cut down cost when and if the need arises.

Therefore, even though an open registry operator may pay comparable basic wages as his counterparts in the developed nations, it is not likely, in most cases, that he would pay the same amount of indirect remuneration. This is evidenced by the fact that in 1980/81 social insurance and pension expenses accounted for 15.3% of total manning costs on European-flag tankers and 10.8% on open registry tankers - the 1973/74 figures were 14.7% and 6.3% respectively (Drewry, 1983). For bulk carriers the proportions for 1980/81 are: 13.8% for European ships and 8.6% for open registry ships with 12.6% and 4.6% respectively representing the 1973 figures (Drewry, 1984). Goss (1985b) also expresses the view that the social cost element gives the open registry operator a competitive edge over his traditional maritime counterpart who incurs total wage costs 61-65% higher due to the social cost element. Labour cost considerations may therefore be more important than fiscal considerations in the expansion of open registry fleets.

C.2.3 Repairs and Maintenance Costs

This cost centre is the second largest cost element of operating costs and covers all costs necessary for the technical seaworthiness and upkeep of the vessel according to the standard specified by the classification society and/or required by the owner. Naturally, it includes routine maintenance expenditures, provisions for periodic surveys ranging from annual surveys, drydocking surveys, tail-shaft surveys, boiler surveys, and reclassification or special surveys. Repairs and Maintenance costs can vary widely amongst vessels of the same type and size due to differences in vessel age profile and their technical conditions, and thus the extent of repair and replacements necessary to meet international safety requirements, and also the owner's operating policy and experience. Generally, repairs and maintenance costs are governed by both internal and external factors including: classification society rules, company policy, ship repair technology and the state of the freight market (Drewry, 1982).

(a) Classification Society Rules

Classification Societies are private organisations responsible for certifying the technical and structural seaworthiness of ships. When a vessel is in 'class' it is construed to mean that it is in good technical and structural condition. Therefore, for commercial reasons, insurance purposes and safety requirements, it is obligatory on the owner to ensure that the 'class' of his vessel is maintained throughout its economic life in order to obtain the statutory safety certificates required by the SOLAS and MARPOL conventions. ~~dealt with in the preceding chapter~~. This 'class', which lays down the condition of survey under which the vessel was built, the types of cargo for which it is considered suitable and arrangements explaining its operation and safety, is granted by a classification society for a fixed period of time called 'term'. The 'term' is renewable by special surveys after every four or five years in order to maintain a vessel's structural and technical standards.

Classification surveys cover annual surveys for the hull and machinery, periodic surveys - ie. drydocking tail shaft and boiler surveys undertaken at different time intervals, say, every two or four years, and special surveys undertaken for reclassification purposes to ensure that the

required standards of strength, seaworthiness and safety are maintained. These rules of themselves determine the level of repair and maintenance costs for ships of different age profiles. Also as profit-making concerns, these societies are in competition with each other. Competition will affect standards - particularly with the proliferation in the number of societies in recent years - and hence variations in the repair and maintenance element of costs.

(b) Company policy

Repairs and Maintenance costs can be greatly influenced by the shipowner's operating policy and managerial experience in as much as repairs and maintenance costs consist not only of external but also of internal costs. As the periodic and special surveys outlined above are often extremely expensive, it is an important function of ship management, particularly at times of poor market conditions when freight rates barely cover operating costs, to contain costs by exploiting substitution possibilities. To this end, the ship's crew can perform a large portion of the routine maintenance necessary for the upkeep of the vessel. This, of course, will depend on the quality of the crew in terms of their level of training and experience and also their size. Most repair work can also be undertaken whilst the vessel is en route by the use of 'riding crews' who can easily be transported by helicopters to the vessel.

The treatment of repair and maintenance costs, particularly the obligatory ones, is another area in which ship management has advanced in recent years. Almost all the reputable shipping companies now operate planned maintenance schemes as an important part of their financial control. This scheme is based on a running survey concept, as opposed to the traditional major survey every four or five years. This is made possible by the computerisation of performance monitoring. The cost of major drydockings and special surveys, instead of being charged to the accounts in the year they are incurred, are spread equally over the four or five year period and charged annually to the repair and maintenance accounts. The expense is often treated as a deferred charge and allocated to the accounts annually in the intervening period before the next major survey

as a provision towards the survey. In a management accounting sense, such a treatment shows more clearly movements in repair costs over time even though it does not correctly reflect the actual cash flow situation (Drewry, 1984). The advantage of the planned maintenance concept is that it enables work to be carried out in a continuous cycle and allows costs to be met on a regular basis.

Whilst planned maintenance systems are widespread amongst reputable owners and ship management companies, some owners still write-off costs only in the year in which they are actually incurred, thereby making themselves far more vulnerable; other owners are more innovative by treating repair expenditure as a kind of deferred asset. In this regard the argument is that repair work actually increases the ~~longevity of the~~ life of the ship and thereby increases its capital value. This approach is different from that discussed above, which is a deferred maintenance allowance and, as such, part of a planned maintenance policy. Thus the shift away from the quinquennial major survey towards a continuous process and different accounting practices are all functions of company policy and therefore underlie reported repair and maintenance costs.

(c) Ship Repair Technology

The last decade has seen an advancement in ship repair methods and techniques, such that the duration and frequency of drydocking have been reduced. Interdocking intervals have thus been extended up to 2½ years. The development of anti-fouling agents such as self-polishing copolymers, apart from their fuel savings which can range between 8-9% (Oakes and Woodward, 1983), have also contributed to the reduction of drydockings necessitated by regular fouling of hulls. Although repairs and maintenance costs are largely determined by the various rules of the classification societies, the extent to which owners use the new technological innovations on offer also plays a vital role in repair and maintenance costs differentials. See Drewry (op. cit) and Seatrade (1983) for the advances in ship repair technology.

(d) The State of the Freight Market

In as much as the shipowner depends on the freight markets for his revenues, his success or failure depends on the conditions of these markets in relation to his costs. Within the constraints imposed by classification rules, the shipowner has some degree of flexibility regarding the choice of drydocking frequency and the amount of deterioration in the condition and performance of his ship which he can contain in order to respond to market conditions. The flexibility is normally exercised during periods of changing market conditions. Experience has shown that when freight rates are high, repair demand rises in order to ensure that 'off-hire' periods are minimised at a time of high earning potential. At such times owners may drydock their vessels even more readily and frequently than classification rules require in order to enhance their earning potential. But when rates fall repair demand is likely to fall. Expectations of a quick upturn, however, can induce owners to get their vessels into prime condition ready for the anticipated upturn. But as Drewry (op. cit) notes, these reactions by shipowners were more characteristic of the mid-1970's than the 1980's. Due to the very prolonged shipping recession, any indication of an upturn in rates is now accompanied by a tendency for owners to keep their ships out of drydocks for as long as possible in order to maximise short term revenues.

C.2.4 Lubricating oil, stores and provisions

This costhead covers all expenditures on lubricating oils for the ship's engine and auxiliary equipment, all consumable deck and engine room supplies, equipment, tools and spare parts. The cost of lubricating oil varies between vessels according to a vessel's engine type. Diesel-engined ships are wholly dependent on lubricants whereas, turbine-propelled ships use little or no lubricating oil at all. Hence it is to be expected that lube oils will comprise a large element of this costhead for motor ships than for large turbines.

The majority of the world's bulk carriers (90%) are diesel-engined whilst a majority of the world's tankers (60%), mostly at the larger size end are turbine-engined. Diesel-engined ships may consume between 200-400 litres of lube oils per day while at sea, with the price varying according

to the geographical area in which the vessel is trading. This will depend largely on the average number of days at sea per annum, the size of the engine and number of auxiliaries and therefore will be higher when the vessel is steaming than when it is in port.

This raises the question as to whether lubricating oils should be part of stores and provisions or part of fuel costs (Goss, 1985a). Our evidence from the Council of European and Japanese National Shipowners Association (CENSA), suggests that for this reason some owners treat this cost element as part of voyage costs (Ross-Bell, 1984). Ideally it would have been more appropriate to treat lubricating oils as part of the voyage accounts but this could not be done for two reasons: first, the inclusion of lubricating oils in the voyage accounts is not widespread in the industry and more conventionally lubricating oil costs form part of a ship's operating costs. This is evidenced by our own operating cost survey discussed in chapter 5 and the manner in which operating costs are reported in published sources. Secondly, and more important, is the fact that the study is addressed to costs borne by the shipowner in a time-charter arrangement and therefore voyage cost is not relevant to its purpose.

Ship supplies encompass a wide variety of consumables for the deck and engine departments. Deck stores cover essential provisions and supplies such as paint (for routine maintenance), cleaning materials, mooring ropes, painting equipment, cargo equipment (where necessary), safety equipment and in some cases fresh water. Sometimes catering stores other than victuals are included under deck stores. Engine stores cover lubricating and other oils, in addition to other essential supplies for the efficient operation of mechanical and electrical systems such as: spare parts, ie. piston rings, gaskets, liners, etc., tools, fuses, bulbs, etc., chemicals, gases -ie. carbon dioxide (CO_2), and acetylene. With respect to a ship's stock of spare parts, its level will depend on the rules of classification societies since it is directly related to repairs and maintenance costs, recommendations from engine builders and equipment manufacturers, the shipping companies' policy regarding

maintenance and the efficiency with which routine maintenance is carried out by the crew. It is notable that some shipowners include victualling under stores and provisions, the wider practice, however, is to include it under manning cost since it is directly related to the size of the crew. This approach is adopted for this study.

C.2.5 Insurance Costs

There are a wide variety of risks against which the shipowner may insure his vessel. These risks include covers for such policies as hull and machinery (H & M), protection and indemnity (P & I), loss of earnings, currency fluctuations, war risks (H & M), strikes, pollution, etc. But insurance costs are mainly governed by the mandatory costs of H & M insurance which is a cover against total loss (physical loss) and damage, and P & I cover against third party liabilities. The other forms of cover may be taken at the owner's discretion. In general, insurance premia are determined by five main factors (Proctor, 1985):

a) type of vessel, its size, age, propelling machinery, flag and classification society;
b) valuation of the value of the vessel;
c) area of operation; (some areas are more hazardous than others, ie. congested waters)
d) conditions of insurance; and
e) reputation of management and past claims record.

To these may be added the prevailing state of ship repair costs and competition within the insurance market. Of all these factors the two most important determinants of the premium an individual shipowner pays are the owner's claims record and the assessed hull value of the ship. The hull value of a ship generally is determined by freight market conditions as we shall see in chapter 6, and, therefore, fluctuates with the movements in freight rates. This makes valuation very difficult. It is not unusual for owners to take out separate cover$ to account for these fluctuations as a security in the event of total loss. Naturally, the age of the vessel will play a very important role in its value as shown in chapter 6. Because hull covers normally cover the cost of

repairing damage, the age of the ship becomes vital in fixing premium. This is because the cost of repairing an old ship may far exceed its scrap value, therefore, the usual practice is to base hull insurance premia on two values on total constructive loss or on damage/repair. The premium based on total loss will be lower since it is based on the age of the ship and that including damage/repair liability higher. So it is up to the shipowner to choose which premium to pay.

Protection and Indemnity is the traditional name given to third party insurance and is handled by P & I clubs which developed in the middle of the 19th century in England by shipowners for their mutual protection against those risks and certain contractual liabilities, ie. loss or damage of cargo or loss of earning which were not covered by the orthodox insurance market. The clubs started by insuring one-quarter of an owner's liability leaving him to bear the rest, such as: damage to fixed objects (ie. jetties and quays) and liability for death and personal injury (see Leader, 1985). P & I costs like hull costs will be determined by the owner's loss or claims record and such other factors as cargo/cargoes to be carried, nationality of the crew, vessel registry, and intended trading area.

Covers for loss of earning - ie. loss of hire and loss of freight - are sold on the open market. The first of the two types of cover under loss of earning insurance, covers the owner for revenues lost due to excessive off-hire periods occassioned either by damage or breakdowns and the second for the loss of cargo or freight. Other forms of insurance handled by the P & I clubs which ought to be mentioned are war risk and pollution damage insurance.

C.2.6 Administration costs

This cost item is composed of costs charged to the accounts to cover the owner's administrative overheads such as general office expenses and shore staff salaries and wages, and may include management fees paid to a ship management company for the running of the ship. Generally, ship management functions include: crew selection and recruitment, rotation

and travel arrangements, purchase of ship supplies and victuals, liaison with port agents, purchase of bunkers and arrangements thereof, and the arrangement and supervision of ship repair and maintenance plans. Administration cost can vary widely amongst companies due to differences in accounting methods, the size and composition of the fleet, and the location of the owner or management company.

The primary cause of variations in administrative costs is fleet size, but differences in accounting methods such as charging ship management costs to corporate management instead of apportioning it to ship management accounts can cause a great deal of difference in the level of this cost element reported by different shipowners. Depending on the fleet size and hence the degree of administrative economies, the shipowner has an option to perform all administrative functions himself through his shore staff or alternatively to contract out some or all of the management functions to professional ship managers. Location of the owner or management company is also a variant, ie. the long-established ship management companies in Europe have higher costs than the new management companies springing up in the Far East, especially in Hong Kong (for example see Seatrade, 1984).

Summing up, it is clear that the operating cost levels of shipping companies do vary because of various factors relating to the differences in ship types and thus their technical characteristics, differences in the employment characteristics of the vessel which will vary with the route structure, commodity carried and port conditions; differences in management policies, and hence differences in accounting practices; and, of course, differences in vessel registry and hence crew nationality. In addition to all this are the differences in cost levels caused by exchange rate fluctuations. The U.S. dollar, as already mentioned, is the unit of account in shipping. Consequently, the costs and revenues associated with bulk shipping are highly sensitive to changes in the dollar parity. This sensitivity is due to the fact that shipping, as an international business, incurs costs in various currencies, so that total costs will vary according

to the dollar exchange rate prevailing against the currencies in which costs were incurred. This feature of shipping costs is most evident in manning cost levels where the conversion into dollars of costs, ie. salaries and wages paid in the national currency of a ship's flag or crew can underlie considerable actual differences (ie. increases or decreases) in annual manning costs reported. In much a parallel manner, all cost elements reported by shipping companies will vary according to the level of inflation prevalent in the country in whose currency costs were incurred. Generally, costs will also vary according to vessel size and age because, in the case of the former, it is the principal determinant of economies of scale and hence unit cost as chapter 5 reveals.

APPENDIX D.1

OPERATING COST SURVEY QUESTIONNAIRE

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DEPARTMENT OF TRANSPORT TECHNOLOGY

N. J. ASHFORD
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Ext. 381/336

Dear Sir,

We are carrying out a research project in this department to assess the impact of abolishing open registry shipping following the UNCTAD proposal on the subject. The aim of the project is to quantify the relevant costs and benefits of this proposal as they would affect different interest groups within the maritime community.

Such a project certainly cannot be successfully undertaken without some support and assistance from the shipping community in the form of vital information regarding operating costs. We are working on the premise that freight rates are influenced by operating costs in addition to the other determinants of rates. Hence, the hypothesis that lower operating costs may breed lower freight rates. To help us establish this working framework, we would earnestly like to request some information regarding the cost of operating your bulk-carrier and tanker fleet under flags of convenience and other countries. If you do not own tonnage under a flag of convenience, we will still be glad to receive data on your fleet under other countries.

We know from experience that such information is difficult to divulge because of its confidential nature, but we candidly promise to maintain this veil of confidentiality in the use to which the data received will be put. The data will be used in a strictly anonymous analysis to show amongst other variables how differences in unit cost of operation can influence the level of freight rates in the freight markets as a first step towards determining the economic impact of the UNCTAD abolition proposal.

We shall, therefore, be profoundly grateful if you could kindly assist by giving the information required on the attached sheet. Data will be welcome for any year and for any number of ships you provide.

Thank you in advance for the courtesy of your time and we also apologize for any inconvenience this request may have to cause you.
Yours sincerely,

S.R. Tolofari
(Transport Systems Assessment Group)

E.J. Gubbins
Project Supervisor

OPERATING COSTS SURVEY (1982 costs)

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A. SHIP CHARACTERISTICS	SHIP 1	SHIP 2	SHIP 3	SHIP 4	SHIP 5	SHIP 6
Flag of registry						
Vessel type (Tanker/B/C, etc.)						
Vessel size (dwt)						
Engine type (Diesel or Turbine)						
Design speed (knots)						
Consumption (tons/day): Fuel oil						
Marine diesel						
Year of build						
B. TRADING CHARACTERISTICS						
Annual trading period (days)						
Out of service time (days)						
Due to: breakdown						
dry docking						
lay-up						
industrial dispute						

C. MANNING CHARACTERISTICS	Nationality	Number	Nationality	Number	Nationality	Number	Nationality	Number	Nationality	Number	Nationality	Number
(Annual average) Total crew (Number)												
Officers: Deck + Radio												
Engine room												
Crew : Deck												
: Engine room												

D. ANNUAL OPERATING COSTS	1982	1982	1982	1982	1982	1982
(Costs and currency units) Total manning costs(1) of which:						
Social security & Pensions						
Stores & Provisions						
Maintenance & Repairs(2):						
in dry dock						
'in-service'						
Classification & Survey(2)(3)						
Insurance: Hull & Machinery						
P + I						
Other 'club calls'						
Administration Costs:						
of which Management Cost:						
Other costs : Lube oil						
(other than capital charges:other and voyage costs)						
Total Operating Costs						

(1) Please include under this component the cost of wages, crew repatriation, annual leave, victualling, social security and pension contributions, and other costs of maintaining the crew.

(2) Please indicate by marking "A" for average annual cost, "B" for costs incurred in the year of the data or "C" for cost incurred in respect of the MARPOL requirement.

(The Questionnaire format was inspired by Drewry sources).

A. SHIP CHARACTERISTICS	SHIP	SHIP	SHIP	SHIP	SHIP	SHIP
Flag of registry						
Vessel type (Tanker/B/C, etc.)						
Vessel size (dwt)						
Engine type (Diesel or Turbine)						
Design speed (knots)						
Consumption (tons/day): Fuel oil						
Marine diesel						
Year of build						
B. TRADING CHARACTERISTICS						
Annual trading period (days)						
Out of service time (days)						
Due to: breakdown						
dry docking						
lay-up						
industrial dispute						

C. MANNING CHARACTERISTICS	Nationality	Number	Nationality	Number	Nationality	Number	Nationality	Number	Nationality	Number	Nationality	Number
(Annual average) Total crew (Number)												
Officers: Deck + Radio												
Engine room												
Crew : Deck												
: Engine room												

D. ANNUAL OPERATING COSTS	1982	1982	1982	1982	1982	1982
(Costs and currency units) Total manning costs(1) of which:						
Social security & Pensions						
Stores & Provisions						
Maintenance & Repairs(2):						
in dry dock						
'in-service'						
Classification & Survey(2)(3)						
Insurance: Hull & Machinery						
P + I						
Other 'club calls'						
Administration Costs:						
of which Management Cost:						
Other costs : Lube oil						
(other than capital charges:other and voyage costs)						
Total Operating Costs						

(1) Please include under this component the cost of wages, crew repatriation, annual leave, victualling, social security and pension contributions, and other costs of maintaining the crew.

(2) Please indicate by marking "A" for average annual cost, "B" for costs incurred in the year of the data or "D" for cost incurred in respect of the MARPOL requirement.

APPENDIX D.2

WEIGHTED INDICES FOR OPERATING COSTS, 1973-1983

Tanker Total Operating Costs Weighted Average ($1000 per annum)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Open Registry Costs											
20- 39 999	755	865	980	1 075	1 205	1 390	1 570	1 910	2 250	2 579	2 956
40- 69 999	855	985	1 050	1 225	1 430	1 700	1 865	2 160	2 470	2 820	3 220
70- 99 999	965	1 035	1 140	1 280	1 495	1 730	2 070	2 445	2 660	3 019	3 427
100-174 999	1 285	1 395	1 450	1 535	1 660	1 855	2 050	2 330	2 545	2 772	3 109
175 000 +	1 855	1 910	1 900	1 690	1 730	1 940	2 180	2 570	2 850	3 007	3 173
North European Costs											
20- 39 999	1 265	1 455	1 640	1 790	2 000	2 220	2 415	2 640	2 405	2 606	2 824
40- 69 999	1 420	1 605	1 820	1 965	2 195	2 459	2 799	2 955	2 745	2 981	3 237
70- 99 999	1 545	1 785	2 060	2 310	2 550	2 675	2 960	3 260	2 970	3 223	3 497
100-174 999	2 020	2 110	2 365	2 520	2 595	2 870	3 195	3 560	3 355	3 575	3 809
175 000 +	2 470	2 780	2 800	2 890	2 950	3 190	3 470	3 915	3 815	4 028	4 253
Weighted Average Costs											
20- 39 999	1 074	1 235	1 393	1 522	1 701	1 900	2 082	2 334	2 330	2 593	2 892
40- 69 999	1 208	1 369	1 538	1 681	1 893	2 143	2 359	2 619	2 615	2 903	3 229
70- 99 999	1 322	1 510	1 732	1 943	2 160	2 304	2 594	2 911	2 824	3 124	3 462
100-174 999	1 734	1 825	2 017	2 147	2 230	2 472	2 747	3 073	3 006	3 224	3 460
175 000 +	2 206	2 426	2 436	2 447	2 499	2 717	2 972	3 382	2 402	3 592	2 792
Index of Weighted Average											
20- 39 999		1.15	1.30	1.42	1.58	1.77	1.94	2.17	2.17	2.41	2.69
40- 69 999		1.13	1.27	1.39	1.57	1.77	1.95	2.17	2.16	2.40	2.67
70- 99 999		1.14	1.31	1.47	1.63	1.74	1.96	2.20	2.14	2.36	2.62
100-174 999		1.05	1.16	1.24	1.29	1.43	1.58	1.77	1.73	1.86	2.00
175 000 +		1.10	1.10	1.11	1.13	1.23	1.35	1.53	1.54	1.63	1.72

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Tanker Operating Costs ($1000) per annum - Manning

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Open Registry Costs											
20-39 999	380	430	480	550	640	720	810	900	960	1 078	1 210
40-69 999	390	440	500	570	650	750	810	910	1 020	1 150	1 297
70-99 999	420	480	540	590	680	760	850	970	1 050	1 177	1 320
100-174 999	410	470	530	610	670	770	870	980	1 090	1 232	1 392
175 000 +	420	490	570	630	710	810	900	1 030	1 160	1 317	1 495
North European Costs											
20-39 999	660	745	850	960	1 090	1 240	1 405	1 600	1 360	1 489	1 629
40-69 999	700	780	900	980	1 170	1 320	1 500	1 700	1 445	1 582	1 732
70-99 999	750	840	950	1 100	1 270	1 440	1 640	1 860	1 580	1 734	1 904
100-174 999	760	860	990	1 140	1 280	1 450	1 650	1 890	1 700	1 880	2 079
175 000 +	770	850	960	1 160	1 320	1 490	1 700	1 920	1 730	1 914	2 118
Weighted Average Costs											
20-39 999	558	630	716	811	924	1 049	1 187	1 348	1 195	1 316	1 451
40-69 999	590	656	757	829	984	1 114	1 258	1 425	1 269	1 400	1 546
70-99 999	632	709	801	922	1 064	1 205	1 370	1 555	1 368	1 509	1 664
100-174 999	638	722	830	955	1 070	1 214	1 381	1 579	1 462	1 623	1 804
175 000 +	646	718	815	937	1 107	1 251	1 423	1 609	1 501	1 671	1 860
Weighted Index Nos. 1973=100											
20-39 999	100	1.13	1.28	1.45	1.66	1.88	2.13	2.42	2.14	2.36	2.60
40-69 999	100	1.11	1.28	1.41	1.67	1.89	2.13	2.42	2.15	2.37	2.62
70-99 999	100	1.12	1.27	1.46	1.68	1.91	2.17	2.46	2.16	2.39	2.63
100-174 999	100	1.13	1.30	1.50	1.68	1.90	2.17	2.48	2.29	2.54	2.83
175 000 +	100	1.11	1.26	1.51	1.71	1.94	2.20	2.49	2.32	2.59	2.88

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Tanker Opcost ($1000) per annum - Repairs + Maintenance 1973-1983 (Weighted Av)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Open Registry Costs											
20- 39 999	120	150	180	200	210	220	250	400	540	652	786
40- 69 999	140	170	200	250	310	380	450	550	650	788	995
70- 99 999	100	190	250	310	370	440	520	670	750	910	1 104
100-174 999	220	290	350	380	410	450	480	510	550	617	692
175 000 +	370	465	580	500	450	480	550	700	750	819	985
North European											
20- 39 999	195	245	280	300	325	350	370	405	430	465	524
40- 69 999	230	280	320	350	370	400	430	460	500	551	607
70- 99 999	250	320	400	420	440	400	485	510	540	595	655
100-174 999	310	390	490	510	530	550	570	600	630	688	760
175 000 +	490	610	750	620	500	530	600	810	920	995	1 077
Weighted Average Costs											
20- 39 999	166	209	241	260	280	300	322	403	491	577	681
40- 69 999	196	238	274	308	343	390	440	509	585	691	820
70- 99 999	215	272	342	373	408	450	503	601	662	786	937
100-174 999	273	347	432	455	478	505	529	559	593	654	728
175 000 +	438	547	676	566	476	506	576	759	844	916	994
Weighted Index 1973 = 100											
20- 39 999	100	1.26	1.45	1.57	1.69	1.81	1.94	2.43	2.96	3.48	4.10
40- 69 999	100	1.21	1.40	1.57	1.57	1.75	1.99	2.25	2.60	3.53	4.18
70- 99 999	100	1.27	2.59	1.74	1.90	2.09	2.34	2.80	3.08	3.66	4.36
100-174 999	100	1.27	1.58	1.67	1.75	1.85	1.94	2.05	2.17	2.40	2.67
175 000 +	100	1.25	1.54	1.29	1.09	1.16	1.32	1.73	1.93	2.09	2.27

Tanker Opcost ($1000 per annum) - Stores and Provisions

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Open Registry											
20- 39 999	75	90	100	125	155	190	220	290	380	465	570
40- 69 999	85	100	105	130	165	270	320	375	410	499	607
70- 99 999	95	105	110	130	170	220	350	400	430	519	627
100-174 999	95	110	120	140	180	220	290	420	460	560	682
175 000 +	85	95	100	120	130	170	230	290	360	431	516
North European											
20- 39 999	125	145	160	170	180	200	210	220	230	248	268
40- 69 999	130	155	170	190	220	240	270	290	320	358	401
70- 99 999	150	180	220	240	260	290	320	350	380	427	480
100-174 999	170	200	240	270	305	340	380	430	490	559	638
175 000 +	140	150	140	165	200	220	250	300	350	392	440
Weighted Average Costs											
20- 39 999	106	124	137	151	168	195	215	260	323	390	473
40- 69 999	112	133	145	166	196	256	297	338	371	440	525
70- 99 999	129	152	183	201	224	260	336	377	407	478	563
100-174 999	143	168	200	226	259	293	431	425	475	560	661
175 000 +	119	129	123	146	172	198	240	295	355	412	481
Index of Weighted Average											
20- 39 999	100	1.17	1.29	1.42	1.58	1.84	2.03	2.45	3.05	3.68	4.46
40-69 999	100	1.19	1.29	1.48	1.75	2.29	2.65	3.02	3.31	3.93	4.69
70- 99 999	100	1.18	1.42	1.56	1.74	2.02	2.60	2.92	3.16	3.71	4.36
100-174 999	100	1.17	1.40	1.58	1.81	2.05	2.38	2.97	3.33	3.92	4.62
175 000 +	100	1.08	1.03	1.23	1.45	1.66	2.02	2.48	2.98	3.46	4.04

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Tanker Opcost ($1000 per annum) - Insurance Cost

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1982
Open Register											
20- 39 999	105	110	120	100	95	120	130	140	160	167	176
40- 69 999	130	160	140	160	175	150	120	134	180	187	195
70- 99 999	190	155	130	125	135	150	170	200	200	201	202
100-174 999	450	400	310	255	240	240	230	220	230	211	194
175 000 +	850	740	530	320	300	300	300	340	360	323	290
North European											
20- 39 999	185	210	230	240	280	300	295	275	240	248	256
40- 69 999	240	265	300	310	290	330	330	330	300	308	317
70- 99 999	270	300	350	400	420	315	330	345	260	259	258
100-174 999	620	470	430	380	250	290	354	390	280	243	219
175 000 +	880	940	700	680	650	650	600	550	455	419	386
Weighted Average Cost											
20- 39 999	156	176	192	199	233	249	245	239	298	215	223
40- 69 999	201	225	249	259	247	274	274	273	255	262	271
70- 99 999	237	251	290	335	351	262	276	292	234	234	233
100-174 999	549	438	380	330	245	267	305	329	252	228	207
175 000 +	865	852	627	565	539	539	500	470	413	377	345
Index of Weighted Average											
20- 39 999	100	1.13	1.23	1.28	1.49	1.60	1.57	1.47	1.33	1.38	1.43
40- 69 999	100	1.12	1.24	1.29	1.23	1.36	1.36	1.36	1.27	1.30	1.35
70- 99 999	100	1.06	1.22	1.41	1.48	1.11	1.17	1.23	0.99	0.99	0.98
100-174 999	100	0.80	0.69	0.60	0.45	0.49	0.56	0.60	0.46	0.42	0.38
175 000 +	100	0.98	0.72	0.65	0.62	0.62	0.58	0.54	0.48	0.44	0.40

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Tanker Administration Cost ($1000 per annum)

	1973	1974	1975	1976	1977	1978	1979	1780	1981	1982	1983
Open Register											
20- 39 999	75	85	100	100	105	140	160	180	210	239	272
40- 69 999	110	115	105	115	130	150	165	190	210	228	247
70- 99 999	100	105	110	125	140	160	180	205	230	255	283
100-174 999	110	125	140	150	160	175	180	200	215	234	254
175 000 +	130	120	120	120	140	180	200	210	220	235	251
North European											
20- 39 999	100	110	120	120	125	130	135	140	145	152	159
40- 69 999	120	125	130	135	145	160	170	175	180	189	199
70- 99 999	125	135	140	150	160	170	185	195	210	224	239
100-174 999	160	190	215	220	230	240	245	250	265	282	350
175 000 +	190	230	250	265	280	300	320	335	260	390	422
Weighted Average Costs											
20- 39 999	89	99	111	111	116	135	149	163	183	205	230
40- 69 999	115	120	119	126	138	155	168	183	196	219	226
70- 99 999	114	122	127	139	151	165	183	200	220	241	263
100-174 999	140	164	185	192	201	213	217	228	243	260	279
175 000 +	166	192	208	220	233	255	274	287	307	332	358
Index of Weighted Average											
20- 39 999	100	1.11	1.25	1.25	1.30	1.52	1.67	1.83	2.06	2.30	2.58
40- 69 999	100	1.04	1.03	1.10	1.20	1.35	1.46	1.59	1.70	1.83	1.97
70- 99 999	100	1.07	1.11	1.57	1.32	1.45	1.61	1.75	1.93	2.11	2.31
100-174 999	100	1.17	1.32	1.37	1.44	1.52	1.55	1.63	1.74	1.86	1.99
175 000 +	100	1.16	1.25	1.33	1.40	1.54	1.65	1.73	1.85	2.00	2.16

Bulk Carrier Total Operating Costs ($ million/annum) 1973-1983

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Open Registry Costs											
2 5000	0.67	0.73	0.79	0.85	0.91	1.04	1.17	1.27	1.35	1.49	1.58
40 000	0.84	0.92	1.01	1.13	1.23	1.29	1.34	1.41	1.48	1.61	1.72
60 000	0.98	1.06	1.14	1.23	1.31	1.40	1.50	1.55	1.60	1.76	1.84
120 000	1.19	1.26	1.36	1.44	1.53	1.63	1.74	1.80	1.86	2.00	2.09
North European Costs											
2 5000	0.83	0.94	1.05	1.16	1.27	1.38	1.50	1.58	1.62	1.66	1.68
40 000	0.96	1.05	1.16	1.27	1.41	1.53	1.65	1.73	1.79	1.75	1.80
60 000	1.05	1.15	1.26	1.40	1.53	1.66	1.80	1.86	1.91	1.88	1.91
120 000	1.27	1.41	1.53	1.64	1.75	1.87	1.99	2.08	2.13	2.12	2.17
Weighted Average											
2 5000	0.76	0.85	0.94	1.03	1.12	1.23	1.36	1.44	1.50	1.58	1.63
40 000	0.90	0.99	1.09	1.20	1.33	1.42	1.51	1.59	1.65	1.68	1.76
60 000	1.02	1.11	1.20	1.32	1.54	1.54	1.66	1.72	1.77	1.82	1.88
120 000	1.23	1.34	1.45	1.55	1.65	1.76	1.87	1.95	2.00	2.06	2.13
Weighted Average Index											
2 5000	100	1.12	1.24	1.36	1.47	1.62	1.79	1.89	1.97	2.08	2.14
40 000	100	1.10	1.21	1.33	1.48	1.58	1.68	1.77	1.83	1.87	1.96
60 000	100	1.09	1.18	1.29	1.51	1.51	1.63	1.69	1.74	1.78	1.84
120 000	100	1.09	1.18	1.26	1.34	1.43	1.52	1.59	1.63	1.67	1.73

Bulk Carriers - Manning Costs 1973-1983 ($100 K annum)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Open Registry Costs											
2 500 dwt ±	320	350	383	419	459	502	549	601	658	720	788
40 000 ±	335	366	401	438	479	524	573	627	686	750	820
60 000 ±	345	379	416	457	501	550	604	664	729	800	878
12 000 ±	420	457	498	541	589	641	698	769	827	900	980
North European Costs											
2 500 ±	470	510	553	599	650	705	764	829	899	975	1 057
40 000	495	535	578	625	675	730	788	852	921	995	1 075
60 000	515	556	601	649	701	757	818	883	954	1 030	1 112
12 000	600	643	690	740	793	851	912	978	1 049	1 125	1 206
Weighted Average Costs											
2 500	409	445	483	525	571	621	674	733	797	867	942
40 000	430	466	506	548	594	644	697	757	821	890	965
60 000	447	484	525	570	618	670	727	789	857	929	1 009
12 000	526	566	610	656	706	761	819	883	951	1 025	1 105
Weighted Average Index											
2 500	100	1.09	1.18	1.28	1.40	1.52	1.65	1.79	1.95	2.12	2.30
40 000	100	1.08	1.18	1.27	1.38	1.50	1.62	1.76	1.91	2.07	2.24
60 000	100	1.08	1.17	1.28	1.38	1.50	1.63	1.77	1.92	2.08	2.26
12 000	100	1.08	1.16	1.25	1.34	1.45	1.56	1.68	1.81	1.95	2.10

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Bulk Carriers - Repairs and Maintenance ($1,000 per annum)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Open Registry Costs											
25 000	95	107	120	135	152	171	193	217	225	275	309
40 000	155	167	179	193	208	224	241	259	240	300	323
60 000	205	216	227	239	252	264	279	293	270	325	342
120 000	260	269	278	287	297	3-7	317	328	330	350	362
North European Costs											
25 000	85	93	102	111	122	133	145	159	220	190	208
40 000	125	132	140	149	157	167	177	187	240	210	222
60 000	145	153	161	170	180	190	200	211	265	235	248
120 000	175	184	193	202	212	223	234	245	290	270	283
Weighted Average Costs											
25 000	90	100	112	124	139	154	172	192	223	240	268
40 000	142	152	162	174	186	200	214	229	240	263	282
60 000	180	190	200	210	222	233	246	259	268	287	302
120 000	226	234	243	252	262	272	282	293	311	315	327
Weighted Average Index											
25 000	100	1.11	1.24	1.38	1.54	1.71	1.91	2.13	2.48	2.67	2.98
40 000	100	1.07	1.14	1.23	1.31	1.41	1.51	1.61	1.69	1.85	1.99
60 000	100	1.06	1.11	1.17	1.23	1.29	1.37	1.44	1.49	1.59	1.68
120 000	100	1.04	1.08	1.12	1.16	1.20	1.25	1.29	1.38	1.39	1.45

Bulk Carrier Costs - Stores and Provisions ($'000/annum), 1973-1983

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Open Registry Costs											
2 5000	80	87	95	103	112	122	132	144	180	170	185
40 000	130	136	141	148	154	161	167	175	210	190	198
60 000	160	166	172	178	184	191	198	205	240	220	228
120 000	200	210	220	231	243	255	268	281	300	310	325
North European											
2 5000	50	57	65	74	84	95	109	124	160	160	182
40 000	70	78	86	95	105	116	129	143	190	175	194
60 000	90	98	106	114	124	134	146	158	200	185	200
120 000	145	151	158	165	173	180	189	197	225	215	225
Weighted Average Cost											
2 5000	68	75	83	91	100	110	122	135	171	165	184
40 000	109	115	120	127	134	142	150	161	201	183	196
60 000	135	141	147	153	160	167	176	185	222	204	215
120 000	177	185	194	204	214	224	235	246	268	271	284
Weighted Average Costs Index											
2 5000	100	1.10	1.22	1.34	1.47	1.62	1.79	1.99	2.51	2.43	2.71
40 000	100	1.06	1.10	1.17	1.23	1.30	1.38	1.48	1.84	1.68	1.80
60 000	100	1.04	1.09	1.13	1.19	1.24	1.30	1.37	1.64	1.51	1.59
120 000	100	1.05	1.10	1.15	1.21	1.27	1.33	1.39	1.51	1.53	1.60

Bulk Carrier Costs - Insurance ($'000/annum), 1973-1983

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Open Registry Costs											
2 5000	120	123	126	129	133	136	139	143	140	150	154
40 000	150	154	158	162	167	171	176	180	185	190	195
60 000	180	184	188	192	197	201	206	210	200	220	225
120 000	185	190	196	202	208	214	220	227	220	240	247
North European Costs											
2 5000	95	100	105	111	116	122	129	136	125	150	158
40 000	120	125	130	135	140	146	151	157	165	170	177
60 000	150	156	162	168	174	181	188	195	205	210	218
120 000	210	216	223	230	237	244	251	259	260	275	283
Weighted Average Cost											
2 5000	109	113	116	121	125	129	134	140	133	150	156
40 000	137	141	145	150	155	159	164	169	176	181	186
60 000	166	171	176	181	186	192	197	203	203	215	222
120 000	198	204	210	217	223	230	237	244	242	259	266
Weighted Average Costs Index											
2 5000	100	1.04	1.06	1.11	1.15	1.18	1.23	1.28	1.22	1.38	1.43
40 000	100	1.03	1.06	1.09	1.13	1.16	1.20	1.23	1.28	1.32	1.36
60 000	100	1.03	1.06	1.09	1.12	1.16	1.19	1.22	1.22	1.30	1.34
120 000	100	1.03	1.06	1.10	1.13	1.16	1.20	1.23	1.22	1.31	1.34

Bulk Carrier Costs - Administration ($'000/annum), 1973-1983

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Open Registry Costs											
2 500	55	62	71	80	91	103	117	132	150	170	193
40 000	65	73	82	91	102	114	128	144	161	180	202
60 000	90	98	106	115	125	136	148	161	175	190	206
120 000	120	127	134	142	151	159	169	179	189	200	212
North European Costs											
2 500	125	130	136	141	147	153	159	166	173	180	187
40 000	145	150	156	161	167	173	180	186	193	200	207
60 000	150	157	163	170	178	186	194	202	211	220	230
120 000	135	143	152	161	171	182	193	204	217	230	244
Weighted Average Costs											
2 500	104	108	114	119	126	123	141	151	162	175	190
40 000	120	125	131	136	142	150	158	168	178	191	205
60 000	128	134	141	148	156	165	174	184	195	206	219
120 000	128	135	144	152	162	171	182	192	204	216	229
Weighted Average Index											
2 500	100	1.04	1.10	1.14	1.21	1.28	1.36	1.45	1.56	1.68	1.83
40 000	100	1.04	1.09	1.13	1.18	1.25	1.32	1.40	1.48	1.59	1.70
60 000	100	1.05	1.10	1.16	1.22	1.29	1.36	1.44	1.52	1.61	1.71
120 000	100	1.05	1.13	1.19	1.27	1.34	1.42	1.50	1.59	1.69	1.79

APPENDIX E

TRANSLOG RESULTS

Table 7.2 Estimated Parameters of the Normalised Translog Total Cost Function: Traditional Shipping Nations - Bulk Carriers (T-Ratios in Parentheses)

	Hypotheses				
	Model 1	Model 2	Model 3	Model 4	Model 1
Parameter	Non-Homothetic	Homothetic	Linear Separability	Constant Elasticity	TC (2)
α_0	-0.585 (-7.2372)	-0.425 (-2.7767)	-0.0040 (-0.4557)	0.0005 (0.0590)	-0.0377 (-4.6468)
α_Q	0.5493 (49.547)	0.6690 (59.945)	0.4931 (49.490)	0.5100 (19.454)	0.6258 (52.343)
ξ_{QQ}	0.2080 (17.511)	-0.1314 (-7.1494)	0.1266 (3.1491)		0.2093 (11.853)
β_K	0.4376 (118.920)	0.4575 (42.194)	0.4469 (54.178)	0.3764 (10.516)	0.4876 (111.36)
β_M	0.3442 (70.720)	0.3363 (36.276)	0.3437 (49.384)	0.2758 (7.5456)	0.3293 (65.842)
β_R	0.1578 (44.532)	0.1423 (26.749)	0.1484 (25.393)	0.2033 (14.886)	0.1203 (27.907)
β_S	0.0604 (87.247)	0.0640 (32.559)	0.0610 (30.694)	0.1446 (4.1735)	0.0628 (92.556)
γ_{KK}	0.2245 (51.695)	0.1388 (14.230)	-0.1838 (-2.5311)		0.2483 (42.041)
γ_{MM}	0.2013 (37.818)	0.1599 (13.171)	-0.2365 (-2.1816)		0.2186 (40.194)
γ_{RR}	0.1126 (34.755)	0.0889 (23.130)	0.0854 (6.8100)		0.1157 (26.830)
γ_{SS}	0.0595 (40.165)	0.0586 (50.823)	0.0748 (1.4613)		0.0615 (46.567)
γ_{KM}	-0.1380 (-34.323)	-0.0792 (-8.0774)			-0.1541 (-32.452)
γ_{KR}	-0.0602 (-23.611)	-0.0172 (-3.6479)			-0.0600 (-17.752)
γ_{KS}	-0.0263 (-17.051)	-0.0424 (-22.589)			-0.0343 (-17.752)
γ_{MR}	-0.0412 (-14.400)	-0.0680 (-13.637)			-0.0466 (-14.264)
γ_{MS}	-0.0221 (-14.475)	-0.0126 (-7.2774)			-0.0180 (-12.995)
γ_{RS}	-0.0112 (-16.214)	-0.0036 (-4.1804)			-0.0092 (-12.530)
ρ_{KQ}	0.1813 (30.569)		0.0822 (5.2346)		0.1859 (21.602)
ρ_{MQ}	-0.1235 (-18.404)		-0.0651 (-6.2321)		-0.1127 (-14.531)
ρ_{RQ}	-0.0898 (-19.502)		-0.0220 (-1.6794)		-0.0978 (-11.432)
ρ_{SQ}	0.0319 (22.948)		0.0048 (1.6375)		0.0246 (14.388)
R^2 adjusted	0.8968	0.5885	0.9270	0.8998	0.9071
Likelihood Function	675.04	551.23	417.68	75.43	519.67

Table 7.3 Estimated Parameters of the Normalised (Total) Translog Cost Function - Open Registers: Bulk Carriers (T-ratios in parentheses)

	Hypotheses			
	Model 1	Model 2	Model 3	Model 4
Parameter	Non-Homothetic	Homothetic	Linear Separability	Constant Elasticity
α_0	-0.0306 (-3.7910)	-0.0198 (-2.3335)	0.0183 (1.5486)	0.0001 (0.0209)
α_Q	0.6769 (62.886)	0.6833 (67.728)	0.6709 (53.951)	0.6894 (26.362)
ξ_{QQ}	0.1774 (14.826)	-0.0192 (-1.2234)	0.0781 (0.9053)	
β_K	0.5510 (145.90)	0.5585 (70.446)	0.541 (632.099)	0.5926 (16.065)
β_M	0.2612 (56.061)	0.2555 (35.805)	0.2575 (30.064)	0.2015 (9.6778)
β_R	0.1081 (64.917)	0.1050 (30.231)	0.1084 (17.824)	0.1309 (8.5315)
β_S	0.0798 (116.530)	0.0810 (62.390)	0.0800 (23.625)	0.0751 (2.6388)
γ_{KK}	0.2294 (38.763)	0.0834 (7.3155)	-0.2175 (-1.4068)	
γ_{MM}	0.1714 (37.476)	0.0885 (9.0551)	0.0739 (0.7613)	
γ_{RR}	0.0797 (22.838)	0.0642 (22.853)	-0.0341 (-1.0406)	
γ_{SS}	0.0739 (31.881)	0.0697 (30.084)	-0.0319 (-0.575)	
γ_{KM}	-0.1320 (-31.416)	-0.0191 (-1.8719)		
γ_{KR}	-0.0515 (-15.794)	0.0034 (0.8296)		
γ_{KS}	-0.0459 (-16.601)	-0.0678 (-26.246)		
γ_{MR}	-0.0198 (-7.3751)	-0.0675 (-18.169)		
γ_{MS}	-0.-196 (-10.690)	-0.0019 (-0.9438)		
γ_{RS}	-0.0083 (-5.8887)	-0.00006 (-0.0542)		
ρ_{KQ}	0.1591 (25.651)		0.0054 (0.4311)	
ρ_{MQ}	-0.1242 (-20.074)		-0.0344 (-2.7296)	
ρ_{RQ}	-0.0594 (-13.018)		0.0149 (1.6153)	
ρ_{SQ}	0.0245 (10.609)		0.0140 (2.8840)	
R^2 adjusted	0.9319	0.9375	0.9684	0.9781
Log of Likelihood Function	351.11	304.51	221.67	55.46

Table 7.5 Allen-Uzawa Partial Elasticities of Substitution for the Total Cost Function: Bulk Carriers; (Asymptotic errors in parentheses)

σ_{ii}, σ_{ij}	All Ships	Traditional Registries (1)	Traditional Registries (2)	Open Registries
σ_{KK}	-0.0998* (0.0036)	-0.1131* (0.0050)	-0.0067 (0.0060)	-0.0598* (0.0054)
σ_{MM}	-0.2271* (0.0063)	-0.1998* (0.0077)	-0.0230* (0.0083)	-0.3107* (0.0088)
σ_{RR}	-0.4102* (0.0102)	-0.8516* (0.0103)	0.7014* (0.0179)	-1.5041* (0.0161)
σ_{SS}	0.1101* (0.0101)	0.8611* (0.0123)	1.4170* (0.0105)	0.0469* (0.0145)
σ_{KM}	0.1049* (0.0187)	0.0775* (0.0267)	0.0470* (0.0296)	0.0769* (0.0292)
σ_{KR}	0.0658* (0.0331)	0.1449* (0.0369)	-0.0204 (0.0592)	0.1488* (0.0547)
σ_{KS}	0.0637 (0.0431)	0.0038 (0.0583)	-0.1667* (0.0631)	-0.0432 (0.0629)
σ_{MR}	0.1504* (0.0559)	0.2426* (0.0527)	-0.1768* (0.0825)	0.3077* (0.0953)
σ_{MS}	0.0076 (0.0521)	-0.0833 (0.0733)	0.0909 (0.0669)	0.0577 (0.0881)
σ_{RS}	-0.2717* (0.0677)	-0.1667* (0.0722)	-0.2778* (0.0974)	0.0568 (0.1640)

Note: * denotes significance at 5% level

Asymptotic standard errors were based on the formula

$SE(\sigma_{ij}) = SE(\sigma_{ij})/S_i S_j$

For traditional registries (1) and (2) see text

Table 7.6 Bulk Carrier Own-Price and Cross-Price Elasticities of Factor Demand - Total Cost Function

E_{ii}, E_{ij}	All Ships	Traditional Registries (1)	Traditional Registries (2)	Open Registries
E_{KK}	-0.0471	-0.0498	-0.0033	-00330
E_{KM}	0.0332	0.0271	0.0155	0.0120
E_{KR}	0.0096	0.0232	-0.0024	0.0161
E_{KS}	0.0042	0.0002	-0.0100	-0.0035
E_{MK}	0.0494	0.0341	0.0230	0.0423
E_{MM}	-0.0719	-0.0699	-0.0076	-0.0808
E_{MR}	0.0220	0.0388	-0.0212	0.0338
E_{MS}	0.0005	-0.0050	0.0055	0.0046
E_{RK}	0.0310	0.0638	-0.0100	0.0818
E_{RM}	0.0476	0.0849	-0.0583	0.0800
E_{RR}	-0.0599	-0.1363	0.0842	-0.1655
E_{RS}	-0.0180	-0.0100	-0.0100	0.0045
E_{SK}	0.0300	0.0017	-0.0817	-0.0238
E_{SM}	0.0024	-0.0292	0.0300	0.0150
E_{SR}	-0.0397	-0.0267	-0.0333	0.0062
E_{SS}	0.0073	0.0517	0.0850	0.0037

Table 7.7 Estimated Parameters of the Normalised Translog Operating Cost Function: Bulk Carriers - Traditional and Open Registries (T-ratios in parentheses)

	All Data	TC(1)	TC(2)	OR
α_0	-0.07729	-0.0858	-0.0572	-0.0620
	(-4.1125)	(-6.6506)	(-4.7078)	(-4.8052)
α_Q	0.1820	0.1774	0.2273	0.1986
	(14.254)	(10.328)	(13.575)	(14.457)
ξ_{QQ}	0.0232	0.0419	0.0676	0.1281
	(1.5063)	(2.5314)	(4.0032)	(10.834)
β_M	0.5036	0.5263	0.5270	0.4438
	(133.83)	(103.440)	(80.738)	(71.807)
β_R	0.2133	0.2263	0.1880	0.1817
	(60.168)	(50.215)	(36.167)	(66.628)
β_S	0.1068	0.0938	0.1003	0.1364
	(89.100)	(70.752)	(65.294)	(103.400)
β_{IA}	0.1764	0.1537	0.1846	0.2381
	(74.963)	(61.935)	(64.124)	(63.177)
γ_{MM}	0.2111	0.2275	0.2633	0.2244
	(39.962)	(29.964)	(28.043)	(46.491)
γ_{RR}	0.1609	0.1611	0.1612	0.1316
	(47.722)	(37.407)	(23.803)	(28.348)
γ_{SS}	0.0963	0.0852	0.0901	0.1153
	(41.030)	(42.678)	(54.793)	(26.183)
γ_{IAIA}	0.1127	0.1092	0.1369	0.1749
	(35.690)	(29.068)	(33.987)	(40.914)
γ_{MR}	-0.0972	-0.1109	-0.1179	-0.0661
	(-27.095)	(-23.387)	(-16.675)	(-20.594)
γ_{MS}	-0.0520	-0.0463	-0.0457	0.0537
	(-25.181)	(-19.611)	(-20.160)	(-15.218)
γ_{MIA}	-0.0620	-0.0704	-0.0997	-0.1046
	(-18.431)	(-15.128)	(-19.466)	(-31.780)
γ_{RS}	-0.-286	-0.0251	-0.0252	-0.0284
	(-20.468)	(-18.900)	(-14.997)	(-9.037)
γ_{RIA}	-0.0351	-0.0251	-0.0180	-0.0370
	(-14.958)	(-8.5239)	(-5.2437)	(-10.145)
γ_{SIA}	-0.0156	-0.0138	-0.0192	-0.0332
	(-10.597)	(-9.5953)	(-12.862)	(-10.708)
ρ_{MQ}	-0.0258	-0.0057	0.0288	-0.0269
	(-4.1813)	(-0.6775)	(2.4816)	(-3.9360)
ρ_{RQ}	-0.0440	-0.0470	-0.0642	-0.0332
	(-8.4478)	(-7.4855)	(-6.3659)	(-8.1687)
ρ_{SQ}	0.0912	0.0805	0.0820	0.1115
	(31.520)	(27.959)	(25.583)	(29.275)
ρ_{IAQ}	-0.0214	-0.0277	-0.0467	-0.0513
	(-5.2843)	(-5.6234)	(-8.4102)	(-11.061)
R^2 (adjusted)	0.8723	0.7945	0.8893	0.8785

Log of the Likelihood Function:
808.17

Table 7.8 Allen-Uzawa Partial Elasticities of Substitution and Factor Own-Price and Cross-Price Elasticities of Demand - Bulk Carriers: Operating Cost Function

Partial Elasticities of Substitution				Factor Price Elasticities			
	TCs(1)-Model 1	TCs(2)-Model(1)	ORs-Model 1		TC(1)	TC(2)	OR
σ_{MM}	-0.0769* (0.0072)	0.0505* (0.0089)	-0.1136* (0.0054)	E_{MM}	-0.0408	0.0268	-0.0500
σ_{RR}	-0.3025* (0.0095)	0.2022* (0.0180)	-0.4938* (0.0128)	E_{MR}	0.0207	-0.0325	0.0298
σ_{SS}	0.4074* (0.0106)	0.0100 (0.0082)	-0.2602* (0.0161)	E_{MS}	0.0026	0.0138	0.0179
σ_{IA}	-0.8133* (0.0122)	-0.3998* (0.0109)	-0.1302* (0.0090)	E_{MIA}	-0.0172	0.0081	0.0227
σ_{MR}	0.0902* (0.0398)	-0.1708* (0.0714)	0.1654* (0.0398)	E_{RM}	0.0478	-0.0905	0.0728
σ_{MS}	0.0294 (0.0478)	0.1377* (0.0429)	0.1282* (0.0583)	E_{RR}	-0.0696	0.0384	-0.0889
σ_{MIA}	0.1145* (0.0575)	-0.0451 (0.0526)	0.0947* (0.0312)	E_{RS}	-0.0191	-0.0326	-0.0178
σ_{RS}	-0.2126* (0.0627)	-0.3263* (0.0892)	-0.1270 (0.1232)	E_{RIA}	0.0419	0.0874	0.0342
σ_{RIA}	0.2784* (0.0845)	0.4737* (0.0989)	0.1435 (0.0843)	E_{SM}	0.0156	0.0730	0.0564
σ_{SIA}	-0.0222 (0.996)	-0.0667 (0.0807)	-0.8452* (0.0956)	E_{SR}	-0.0481	-0.0613	-0.0231
				E_{SS}	0.0382	0.0010	-0.0355
				E_{SIA}	-0.0034	-0.0123	-0.2012
				E_{IAM}	0.0607	-0.0239	0.0417
				E_{IAR}	0.0627	0.0900	0.0258
				E_{IAS}	-0.0021	-0.0067	-0.1153
				E_{IAIA}	-0.1250	-0.0738	-0.0310

Note: Asymptotic standard errors in parentheses

* Significant at 5% level

Table 7.11 Estimated Co-efficients of the Normalised Translog Tanker Total Cost Function for Traditional Registries (T-ratios in parentheses)

	Hypotheses			
	Model 1	Model 2	Model 3	Model 4
Parameter	Non-Homothetic	Homothetic	Linear Separability	Constant Elasticity
α_0	-0.0700	-0.0502	-0.0562	-0.0005
	(-5.4518)	(-2.5262)	(-2.6348)	(-0.0280)
α_Q	0.4569	0.4599	0.4836	0.3974
	(34.9650)	(19.1590)	(21.2960)	(9.4792)
ξ_{QQ}	0.2891	0.0006	-0.1088	
	(10.1650)	(0.0142)	(-1.1574)	
β_K	0.3726	0.3739	0.3792	0.3327
	(82.6070)	(25.9640)	(22.9030)	(8.0760)
β_M	0.3859	0.3854	0.3771	0.4371
	(75.0860)	(32.6340)	(22.0140)	(11.3240)
β_R	0.1636	0.1634	0.1694	0.1457
	(44.6760)	(25.8030)	(13.5680)	(5.4227)
β_S	0.0779	0.0773	0.0743	0.0845
	(12.3930)	(11.8180)	(9.1549)	(2.5801)
γ_{KK}	0.2279	0.0939	0.1353	
	(27.2620)	(5.6935)	(1.5522)	
γ_{MM}	0.2049	0.1252	0.0626	
	(20.8140)	(9.7967)	(0.7273)	
γ_{RR}	0.2050	0.0886	0.1478	
	(19.5220)	(17.1960)	(4.2421)	
γ_{SS}	0.0334	0.0391	0.0617	
	(4.2710)	(3.9132)	(0.7801)	
γ_{KM}	-0.1499	-0.0428		
	(-21.8110)	(-3.3916)		
γ_{KR}	-0.0517	-0.0025		
	(-10.4910)	(-0.3511)		
γ_{KS}	-0.0264	-0.0485		
	(-4.2365)	(-5.0757)		
γ_{MR}	-0.0521	-0.0890		
	(-9.5715)	(-12.9160)		
γ_{MS}	-0.0030	0.0066		
	(-0.4224)	(0.8339)		
γ_{RS}	-0.00400	0.0029		
	(-0.7483)	(0.5513)		
ρ_{KQ}	0.2030		0.0169	
	(21.7220)		(0.7534)	
ρ_{MQ}	-0.1494		-0.0365	
	(-14.6030)		(-1.7288)	
ρ_{RQ}	-0.0753		-0.0012	
	(-10.2900)		(-0.0145)	
ρ_{SQ}	0.0217		0.0209	
	(2.1106)		(2.0443)	
R^2 adjusted for degrees of freedom:				
Cost Eqtn.	0.9517	0.9110	0.9604	0.9348
Capital "	0.9470	0.3128	-0.0900	
Manning "	0.9173	0.4599	-0.0172	
Repairs "	0.9312	0.7512	-0.0545	
Log of Likelihood Function:				
	212.99	163.78	130.63	27.94

Table 7.12 Estimated Parameters of the Generalised Translog Total Cost Function for Tankers: Open registries (T-ratios in parentheses)

	Hypotheses			
	Model 1	Model 2	Model 3	Model 4
Parameter	Non-Homothetic	Homothetic	Linear Separability	Constant Elasticity
α_o	-0.0422 (-8.7786)	-0.373 (-4.4200)	-0.459 (-6.7841)	-0.0006 (-0.0537)
α_Q	0.5872 (93.9740)	0.6045 (47.6370)	0.5991 (56.0460)	0.6640 (10.0280)
ξ_{QQ}	0.1790 (19.2990)	-0.0453 (-2.6599)	-0.1698 (-4.9600)	
β_K	0.4624 (135.7100)	0.4738 (49.0900)	0.4705 (36.5570)	0.4902 (12.8660)
β_M	0.3244 (93.2560)	0.3219 (37.4250)	0.3081 (30.5000)	0.2975 (5.8584)
β_R	0.1229 (33.4030)	0.1131 (25.9370)	0.1301 (26.1630)	0.0856 (4.5492)
β_S	0.0903 (77.2570)	0.0913 (64.1110)	0.0913 (21.3290)	0.1267 (3.2899)
γ_{KK}	0.2342 (56.6260)	0.0936 (10.6370)	0.1010 (3.3138)	
γ_{MM}	0.1955 (41.4930)	0.0931 (10.3360)	0.3491 (3.0980)	
γ_{RR}	0.0717 (22.5930)	0.0660 (14.7900)	0.1086 (8.4338)	
γ_{SS}	0.0618 (18.7380)	0.0601 (29.1400)	0.0133 (1.1079)	
γ_{KM}	-0.1491 (-46.0000)	-0.0283 (-3.6739)		
γ_{KR}	-0.0425 (-13.8570)	-0.0092 (-2.1950)		
γ_{KS}	-0.0427 (-18.3730)	-0.0561 (-25.2970)		
γ_{MR}	-0.0283 (-8.5103)	-0.0588. (-11.9800)		
γ_{MS}	-0.0181 (-5.7762)	-0.0059 (-3.6566)		
γ_{RS}	-0.0009 (-0.5377)	0.0020 (1.5978)		
ρ_{KQ}	0.1774 (34.9940)		-0.0092 (-0.5387)	
ρ_{MQ}	-0.1410 (-22.4260)		0.0481 (4.0380)	
ρ_{RQ}	-0.0542 (-15.9930)		-0.0272 (-4.0111)	
ρ_{SQ}	0.0178 (4.1773)		-0.0118 (-2.1329)	
R^2 adjusted for degrees of freedom:				
Cost Eqtn.	0.9137	0.8706	0.9352	0.7516
Capital "	0.9472	0.6284	0.0031	
Manning "	0.9124	0.5764	-0.1160	
Repairs "	0.7787	0.8389	-0.3595	
Log of likelihood function relating to cost equation	278.54	222.64	170.90	36.38

Table 7.13 Estimated Allen-Uzawa Partial Elasticities of Substitution for the Total Cost Function for Tankers; (Asymptotic errors in parentheses)

	All Ships	Traditional Registry	Open Registry
σ_{KK}	-0.0256* (0.0076)	-2.7138* (0.0112)	-1.7515* (0.0045)
σ_{MM}	-0.1731* (0.0087)	-2.4363* (0.0128)	-3.3377* (0.0073)
σ_{RR}	-1.8951* (0.0156)	-11.5187* (0.0169)	-11.3006* (0.0129)
σ_{SS}	-2.4007* (0.0193)	-16.9121* (0.0501)	-16.9688* (0.0183)
σ_{KM}	-0.0442 (0.0343)	-0.0425 (0.0478)	0.0060 (0.0216)
σ_{KR}	0.2426* (0.0568)	0.1519 (0.0808)	0.2521 (0.0204)
σ_{KS}	-0.1078 (0.1030)	0.0905 (0.2145)	-0.0226 (0.0797)
σ_{MR}	0.3525* (0.0793)	0.1748* (0.0862)	0.2902* (0.0835)
σ_{MS}	0.4045* (0.1105)	0.9002* (0.2330)	0.3821* (0.1072)
σ_{RS}	0.5460* (0.1861)	0.6861* (0.4196)	0.9189* (0.0152)

Note: * denote significance at 5% level

Table 7.14 Tanker Own-Price and Cross-Price Elasticity of Factor Demand - Total Cost Function

E_{ii}, E_{ij}	All Ships	Traditional Registry	Open Registry
E_{KK}	-0.0105	-1.0112	-0.8099
E_{KM}	-0.0163	-0.0164	0.0019
E_{KR}	0.0348	0.0249	0.0310
E_{KS}	-0.0083	0.0070	-0.0020
E_{MK}	-0.0182	-0.0158	0.0028
E_{MM}	-0.0637	-0.9402	-1.0827
E_{MR}	0.0506	0.0286	0.0357
E_{MS}	0.0310	0.0701	0.0345
E_{RK}	0.0999	0.0566	0.1166
E_{RM}	0.1296	0.0675	0.0936
E_{RR}	-0.2721	-1.8845	-1.3889
E_{RS}	0.0419	0.0534	0.0830
E_{SK}	-0.0444	0.0337	-0.0105
E_{SM}	0.1488	0.3474	0.1240
E_{SR}	0.0784	0.1122	0.1129
E_{SS}	-0.1841	-1.3175	-1.5323

Table 7.15 Estimated Parameters of the Generalised Translog Cost Function - Operating Costs - for Tankers: all registries (t-ratios in parentheses)

Parameters	Model 1 All data	Model 1 Open registries	Model 1 Trad. registries
α_0	-0.0967 (-8.0098)	-0.537 (-6.2788)	-0.0569 (-4.6185)
α_Q	0.1249 (9.1736)	0.1792 (23.2380)	0.1030 (7.3391)
γ_{QQ}	0.1028 (4.9068)	0.0547 (4.0425)	0.0826 (4.0748)
β_M	0.5021 (105.0900)	0.4584 (104.2100)	0.5228 (118.6600)
β_R	0.1932 (36.1470)	0.1628 (34.9120)	0.2189 (45.9670)
β_S	0.1056 (39.1470)	0.1266 (78.1300)	0.0965 (44.2900)
β_{IA}	0.1991 (54.6300)	0.2522 (88.9230)	0.1619 (57.1060)
γ_{MM}	0.2327 (35.0150)	0.2190 (23.3610)	0.2196 (31.8330)
γ_{RR}	0.1114 (19.1710)	0.10962 (16.2160)	0.1392 (18.8240)
γ_{SS}	0.0704 (18.7370)	0.0776 (16.5660)	0.0591 (17.9460)
γ_{IAIA}	0.1898 (38.0850)	0.1961 (31.6520)	0.1471 (19.5310)
γ_{MR}	-0.0713 (-14.8480)	-0.0572 (-10.3330)	-0.0922 (-17.8610)
γ_{MS}	-0.0316 (-8.5150)	-0.0367 (-6.9484)	-0.0270 (-7.9684)
γ_{MIA}	-0.1299 (-28.6770)	-0.1250](-19.2840)	-0.1004 (-15.8940)
γ_{RS}	-0.0095 (-3.5576)	-0.0043 (-1.8254)	-0.0161 (-5.5076)
γ_{RIA}	-0.0307 (-9.3799)	-0.0346 (-10.0300)	-0.0308 (-8.5384)
γ_{SIA}	-0.0293 (-8.9651)	-0.0365 (-11.1210)	-0.0159 (-4.5613)
ρ_{MQ}	-0.0139 (-2.1650)	-0.0084 (-1.1157)	-0.0141 (-2.2117)
ρ_{RQ}	-0.0178 (-3.0745)	-0.0090 (-1.8119)	-0.0354 (-5.0868)
ρ_{SQ}	0.0743 (15.9830)	0.0730 (14.5620)	0.0649 (15.3630)
ρ_{IAQ}	-0.0426 (-8.3505)	-0.0555 (-12.5940)	-0.0154 (-2.9402)
R^2 (adjusted)			
Cost Equation	0.9500	0.9039	0.9674
Manning "		0.9272	0.9407
Repairs "		0.8816	0.9221
Stores "		0.9415	0.8855
Log of Likelihood function	290.75	244.94	246.56

Table 7.16 Estimated Allen-Uzawa Partial Elasticities of Substitution for the Operating Cost Function for Tankers; (Asymptotic errors in parentheses)

σ_{ii}, σ_{ij}	All Ships	Traditional Registry	Open Registry
σ_{MM}	-0.0686* (0.0066)	-1.2962* (0.0066)	-1.7462* (0.0102)
σ_{RR}	-1.1915* (0.0150)	-5.7897* (0.0169)	-8.1813* (0.0182)
σ_{SS}	-2.1566* (0.0178)	-15.0967* (0.0170)	-11.1276* (0.0185)
σ_{IAIA}	0.7654* (0.0125)	-9.8801* (0.0233)	-5.2706* (0.0123)
σ_{MR}	0.2650* (0.0495)	0.1943* (0.0451)	0.2335* (0.07422)
σ_{MS}	0.4040* (0.0699)	0.4648* (0.0671)	0.3676* (0.0911)
σ_{MIA}	-0.2994* (0.0453)	-0.1862* (0.0746)	-0.0812 (0.0561)
σ_{RS}	0.5344* (0.1308)	0.2378 (0.1387)	0.7914* (0.1153)
σ_{RIA}	0.2019* (0.0850)	0.1309 0.1018)	-0.1573 (0.0840)
σ_{SIA}	-0.3936* (0.1555)	-0.0177 (0.2238)	(0.1432) (0.1029)

* Note: Significant at 5% level

Table 7.17 Tanker Own-Price and Cross-Price Elasticities of Factor Demand - Operating Cost Function

E_{ii}, E_{ij}	All Ships	Traditional Registry	Open Registry
E_{MM}	-0.0344	-0.6777	-0.8005
E_{MR}	0.0512	0.0425	0.0380
E_{MS}	0.0427	0.0449	0.0465
E_{MIA}	-0.0596	-0.0301	-0.0205
E_{RM}	0.1331	0.0891	0.0560
E_{RR}	-0.2302	-1.2674	-1.3319
E_{RS}	0.0564	0.0229	0.1002
E_{RIA}	0.0402	0.0212	0.0397
E_{SM}	0.2028	0.2430	0.1685
E_{SR}	0.1032	0.0521	0.1288
E_{SS}	-0.2277	-1.4568	-1.4088
E_{SIA}	-0.0784	-0.0029	-0.0361
E_{IAM}	-0.1503	-0.0973	-0.0372
E_{IAR}	0.0390	0.0213	0.0256
E_{IAS}	-0.0416	-0.0017	-0.0181
E_{IAIA}	0.1524	-1.6000	-1.3292

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