Econometric Analysis of Bulk Shipping Markets
Implications for Investment Strategies and Financial Decision-Making

Econometrische analyse van de maritieme vervoersmarkten voor bulkgoederen
implicaties voor scheepvaartinvesteringen en financiële besluit vorming

Thesis

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Executive Summary

This thesis provides an econometric analysis of the bulk shipping markets and the implications for shipping investment and financial decision making.

Chapter 1 sets the scene by providing a historic analysis of bulk shipping markets over the last 55 years. From this analysis, four shipping markets (freight, newbuilding, second-hand and demolition) are distinguished as well as a fifth one (ship finance) that acts as a facilitator to the other four. Also, with the help of correlation analysis, the factors influencing these markets are identified. The chapter then considers five critical interdependent forces (economic structure, ship supply and demand capital flows expressed by investor preferences and investment performance) that comprise the shipping market and move in cyclical patterns. This way, the chapter explains the role of the shipping cycle in devising investment strategies. Based on this analysis, Chapter 1 ends by defining the thesis aim and objectives.

Chapter 2 presents the thesis methodology. It critically analyses the methods used in the collection of data and the interpretation of it, as well as the problems experienced while collecting it.

The four subsequent chapters present the results from the analysis of the four shipping markets (freight, newbuilding, second-hand and demolition). Based on theory, Error Correction Models describing and quantifying the relationships between the variables are developed for all four markets. This way the thesis fills a gap in maritime economics literature by estimating models where none of the CLRM assumptions are violated. Consequently, statistical inferences from these models can be made safely. Furthermore, by disaggregating into the different ship types according to size, the thesis finds that different variables have different effects on each type, thus proving that each ship type has its own distinctive characteristics. Finally, chapters 4 to 7 compare different econometric methods, the theoretical Error Correction and the atheoretical family of Auto Regressive Moving Average (ARMA) models. It is found that theoretical models, are still to be preferred if one wants to achieve the classical objectives of Econometric Business Cycle Research simultaneously (to describe and forecast cycles and to evaluate policies and test economic theories). However, if not all goals have to be met with a single vehicle, other methods might serve the purpose equally well or even better as is the case with the Auto Regressive Moving Average method whose forecasts outperform those of the ECM method on many occasions.

With respect to the period or time charter market, the thesis finds that spot rates are the major determinant for period ones. This indicates the validity of the pure expectation hypothesis of the term structure relationship between spot and period rates. However, this hypothesis is not always valid since on two occasions (Panamax bulk carriers and Aframax tankers), fleet changes, a variable incorporated in the model to depict market changes and risks, is found to be statistically significant. This leads to inconclusive evidence regarding the validity of the pure expectation hypothesis of the term structure relationship and needs further investigation. Finally, it is found that the forecasting ability of the models for the timecharter market is superior to that for the freight market. This can be attributed to the dominance of the stochastic component of the spot rates over the deterministic one, which makes their accurate forecasting a very difficult task.

As far as the econometric analysis of new vessel prices is concerned, shipbuilding costs are found to have the most significant effect on the determination of newbuilding prices for all ship types. Time charter rates have an effect only on few ship segments. This is in line with theory that newbuilding prices are cost driven

rather than market driven as second-hand ship prices are. It is also found that actual exchange rates do not affect shipbuilding prices but cost variations due to exchange rate fluctuations do. Orderbook as a percentage of the fleet, used as a proxy for shipyard capacity due to data discrepancies and lack of long enough time series for the later, is found significant only for tankers indicating that shipyards' expansion policy is aimed at high value ships like tankers rather than bulk carriers. Finally, newbuilding prices for some ship types may be driven to a certain extent by asset pricing and speculation.

Newbuilding and timecharter rates have the greatest effect of all variables on the determination of second-hand prices, in most cases both in the short and the long run. The cost of capital is only significant for bulk carrier owners. The only exception is the Suezmax segment. Suezmax prices have been closely pegged to VLCCs with a discount but not proportional to the size. In other words Suezmaxes are rarely bargain vessels. Second-hand prices of Suezmaxes could therefore be more closely tied to newbuilding prices than for other tanker sizes. Finally, orderbook as a percentage of the fleet has a negative effect on the prices of second-hand vessels only in the long run and only in large and Panamax tankers.

The thesis also finds that demolition prices are primarily driven by market conditions and expectations. In addition, the price of scrap steel is also found to have a significant effect on VLCCs due to increasing demand for scrap steel that makes demolition traders eager to offer higher prices for larger tankers to satisfy demand. Finally, it is found that the volume of scrapped ships has a negative effect on the demolition price of medium and large tankers. This is due to new legislation usually stemming from an accident or environmental campaigns that may force shipowners to scrap their ships earlier than they had originally anticipated.

Shipowners invest in different ship markets and vessel sizes in the expectation of achieving a reduction in risk via the resulting diversification in their income. However, it is frequently observed that shipping companies focusing on a particular ship type achieve equally good or even better risk levels than those investing in various ship types and size. A question therefore arises whether such diversification strategies really reduce the investor's risk. This thesis investigates the potential of risk reduction benefits for a bulk shipping investor through diversification. It first analyses the traditional risk reduction approach of calculating the variance and the standard deviation of a portfolio. Results show that risk reduction benefits are achieved through diversification. Then, the thesis builds upon the shortcomings of correlation, namely the fact that while markets may tend to diverge considerably in the short-run, like periods of up to a year, they may actually be integrated over longer periods. If the income, expressed in time charter equivalent rates, of the various ship types or sizes is very strongly correlated in the long run, diversification will be less effective than if the ship markets or segments operated independently of one another. An important indication of the degree to which long run diversification is available to shipping investors is given by determining whether the markets are cointegrated. The thesis employs the Johansen method on 247 different combinations of investment in the dry and wet bulk markets. It finds that investing in more than one type of bulk carrier nullifies any risk reduction benefits. Furthermore, risk reduction benefits decrease as diversification increases with no risk reduction benefits obtained when investment involves more than five different ship types/sizes.

These results initially seem to be in contrast with portfolio theory which claims that risk reduction benefits increase with higher diversification. However, the reason behind this difference lies with time horizon and the results actually supplement the theory of risk reduction through diversification by showing that the benefits of diversification in most cases may exist in the short run but disappear in the long run. Finally, finding such long run relationships supports the existence of inefficiencies in the shipping freight market, a finding in line with previous research.

This thesis also develops an analytical tool for shipmanagers to measure the possible losses, within a specified time horizon and confidence interval, of their portfolios by calculating Value at Risk with the variance-covariance, historical and Monte Carlo simulation methods. This tool allows managers to identify the extent to which each asset contributes to these possible losses, as well as get an idea of the maximum possible losses should the worst case scenario occur. Based on this framework, shipping firms can then make informed decisions about maintaining or expanding lines of business, or whether to hedge financial risks at the firm level. In our example both VaR and CVaR figures are not high enough for the managers to seek hedging of their positions. The thesis argues that even if managers decide to hedge, it makes more sense to enter some of the ships into period charters, if they can, rather than use freight derivatives due to the high transaction and brokerage costs associated with the latter. However, the purpose of the example is neither to show that shipping is low risk nor disregard the use of freight derivatives as hedging tools but rather to promote VaR and CVaR as essential tools for risk measurement and hedging strategy determination in day-to-day shipping operations. In other words, the thesis argues that shipowners shall first try to determine their level of risk-exposure, then decide whether or not this exposure is acceptable to them and then employ different risk management tools to minimise such exposures. Nevertheless, the thesis argues that VaR-CVaR calculations should only be considered as a first order approximation and users should not be lulled into a state of complacency but rather recognise its limitations.

Finally, this thesis introduces Real Option Analysis and exotic options in particular as an alternative to the traditional capital budgeting technique for evaluating a series of shipping projects. The thesis considers the option to expand, timing and defer options, the option to choose the best of two assets and the option to vary the firm's production methods. Compound option are used to value the expansion option through ordering an additional number of ships at a predetermined price, showing that such options may increase the shareholders' value substantially. Also a framework to critically assess asset play opportunities is developed. Furthermore, by evaluating investment opportunities using American Exchange Options, substantial differences are found compared to the NPV method in both the value of the investment opportunities and the timing of when the project is undertaken. Chooser options are employed to evaluate the various options open to a shipowner in order to optimise strategic decision making. Finally, Exchange options are used to value the decision to invest in a new ship type. Overall, Real Options are useful tools for evaluating projects in an industry as volatile as shipping, where the agents need to value complex projects and make timely strategic decisions on a regular basis.

The thesis contribution to the maritime economics literature can be summed up in the following points:

- It utilises modern econometric techniques thanks to which statistical inferences can be made from estimating the developed theoretical models of the four shipping markets. This way the reader can draw conclusions about the interaction and effects of different variables on the different markets with adequate confidence.

- By analysing the markets at a desegregated level it shows that different ships, differentiated by either or both size and type, are affected to varying degrees by different variables. Therefore, the thesis advocates the use of the modular and desegregated approach rather than the integrated and aggregated one for modelling shipping markets to obtain a more thorough understanding of the industry.
- It comprehends the role of the shipping cycle in devising investment strategies. This is achieved by considering five critical interdependent forces (economic structure, ship supply and demand capital flows expressed by investor preferences and investment performance) that comprise the shipping market and move in cyclic patterns rather than the traditional three (economic structure, ship supply and demand) considered by previous researchers on the topic. It is further enhanced by utilising sophisticated financial tools and techniques employed by more mature industries such as consulting, banking, biotechnology and pharmaceutical.

The data-set used in this thesis may provide some limitations to the study but as data both improves and increases with time and new econometric techniques are developed for more accurate forecasting, further research on the topic will help the author achieve his ultimate aim. To provide the reader and the industry as a whole with an ever better and more thorough understanding of the bulk shipping markets and with sophisticated financial tools to enhance and optimise ship investment strategies and financial decision making processes.

Samenvatting en conclusies

Dit proefschrift verschaft een econometrische analyse van de maritieme vervoersmarkten voor bulkgoederen en de implicaties voor scheepvaartinvesteringen en financiële besluitvorming.

Hoofdstuk 1 geeft een achtergrond door middel van een historische analyse van bulkgoederentransportmarkten, die de laatste 55 jaar omvat. Vanuit deze analyse worden vier scheepvaartmarkten onderscheiden (vracht, nieuwbouw van schepen, handel in tweedehands schepen en sloop van schepen), evenals een vijfde (financiering van schepen) die een faciliterende functie heeft ten opzichte van de overige vier. Met behulp van correlatie-analyse worden verder de factoren geïdentificeerd die deze markten beïnvloeden. Het hoofdstuk neemt vervolgens vijf kritieke onafhankelijke krachten in ogenschouw (economische structuur, aanbod en vraag van schepen, kapitaalstromen uitgedrukt door investeerderspreferenties, en investerings-performance), die de scheepvaartmarkt vormgeven en zich in cyclische patronen bewegen. Op deze manier wordt de rol van de scheepvaartcyclus omvat in het opstellen van investeringsstrategieën. Op basis van deze analyse eindigt Hoofdstuk 1 met het definiëren van de doelstellingen van het proefschrift.

Hoofdstuk 2 presenteert de onderzoeksmethodologie. De methodes die gebruikt worden voor het verzamelen en interpreteren van data worden kritisch geanalyseerd, evenals de problemen die zijn opgetreden bij het verzamelen.

De vier hierna volgende hoofdstukken presenteren de resultaten van deze strategie, die afkomstig zijn de analyse van de vier scheepvaartmarkten (vracht, nieuwbouw, tweedehands schepen en sloop). Op basis van econometrische theorie worden Error Correction modellen ontwikkeld voor alle vier deze markten; deze modellen beschrijven en kwantificeren de relaties tussen de variabelen. Op deze manier vult het proefschrift een opening in de maritiem economische literatuur door modellen te schatten waarbij geen van de CLRM-aannames worden overtreden. Als gevolg hiervan kunnen statistische gevolgtrekkingen op basis van deze modellen veilig getrokken worden. Bovendien onthult het proefschrift, door te disaggregeren in de verschillende scheepstypes naar rato van grootte, dat verschillende variableen verschillende effecten hebben op ieder scheepstype, waardoor wordt bewezen dat ieder scheepstype eigen onderscheidende eigenschappen heeft. Hoofdstukken 4 tot en met 7 vergelijken tenslotte ook verschillende econometrische methodes, het theoretische Error Correction en de atheoretische familie van Auto Regressieve Moving Average (ARMA) modellen. Er wordt vastgesteld dat theoretische modellen nog steeds verkiesbaar zijn indien men de klassieke doelstellingen van Econometric Business Cycle Research gelijktijdig wil bereiken (om cycli te beschrijven en voorspellen, om beleid te evalueren en om economische theorieën te testen). Als echter niet alle doelen gehaald hoeven te worden met een enkel middel, kunnen andere methodes de functie evenzeer of zelfs beter vervullen, zoals het geval is bij de Auto Regressive Moving Average methode, waarvan de voorspellingen die van de ECM-methode in veel gevallen overtreffen.

Wat betreft de periode- of tijdcharter markt, concludeert het proefschrift dat enkelvoudige prijstarieven de voornaamste determinant zijn voor de periodetarieven. Dit toont de geldigheid aan van de Pure Expectation-hypothese van de periodestructuur-relatie tussen enkelvoudige en periode prijstarieven. Deze hypothese is echter niet altijd geldig, aangezien in twee gevallen (Panamax bulk carriers en Aframax tankers) van vlootveranderingen, een variabele die is geïncorporeerd in het model om marktverandering en risico weer te geven, aangetoond is dat deze

statistisch significant zijn. Dit leidt tot onafdoende bewijs aangaande de geldigheid van de Pure Expectation-hypothese van de periodestructuur relatie; dit vereist daarom nader onderzoek. Tenslotte wordt aangetoond dat het voorspellend vermogen van de modellen wat betreft de time charter markt superieur is aan die voor de vrachtmarkt. Dit kan verklaard worden aan de hand van de dominantie van de stochastische component van de enkelvoudige tarieven over de deterministische component, waardoor nauwkeurige voorspelling van deze tarieven een zeer moeilijke taak wordt.
Aangaande econometrische analyse van nieuwbouwprijzen voor schepen is aangetoond dat scheepsbouwkosten het meest significante effect op de bepaling van nieuwbouwprijzen hebben voor alle scheepstypes. Tijdcharter tarieven hebben slechts op enkele scheepssegmenten enig effect. Dit is in lijn met theorieën die stellen dat nieuwbouwprijzen gedreven worden door kosten (cost driven), en niet door de markt (market criven), zoals in het geval van prijzen voor tweedehands schepen. Er wordt ook aangetoond dat feitelijke wisselkoersen niet van invloed zijn op scheepsbouwprijzen, maar kostenvariaties als gevolg van wisselkoersfluctuaties wel. Het is aangetoond dat het gebruik van orderportefeuilles als percentage van de vloot slechts significant is als benadering voor scheepswerfcapaciteit in het geval van tankers, wat aangeeft dat het uitbreidingsbeleid van scheepswerven gericht is op schepen met een hoge waarde zoals tankers, en niet bulk carriers. Tenslotte kunnen nieuwbouwprijzen voor sommige scheepstypes tot op zekere hoogte gedreven worden door prijsvorming van activa en door speculatie.
Nieuwbouw- en tijdcharter tarieven hebben van alle variabelen het grootste effect op de bepaling van tweedehands (scheeps-)prijzen, in de meeste gevallen zowel op de korte als de lange termijn. De kapitaalkosten zijn alleen significant voor eigenaren van bulk carrier schepen. De enige uitzondering is het Suezmax-segment, vanwege zijn specifieke eigenschappen. Tenslotte heeft de orderportefeuille als percentage van de vloot alleen een negatief effect op de prijzen van tweedehands schepen op de lange termijn, en alleen bij grote en Panamax-tankers.
Het proefschrift toont ook aan dat sloopprijzen in eerste instantie worden gedreven door marktomstandigheden en verwachtingen. Verder wordt ook aangetoond dat de schrootprijs voor staal een significant effect heeft op VLCCs vanwege een toenemende vraag naar staalresten, waardoor sloophandelaren gretig zijn om hogere prijzen te bieden voor grote tankers om deze vraag te beantwoorden. Tenslotte wordt aangetoond dat het volume van gesloopte schepen een negatief gevolg heeft voor de afbraakprijzen van middelgrote en grote tankers. Dit wordt veroorzaakt door nieuwe wetgeveing die meestal voortkomt uit een scheepvaartongeluk of milieucampagnes, waardoor scheepseigenaren worden gedwongen om hun schepen eerder af te breken dan zij oorspronkelijk van plan waren.

Scheepseigenaren investeren in verschillende scheepsmarkten en scheepsgrootten met de verwachting dat het risico wordt verlaagd door de diversificatie van hun inkomen. Echter, er wordt vaak gezien dat scheepvaartbedrijven die zich concentreren op een specifiek scheepstype, een gelijkwaardig of zelfs beter risico niveau behalen dan de bedrijven die zich specialiseren in verschillende scheepstypen en – grootten. Hieruit komt de vraag voort of zulke diversificatie strategieën daadwerkelijk het investeringsrisico verminderen. Dit proefschrift onderzoekt of het risico voor een investeerder in de bulksector door diversificatie verminderd kan worden. Allereerst wordt de variantie en de standaarddeviatie van een portefeuille. De resultaten laten zien dat risico reductie wordt behaald door diversificatie. Vervolgens, gaat het proefschrift in op te tekortkomingen van de correlatie namelijk het feit dat markten in de korte termijn, tot een jaar, aanzienlijk kunnen afwijken en kunnen worden geïntegreerd over een langere periode. Indien het inkomen, weergegeven in het tarief equivalent aan een tijdcharter, van verscheidene scheepstypen of –grootten sterk gecorreleerd is op de lange termijn zal diversificatie minder effectief zijn dan in scheepsmarkten of segmenten die onafhankelijk van elkaar opereren. Een belangrijke indicatie van de mate waarin diversificatie op lange termijn voor scheepsinvesteerders beschikbaar is, wordt gegeven door te bepalen of markten gecointegreerd zijn. Het proefschrift gebruikt de Johansen methode op 247 verschillende combinaties van investeringen in de droge en natte bulk marketen. Er wordt bevonden dat het investeren in meer dan één type bulkschip enig voordeel van risico reductie tenietdoet. Verder, risico wordt niet verder gereduceerd naarmate er meer diversificatie is en er is sprake van geheel geen vermindering van het risico wanneer een investering meer dan vijf verschillende scheepstypen/-grootten behelst.

Deze resultaten zijn in eerste instantie in tegenstelling tot de portfolio risk management theorie die beweert dat risico gereduceerd wordt door diversificatie. Echter, de tijdsspanne verklaart dit verschil en vult deze theorie aan door te laten zien dat de voordelen van diversificatie in de korte termijn wellicht bestaan maar in de lange termijn kunnen verdwijnen. Tot besluit, het vinden van dergelijke lange termijn relaties ondersteunen het bestaan van inefficiënties in de scheepvaartmarkt, hetgeen ook strookt met eerder gedaan onderzoek.

Dit proefschrift ontwikkelt ook een analytisch hulpmiddel voor scheepsmanagers voor het meten van mogelijke verliezen in een gedefinieerde tijdspanne en confidence interval van hun portefeuilles door het berekenen van Value at Risk met de variantie-covariantie, historische en Monte Carlo simulatie modellen. Het geeft managers de mogelijkheid te identificeren tot welke mate bepaalde assets een bijdrage leveren aan deze mogelijke verliezen en tevens een idee geeft welke maximale mogelijke verliezen behaald kunnen worden in de slechts mogelijke scenario. Op basis van dit framewerk kunnen scheepsbedrijven beslissingen maken omtrent het behouden of vergroten van hun bedrijf of hun financieel risico te hedgen op bedrijfsniveau. In ons voorbeeld zijn zowel VaR als CVar niet hoog genoeg zodat manager zullen hedgen. Dit proefschrift bepleit dat zelfs wanneer managers beslissen om te hedgen, het meer voor de hand ligt sommige schepen te charteren voor een bepaalde periode dan het gebruiken van freight derivatives door de hoge transactiekosten en bemiddelingskosten die het laatst genoemde voortkomen. Desondanks bepleit dit proefschrift dat VaR-CVAR calculaties alleen overwogen moeten worden als een eerste-orde benadering en gebruikers zouden het niet als uitputtend beschouwen maar eerder de beperkingen erkennen.

Tot besluit introduceert dit proefschrift Real Option Analysis en exotische mogelijkheden in het bijzonder als alternatieven voor de traditionele capital budgeting technique voor het evalueren van een serie scheepsprojecten. Het proefschrift neemt in overweging de optie om opties uit te breiden, tijdsplanning en op te schorten, de optie op de beste van twee assets te keizen en de optie om de productie methoden van het bedrijf te variëren. Een compound opties worden gebruikt om de waarde van de optie voor uitbreiding te bepalen door het bestellen van een additioneel aantal schepen tegen een vastgestelde prijs, dat dergelijke opties waarde voor de aandeelhouderssubstantieel verhogen.Verder wordt er ook nog een framework ontwikkeld die de asset play mogelijkheden kritisch evalueren. Bovendien, by het evalueren van investeringsmogelijkheden met gebruik van American Exchange Opties, worden aanzienlijke verschillen gevonden in vergelijking met de NVP methode in zowel de waarde van de investeringsmogelijkheden en de tijdsbepaling in de uitvoering van het project. Chooser Opties worden gebruikt om de verschillende mogelijkheden, die bestaan voor een scheepseigenaar om zijn strategisch beslissingsproces te optimaliseren, te evalueren. Tot besluit worden Exchange Opties gebruikt om het besluit in een nieuw scheepstype te investeren te waarderen. In het algemeen zijn Real Options nuttige hulpmiddelen voor het evalueren van projecten in een dergelijke veranderlijke markt zoals de scheepvaart, waar agenten complexe projecten moeten waarderen en strategische beslissingen met regelmaat moeten maken.

De bijdrage die dit proefschrift levert aan de maritiem economie kan samengevat worden in de volgende punten:

- Het maakt gebruik van econometrische technieken, waarmee statistical inferences kunnen worden getrokken door het bepalen van de theoretische modellen van de vier scheepsmarkten. Op deze manier kan de lezer zijn conclusies omtrent de interactie en effecten van verschillende variabelen in de verschillende markten met zekerheid trekken.
- De analyse van de markt op een gedesegregeerd niveau laat zien dat verschillende schepen, gedifferentieerd door grootte e/of type, in verschillende mate beïnvloed worden de verscheidene variabelen. Dit proefschrift bepleit dan ook voor het gebruik van een modulair gedesegregeerd aanpak in plaats van een geïntegreerd en geaggregeerde voor het modelleren van scheepvaartmarkten om een beter inzicht te krijgen van de industrie.
- Het omvat de rol van de scheepvaart cyclussen door investeringsstrategieen te beramen. Dit wordt bereikt door de vijf kritische onafhankelijke krachten (economische structuur, scheepsvraag en aanbod, vermogen uitgedrukt in de voorkeur van de investeerders en investeringsrendement) die de scheepvaartmarkt omvatten en in cyclische patronen bewegen in tegenstelling tot de traditionele drie (economische structuur, scheepsvraag en aanbod) zoals gebruikt in voorgaand onderzoek. Het wordt verder verbeterd door het gebruik van verfijnde financiële hulpmiddelen en technieken zoals gebruikt door de verder ontwikkelde industrieën zoals consultancy, bank sector, biotechnologie en de farmaceutische industrie.

De data-set die gebruikt wordt in dit proefschrift kan enige beperkingen creëren aan dit onderzoek maar aangezien data steeds verder verbeterd en vergroot met de tijd en nieuwe econometrische technieken zullen worden ontwikkeld voor meer nauwkeurige voorspellingen, zal verder onderzoek in dit onderwerp de auteur zijn uiteindelijke doel kunnen bereiken. Om de lezer en de industrie in het algemeen een beter en meer nauwkeurig inzicht in de bulk scheepvaartmarkten te verschaffen en met gecompliceerde financiële hulpmiddelen de scheepsinvesteringsstrategieën en het financiële beslissingprocess te verbeteren en te optimaliseren.

Table of Contents

Chapter 1: Introduction

Shipping is undoubtedly one of the most fascinating industries in the world. A number of arguments can be put forward to support this statement. First of all shipping was the first truly global industry long before globalisation became a buzzword. The fact that ships and shipping companies operate in a very international environment with owners, charterers, assets, crew and financial institutions sometimes thousands of miles away, gives someone the opportunity to get acquainted with other cultures through extensive communication and travelling as well as establish contacts all over the world. Also, the complexity of the industry and its dependence on world economic conditions require a wealth of knowledge and skills in order to cope with day-to-day operations and events that keep routine away. This complexity and skills requirement make shipowners some of the most respected entrepreneurs in the world that can flourish in almost anything they do besides shipping. Names such as Onassis, Pao and McKinsey-Maersk are testimony to this statement, while the fact that Easyjet, the airline that revolutionised the industry through budget air travel belongs to a shipowner, Hadjioannou, speaks for itself. Finally, another major point is the industry's highly volatile market. Shipping is full of stories about fortunes built and/or lost overnight. At the heart of this volatility is the bulk shipping market. By being one of the best examples of perfect competition thereby distinguishing it from liner shipping with its oligopolistic structure and high barriers to entry, bulk shipping provides to nearly anyone, poor or wealthy, well-educated or not, from different backgrounds to strike it rich or even super rich. All this person needs is one or more of the following important characteristics:

- Ambition.
- Determination
- Foresight
- Patience
- Good public relations skills
- A lot of luck, as in any efficient market full of inefficiencies and,
- Enough cash reserves especially during bad times.

Still however, in addition to these characteristics, in order for someone to succeed in such a complex and international industry as shipping, a thorough understanding of how the market operates is of paramount importance. Therefore, this first chapter of the thesis starts with a brief historic review of the major events that have affected the bulk shipping industry over the past fifty-five years. Based on this analysis, the most important factors affecting bulk shipping markets are identified and the relationship and interaction with each other are investigated. This analysis is then put within a macroeconomic business cycles framework. The chapter concludes by defining the aim and the objectives of the thesis and its structure.

1.1 A historical analysis of the major events that affected bulk shipping over the last six decades[1]

[1] This section is based on data and reports collected from various sources, including ISL, Fearnleys, SSY, and Drewry monthly and annual reports. It is also based on the author's personal experiences as well as stories he heard from people in the industry. Finally, for a market analysis prior to this period see Beenstock and Vergottis (1993) and Stopford (1997).

The first twenty-five years after World War II were dominated by an extraordinary growth in sea trade. This was a period of great technological change in the shipping industry though the emphasis was on organisation as much as hardware. Major shippers in the energy and metal industries took the initiative to develop integrated transport operations designed to reduce their transport costs. The trend towards specialisation was continuous and pervasive. By 1975 all the major trades had been taken over by specialised ships such as tankers and bulk carriers thereby allowing vessel size to increase (Stopford 1997).

1.1.1 The 1950s

In 1951 the Korean War led to a stockpiling boom of strategic reserves in the industrialised countries generating big demand for shipments. At the same time bunker prices increased by over 60%. This restrained supply and created further pressure on rates. The firm prices of the early 1950s led to increased shipbuilding activity. When the Korean crisis ended freights plummeted and so did ship prices due to oversupply. By 1953 laid up tonnage had increased considerably. Second-hand prices give a clear idea of the volatility of that period. The price of a Liberty type ship increased almost fivefold from June 1950 to December 1951. A year later in December 1952 it had lost half its 1951 value (Beenstock and Vergottis 1993).

The market remained depressed during the first half of 1954. In the autumn of 1954 however, the markets started to tighten and by year-end rates were up 30 per cent. World economic growth recovered strongly during 1955 and 1956 and so did the demand for shipping. In 1956, the Suez Canal was closed and freight rates peaked even above their previous peak during the Korean crisis. Legend has it that Onassis, who had most of his fleet operating on the spot market at that period of time made a profit of $80 million until the Canal reopened next year. Lay up went to zero and an ordering frenzy was witnessed.

During 1950-57 demand for tanker shipments was rising at an annual rate of 10.6% per annum. Consequently new tankers had to be ordered to satisfy demand. Therefore, a considerable proportion of the shipbuilding berths had been taken over by tankers thus restraining the growth of the dry bulk fleet.

In March 1957 the Suez Canal reopened, thus reducing the mileage factor in ton-miles. Moreover, world economic growth also fell thus reducing the volume for shipments. Suddenly most of the ships that had been ordered during the boom were not needed. These developments caused quite a severe depression that lasted for six years.

Newbuildings delivered during 1958 and 1959 together constituted 15% of the existing fleet, at a time of lower demand. This caused lay up to rise to 7% (Stopford 1997). The depression also saw prices fall by 70% and rates by 75% from peak to trough with scrapping volumes rising significantly. The low rates could not allow a return to be made on a newbuilding even if it had been bought at cost.

In 1959 the US government imposed a quota on imports and the initiative of producing countries that led to the formation of OPEC.

1.1.2 The 1960s

In the early 1960s the growth rate of the fleet was restrained and with demand growing strongly, the market began to recover in 1963. This contributed to a significant improvement in the freight market balance. Most of the laid up ships were absorbed by this increase. By 1963 lay-up had fallen to 2%. As a result, rates began to oscillate around a higher level. Prices and shipbuilding responded positively while scrapping fell. The market benefited from the second closure of the Suez Canal in the summer of 1967. The closure of the Suez added about 75% to the Gulf North Europe voyage distance and immediately put a huge premium on the largest tanker sizes The following story demonstrates the effect the Suez canal closure had on shipowners profitability.

Hilmar Reksten, a Norwegian shipowner, had taken delivery of a new VLCC, and had spent days on the phone trying to secure a cargo. The market was completely flat, and he was unable to secure any work for the vessel. With no income to make the interest repayments, he knew the ship was no longer his, but the bank's. He left the office and started the lonely drive to the bank. As he drove his car through downtown Oslo, he turned on the radio, only to hear the extraordinary news that the Suez Canal had been closed. He quickly did a U-turn and raced back to the office. All the charterers who for days would not return calls or came up with extremely low counter-offers were suddenly trying to fix his newbuilding. The ship paid for itself in a few voyages. Therefore, by the end of the 1960s the market had become very tight and lay up was at a very low level. These high returns attracted more capital to the industry since more and more people wanted to be part of this highly profitable industry and banks were very eager to finance them.

One of the greatest attractions of the shipping industry to bankers in those days was the widely held view that inflation would protect and enhance ship values throughout their active life and therefore that the security represented by a first priority mortgage was of exceptionally high quality. It was a commonly heard view among bankers that you would always be able to sell a ship after 10 years for more than it would originally cost. With thinking of this kind, it did not take long for the old-established 50% rule of financing to be discarded. Initially, there was a move up to 80% financing, which did no more than match the terms which owners were able to obtain for newbuildings through the shipbuilders anyway. Banks coming into the market at that time did not have the background of prior shipping slumps against which to judge the security of their lending policies and the quality of much of the ship loan documentation in these days was alarmingly poor (Stokes 1997).

Also, in the late 1960s and early 1970s many banks started to cut margins at the same time as they were allowing the security cover for their loans to decrease. The 1.5 to 2% spreads that were a matter of course in the old days came under increasing pressure.

1.1.3 The 1970s

The 1967-73 phase was one of the most profitable of the whole post-war period. The fundamental factors that contributed to this were many. Most important of all was the extreme increase in the growth rate of demand for shipments. Indeed with the closure of the Suez Canal from 1967 to 1975, the growth rate in demand rose to record levels. Despite of full shipyard capacity utilisation and minimal scrapping tanker freights soared nearly to Worldscale 280. At such a rate a VLCC would make a profit of $5 million from one voyage lasting 70 days. The price of this ship in the early 70s would have been $30 million implying that the vessel could have been repaid in just 14 months. VLCCs reached $65 million in value while the orderbook expanded to a level which represented about 90% of the existing fleet! Paradoxically dry cargo deliveries as a percentage of the fleet had been on a downward trend ever since the closure of the Suez Canal in 1967 and the trend continued up to 1975, in spite of the strong market. This may be attributed to the fact that tankers under construction occupied most of the newbuilding berths. Between 1971 and 1976 tanker construction absorbed 52% of actual shipbuilding capacity.

In the early 70s, banks which were hungry for shipping business started offering 90 to 100 % financing and some deals were transacted in which the borrower actually received finance for more than the cost of the vessel. By the time of the final inrush of banks into ship finance in 1972-73 owners were expecting to be charged margins between 0.5 and 1%.

Investors were caught as OPEC unexpectedly raised the oil price in October 1973, which was the time when the tanker market and expectations were at their high peak. As oil price quadrupled the economic boom was suddenly over. The implications for the tanker market were catastrophic. A devastating drop in freight rates and ship values followed the massive 1973 orders and the stagnation of demand. Overnight VLCC values fell by $20 million. A 210,000 dwt VLCC that in 1973 would have been ordered for $47 million would be worth just $5 million in1977. In 1979 the market made a partial recovery as the higher bunker prices associated with the tripling of oil prices and other exogenous fleet inefficiencies led to a freight market shortage. However this short-lived boom was followed by a new depression which was even more severe than the previous one.

There were three problems that contributed to the depth of this recession:

- The oversupply of tankers resulting from the speculative investment in the early 1970s.
- Excess Shipyard capacity. It took a decade of over production to cut capacity to a level more in line with demand.
- The oil price rises in 1973 and 1979 dramatically reduced the demand for oil imports.

By the end of 1974 and early 1975, with financial strains on many tanker owners becoming critical complacency gave way to gloom and panic. Bankers came to realise the extent of the potential losses they could be facing on their tanker loans which were in most cases technically under-secured even if the owners were continuing to repay the principal and interest (Stokes 1997). Furthermore, the existence in the major shipbuilding countries of export credit agencies acting as guarantors or insurers of subsidised fixed interest loans for the majority of the delivered cost of newbuildings represented a distortion likely to encourage the construction of more vessels than actually required by the market. The availability of this credit often with additional commercial finance arranged through banks or trading houses connected with the shipyard, ensured that orders remained in place that would otherwise have been cancelled.

1976 and 1977 were the years in which large sections of the banking industry took a look at their shipping portfolios and decided to overhaul them. The result was a withdrawal of many banks from the market, partly because of a conscious decision to shut their doors on new business and partly because existing problems were monopolising their time. Most of the banks that took this attitude were the ones that had entered the market in the early 1970s in a spirit of misguided optimism. However, there were some banks with a long history in shipping finance, which also decided to exit the market when some relatively heavy losses started to be felt.

For those banks that continued to do business in 1976 and 1977 the rewards were considerable.

For bulk carriers however, the story was different. In 1974 the solid growth in demand and the phenomenal increase in bunker prices caused the already booming time charter rates to reach new peaks. Buoyant economic growth, a phase of stockbuilding in the world economy as a result of commodity price inflation and the heavy congestion in the Middle East and Nigeria resulting from the oil-led boom in these areas boosted this market.

However, demand in dry freight market decreased in 1975 and remained depressed until 1978. The stagnation of tanker demand was important for explaining this dry cargo depression. Some tankers ordered in 1973 were converted into bulk carriers thus increasing supply. The poor performance of the whole shipping industry was directly related to the stagnation and subsequent drop in tanker demand, which left the shipbuilding industry with no other alternative than to build other ship types even at a loss.

Between 1978 and 1980 however, dry bulk demand was growing faster than the fleet and absorbed a significant amount of surplus capacity. In 1979 fuel prices rose again and in combination with the tightening freight market caused rates to increase again. New ships were needed to satisfy the expected growth in demand. Values rose to a new post-war high and the orderbook expanded. Time charter rates more than trebled. There were many reasons for the strength of the recovery (Beenstock and Vergottis 1993):

- Trade in the major bulk commodities grew by 7.5 per cent in 1979, but supply increased by only 2.5 per cent due to the low ordering during the previous recession.
- On top of this came the knock on effect of the 1979 oil price increase. Power utilities around the world switched from oil to coal, giving a major boost to the thermal coal trade.
- This effect was reinforced by congestion. This was widespread in USA but particularly in the Middle East and West Africa where traditional port facilities could not cope with the flood of trade. Cases of ships waiting at the roads of the port of Lagos in Nigeria or in Indian ports were not uncommon at that time.

1.1.4 The 1980s

Tankers

Demand dropped for two consecutive years in 1982 and 1983. This depression was definitely the most severe in modern tanker history. Freight rates, profits, ship prices and shipbuilding hit all-time lows, while scrapping reached an all-time high. Values of VLCCs collapsed to scrap levels. Lay-up rose to 20% of the fleet with the real surplus being as much as 50% according to some estimates. The orderbook remained extremely depressed. Profitability in the freight market was persistently negative.

In 1986 OPEC allowed oil price to drop. These were the first signs of a recovery. Freight rates increased by 70% and VLCC prices doubled from 5 to 10 million USD. In 1989, when the market peaked, the same vessel was worth $38 million despite being three years older.

Bulk Carriers

Rates climbed further in 1980 and at the end of December were 50 per cent over the good average reached in 1979. Banks began competing on cut-throat terms for new Greek business, some of which subsequently turned out to be more costly then they anticipated. At the same time, increasing interest rates started having a devastating effect on shipowners. Shipowners found themselves having to service debt at an interest rate of 15% or more and suddenly began to view some of their commitments with alarm. The freight boom lasted until March 1981 when a sharp fall began. The daily earnings of a Panamax fell from $14,000 per day in January to $8,500 per day in December. 1982 brought a further halving of freight rates. In the time charter market a great number of time charters negotiated in the previous year had to be renegotiated to allow the charterers to survive and many charterers failed to meet their commitments altogether, which resulted in premature redeliveries and further difficulties for shipowners. The initial trigger of the problem was a US coal miners' strike that caused a decline in the Atlantic market (Stopford 1997). The more fundamental problem was the start of a severe recession in the world economy. A fall in commodity prices, a stagnant coal trade and elimination of congestion pushed rates down to levels that by 1983-84 some brokers were describing as the worst ever experienced. The slump in the dry bulk market which commenced in 1982 coming on top of the continuing tanker market depression, in fact heralded a period of extreme financial difficulty for large parts of the Hong Kong shipping community. While the 1970s were notable chiefly for the damage suffered by Norwegian shipowners, the 1980s saw no major shipping centre escape unscathed but Hong Kong certainly produced some of the most spectacular casualties like Wah Kwong and OOCL (Stokes 1997).

Despite the depressed freight rates in 1983-84 large numbers of orders were placed for bulk carriers. The whole process was initiated by Sanko steamship, a Japanese Shipping company, which secretly placed orders for 120 ships as it took its last chance to save itself from its creditors. Their example however was soon followed by a flood of orders from international shipowners particularly Greeks and Norwegians. These shipowners started ordering because they thought that due to its special relationships with the Japanese Government and trading houses, Sanko had good inside information on future market developments and was trying to corner the market by booking every shipbuilding capacity available. Therefore, they were afraid that had they not ordered they would have missed on the upcoming market boom. Unfortunately, when the Sanko deal was made known to the public and the company collapsed, many other shipowners found themselves having ordered ships at high prices that were being delivered to them in a very depressed market. This market could hardly help them to service their debt or even cover their daily operating costs. As a result many ships were arrested auctioned by banks at rock bottom prices.

However, apart from the Sanko deal, the explanation for this counter cyclical ordering is more complex. Shipowners had accumulated large cash reserves during the 1980 boom and banks that had large deposits of petrodollars were keen to lend more. Also, ships were cheap because the shipyards still had overcapacity and no tankers were being ordered. At the same time, the new generation of bulk carriers was much more fuel-efficient. Finally shipowners ordering in 1983 expected to take delivery in a market upswing. If so many owners had not had the same idea it would have been a successful strategy. Expectations that trade would improve were fulfilled. However the combination of heavy deliveries of bulk carrier newbuildings, many ordered speculatively in the previous two years, and the fact that the combined carrier fleet could find little employment in the tanker market ensured that the increase in rates was very limited. Many shipowners who had borrowed heavily to invest in newbuildings now faced acute financial problems. Bank foreclosures and distress sales were common.

In financial terms the market trough was reached in mid-1986 when a five-year old Panamax bulk carrier could be purchased for $6 million compared with a newbuilding price of $28 million in 1980.

As trade started to grow and scrapping increased, the dry bulk market moved into balance with freight rates in both markets reaching a peak in 1989-90.

Freight rates for a Panamax increased from $4,400 in 1986 to $13,200 per day in 1989. This stimulated one of the most profitable asset play markets in the history of the bulk carrier market. The five-year old Panamax, which sold for $6 million in 1986, was worth $12 million in 1987, $17 million in 1988 and $23 million in 1989.

The financial crises of the 1980s were more widely spread than those of the preceding decade and they have left a deeper impression on both shipping companies and credit providers. In all cases of bankruptcy companies suffered due to excessive debt-financed expansion, usually involving over-ordering of new tonnage. In some cases the debt was on the balance sheet, in others it took the form of heavy and long-term off-balance sheet liabilities. The end result was the same and so were the reasons; the persistence of surplus shipbuilding capacity and the excess availability of debt financing.

Overall, the 1980s were catastrophic for numerous shipping groups and their financiers but a slump of such severity also and inevitably created outstanding speculative opportunities for those able to exploit them.

1.1.5 The 1990s and early 2000s

After the 1989 peak, the tanker and bulk carrier markets developed very differently mainly due to the different attitudes of investors in the two markets.

In the tanker market the freight peak was accompanied by three years of heavy ordering from 1988 to 1991. This rush of investment was based on three expected developments in the tanker market:

- The fleet of ageing tankers built in the 1970s construction boom was expected to be scrapped at twenty years of age, creating heavy replacement demand in the mid-1990s.
- Shipbuilding capacity had shrunk so much in the 1980s that a shortage seemed likely when increasing newbuilding prices seemed to support this view. In 1986 a new VLCC had cost less than USD 40 million but by 1990 the price was over USD 90 million.
- New legislation. When the Exxon Valdez ran aground in Alaska, leaking 36,500 tonnes of crude oil into the pristine waters of Prince William Sound in March 1989, it was not by any means the most voluminous of the big tanker spills. But it was the wrong place for it to happen. The severe ecological damage made Washington not to feel obliged to canvass international consent before taking its own action. Consequently, one year after the Exxon Valdez incident, the Oil Pollution Act of 1990 (OPA 90) was approved by congress. Besides the fact that its double hull requirement added substantially to the cost of constructing compliant tankers, OPA 90 also imposed potentially unlimited liabilities on tanker operators unfortunate enough to be caught polluting. Perceived at the time as draconian and unfair, it prompted many shipowners — respectable companies and

rogues alike — to consider avoiding the US trades in the future or invest heavily in new double hull tankers.

- Growing oil demand was expected to be met from long haul Middle East exports, creating rapidly increasing demand for tankers, especially VLCCs.

As it turned out none of these expectations was realised. Most of the 1970s built tankers continued to trade beyond twenty years and Middle East exports stagnated as technical innovation allowed oil production from short haul sources to increase faster than expected.

Delivery of the tanker order book pushed the market into a recession which lasted from early 1992 to middle of 1995 when a recovery finally started and freight rates moved on to a steady improving path.

Conditions in the dry bulk market took the opposite path. Dry bulk freight rates peaked along with tankers in 1989, but over the three years 1988 to 1991 only a few bulk carriers were ordered. Therefore, when the world economy moved into recession in 1992 this tonnage was easily absorbed and after a brief dip dry bulk freight rates recovered, reaching a new peak in 1995. By this time five years of relatively strong earnings had triggered heavy investment in bulk carriers leading to a huge orderbook. As deliveries built up in 1996 the dry bulk market moved into recession.

However, the worst were still to come. Beginning in the middle of 1997, many Eat Asian economies including Indonesia, Korea, Malaysia and Thailand experienced a common set of economic events known collectively as the East Asian crisis (Stiglitz 2002). The macroeconomic phenomena that characterised this crisis were a devaluation of the currency exchange rate with the US dollar, a sharp expansion in the current account and a general contraction in economic production.

Dictated by the International Monetary Fund (IMF), contractionary fiscal and monetary policies combined with misguided financial policies led to massive economic downturns, cutting incomes, which reduced imports and led to huge trade surpluses, giving the countries the resources to pay back foreign creditors (Stiglitz 2002, p.108).

If one country's objective was to increase the size of reserves, then IMF's policy was a success. However, each country's imports were cut back, which is the same as other countries' exports being cut. From the neighbouring countries' perspectives, they could not care why exports were cut. What they saw was the consequence, a reduction of sales abroad. Thus the downturn was exported around the region. Only this time, there was not even the saving grace that as the downturn was exported, domestic economy was strengthened. As the downturn spread around the world, slower growth in the region led to a collapse in commodity prices, like oil and the collapse in those prices wrought havoc in oil-producing countries like Russia (Stiglitz 2002).

In 1998, Russia was deeply in debt and the higher interest rates that the East Asia crisis had provoked created an enormous additional strain. The whole system collapsed when oil prices fell. Due to recessions and depressions in Southeast Asia, which IMF policies had exacerbated, oil demand not only failed to expand as expected but actually contracted. The resulting imbalance between supply and demand of oil turned into a dramatic fall in crude oil prices (down over 40% in the first half of 1998 compared to the average prices of 1997). Oil is both a major export commodity and a source of government tax revenue for Russia, and the drop in prices had a predictably devastating effect. Given the exchange rate at the time and the fact that the price of oil was below the cost of extraction plus transportation of Russian oil, devaluation would be inevitable. The rubble crashed. By January 1999, the rubble had declined in real effective terms by more than 45% from its July 1998 level. The August 17 announcement precipitated a global financial crisis. Interest rates to emerging markets soared higher than they had been at the peak of the East Asian crisis. Even developing countries that had been pursuing sound economic policies found it impossible to raise funds. Brazil's recession deepened and eventually, it too faced a currency crisis. Argentina and other Latin American countries only gradually recovering from previous crises were again pushed nearer the brink. Ecuador and Colombia went into crisis, while in the US the New York Federal Reserve Bank engineered a private bailout of one of nation's largest Hedge Funds, Long Term Capital Management, since the Fed feared its failure could precipitate a global financial crisis (Stiglitz 2002).

All these had a devastating effect on both tanker and bulk carrier markets. Lack of demand led to a drop in commodity prices and subsequently in freight rates. Also, the large number of ships, particularly bulk carriers that were ordered in the booming years of 1995 and 1996 at a high price were being delivered thus creating an oversupply of ships that led to a substantial drop in ship prices. The situation was worsened by the fact that South Korea increased its shipbuilding capacity substantially and, in order to fill it, it was offering newbuilding prices that were much lower than any other country. The Korean shipyard competitiveness was further strengthened thanks to devaluation of the Korean Won against the dollar. As a result Koreans were able to quote prices for building ships that were higher in Korean won terms but lower in US dollar terms. Shipbuilding prices came under more pressure and many shipyards in other countries were forced out of business.

Bulk carriers started recovering first, along with improvements in world economy in late 1999 early 2000. For tankers, a low orderbook and an increase in oil price and trading further tightening the supply demand balance, led to the best freight market for thirty years. However, after the September 11 2001 attacks in the World Trade Center and the economic recession already evident since March 2001 when the dot.com bubble burst, both markets plummeted until the end of 2002. Thanks to an unprecedented growth of the Chinese economy, 2003 showed signs of recovery for the tanker market. However, the Chinese demand for raw materials especially iron ore was responsible for making 2003 one of the best years in history for bulk carriers. One-year time charter rates for Cape size vessels tripled from January to October and spot rates for iron ore shipments from Australia to China exceeded $100,000 per day. The market for bulk carriers peaked in March 2004 with ship prices of 15 year old Panamax bulk carriers exceeding that of a newbuilding one year ago and ships for prompt delivery being sold at double the price they were originally ordered. However, a market correction began happening in April 2004, when the Chinese Government decided to cool down the economy by restraining investment in steel mills and the opening of letters of credit. Nevertheless, the market was still at historic highs, and when these restrictions eased in July, the market continued to be strong.

1.2 First Observations on the Factors affecting Bulk Shipping

From this short historical analysis we can see that there are four distinct shipping markets, the freight, newbuilding, second-hand and scrap, with a fifth one, the ship finance market acting as a facilitator to ship investors.

Furthermore, we can draw some initial conclusions with respect to ship supply and demand. On the one hand, shipping is a derived demand meaning that it depends on the demand for seaborne trade. On the other hand Koopmans (1939) is the first to note the peculiar shape of the supply curve, which is depicted in figure 1.1. He distinguishes two situations in the supply of tankers, namely a case of full and of partial employment. The supply curve's elastic section indicates the possibility of rather flexible fleet reactions to demand changes. The steep section, however, demonstrates the limited possibilities to expand the fleet in the short run, when it is fully employed. According to Koopmans (1939) this particular shape of the supply function is key to understanding freight rate volatility. If the fleet is partially active, the demand curve intersects with the elastic section of the supply curve. This means that, in this case, demand fluctuations do not influence freight rates, because the fleet can easily accommodate such demand changes. However, if the whole fleet is actively trading, a demand increase cannot be met so easily by existing fleet. Consequently, freight rates increase. This is demonstrated in figure 1.2[2], which shows the high correlation (81.4%) between VLCC time charter rates and capacity utilisation. This non-linear shape of the short-term supply curve leads to non-symmetrical freight market cycles.

Insert Figures 1.1, 1.2 somewhere here

The freight market conditions affect ship prices. For instance, an increase in freight rates will increase asset profitability. As a result these assets will be much more sought after by investors who will be eager to pay owners high prices to get them. By the same token, when freight rates fall, these ships are no longer profitable. Consequently, there are not many people wishing to invest in ships and shipowners are eager to accept a lower price for their ships to make ends meet or due to forced sales imposed by the banks. Figure 1.3 shows the high correlation between timecharter rates and second-hand ship prices for a handy size bulk carrier

Insert Figure 1.3 somewhere here

On the other hand, for newbuilding ships there is a time lag between ordering and delivery of a ship. Koopmans (1939) is the first one to observe that the time lag in building new ships is the main reason for freight market developing cyclical tendencies. During high freight rates, people tend to order more ships since their earnings rise and they tend to be bullish about the future. Therefore, it is assumed that the higher the time charter rate, the higher the ships profitability and as a result, the more eager the shipowners are to invest in new ships with a positive effect on their prices. This way, timecharter rates also determine orderbook, since shipowners will be eager to build more ships of the ship size or type yielding the highest returns. The only problem, however, is that ships are ordered based on current market conditions but they are delivered with a time lag of two to three years. This means that upon delivery market conditions may have worsened. Therefore, an already depressed market will be further depressed from increasing oversupply due to the delivery of ships ordered during better times. As figures 1.4 and 1.5 show fleet development and orderbook as a percentage of the fleet are negatively correlated with timecharter rates and newbuilding prices respectively.

[2] All graphs presented in this chapter are based on data collected by the author from various sources. The data is not detrended. See chapter 2 on an analysis of the origin and the collection and construction methods of this data.

Insert Figures 1.4 and 1.5 somewhere here

Furthermore, shipyard capacity is negatively related to newbuilding prices. The higher the number of empty berths, a result of an aggressive expansion of shipyard capacity during periods of market booms, the more eager the shipyards are to fill them by offering discounts to shipowners, with negative effects on newbuilding prices.

Newbuilding and second-hand ship prices are also interrelated and highly and positively correlated as figure 1.6 shows. Second-hand and new ships are substitutes since an increase for example in the price of second-hand ship prices will lead to an increase in the demand for new ships. Moreover, since it is easy for shipowners to switch from second-hand ships to newbuildings, the demand is more elastic thus making these goods close substitutes. In other words, a freight rate increase will increase demand for ships with an immediate positive effect on second-hand ship values, which in effect will make shipowners more eager to order new ships thus pushing newbuilding prices up as well.

Another driving force connecting second-hand and newbuilding markets is speculation. Speculative orders of new ships take place only because either the buyer expects the value of the ship to increase in a relatively short period of time, ideally before the vessel's delivery date or because the seller tries to take advantage of a value increase of a ship he has recently ordered. A considerable body of literature in maritime economics focuses on asset play as the main way to earn supernormal profits in shipping (for example Norman 1982). Therefore, the shipowner/speculator continuously compares the price of a new ship with that of a second-hand. If second-hand prices increase substantially he will be eager to pay more for a newbuilding whereas if they decrease he will ask for a lower price from the shipyard.

Insert Figure 1.6 somewhere here

Also, shipowners will be less eager to send their ships to the scrapyard if the freight market is booming. As a result, the volume of ships sent for scrap will increase with adverse market conditions and decrease with booming freight rates.

Another important observation is that investment tends to increase with booming freight markets. As figure 1.7 shows, investment tends to follow an upward trend in a booming market as the year 2000 was for tankers and a downward trend during market troughs such as the one in 1998 and 1999.

Insert Figure 1.7 somewhere here

Finally, another important issue is the availability of capital to the shipping industry. Bank lending is the primary source of finance in shipping. In bank lending we can distinguish two types of banks. On the one hand there are the well-established ones in the sector who have been providing capital to the industry steadily for many decades and during both market peaks and troughs. On the other hand however, in periods of high freight rates and investment returns, other banks, indulged by the potential for high returns, tend to enter the industry and provide capital, normally at highly competitive terms. This availability of easy and cheap finance makes shipowners spoilt for choice. Therefore, during booming markets they manage to obtain lower spreads over LIBOR[3], higher gearing ratios, use older ships as collateral and achieve longer tenors. In their continuous search for new clients, these banks, usually inexperienced with market troughs, tend to be very generous and often make unwise deals. Therefore, when the market is cooling off, both freight rates and assets collapse and as a result shipowners cannot service their loans. Furthermore, due to lower asset prices, banks are not able to realise much of the initial investment if they foreclose on the ship. A number of distress sales lead to heavy losses for banks that are forced to leave the market, usually by closing their shipping desk. A good example is one of the most competitive ship finance markets, the Greek one. Based on data from Petrofin (2003) we can see from figure 1.8 that more banks tend to finance Greek shipping during market peaks while their number decreases with market troughs.

Insert Figure 1.8 somewhere here

1.3 An Introduction to Business Cycles

In the previous two sections we saw over the last fifty-five years how different variables and events affect the shipping markets and drive them to periods of contraction and expansion. Macroeconomists typically describe the macroeconomy in terms of an irregular pattern of expansion and contraction in economic activity around a trend growth path, where fluctuations around the trend such as the ones analysed in the previous two sections are referred to as business cycles. The macroeconomics literature is used to document how different stages of the business cycle—expansion, recession, lack of credit availability (credit crunch), and reliquification—reflect variations in investment and financial opportunities.

Figure 1.9 displays the stages of the typical business cycle. The remainder of this section describes how the investment and financing opportunity set varies over time as the shipping markets move through the cycle from expansion, to credit crunch, to recession, to reliquification, and on to the following expansion.

Insert Figure 1.9 somewhere here

1.3.1 Expansion

Expansions are uniquely characterized by high growth rates. The interaction of world economy as this is reflected through economic development figures or capital markets and shipping markets and the timing relationships of these interactions is reflected in ship utilisation levels, freight rates, investor returns, interacting waves of capital flows and the ordering of new ships. By the time shipping is a derived demand, an increase in demand for seaborne trade will have a positive effect on ship freight rates and, consequently the ship's profitability. This will have a positive effect on the value of ships. On the one hand their owners will be willing to sell them at a premium or if the ships are old to keep them for further trading rather than sending them for demolition. On the other hand, current players wishing to expand in a strong market and new players entering the market will be willing to pay such a premium. This positive sentiment, further fostered by the availability of ample and cheap finance, will make current and new players more willing to order new ships to satisfy

[3] LIBOR is the acronym of the London Inter-Bank Offered Rate, or the interest rate at which banks lend money one another.

current demand. This influx of orders puts the shipyard at favourable position to charge higher for a newbuilding contract. Consequently, newbuilding prices increase as well. The problem is however, that there is a lag between the time the ship is ordered and the time it is delivered. As a result, the market conditions may be substantially different from the ones under which the decision to invest in a new ship was taken. This leads to the next two stages of the cycle, credit crunch and recession.

1.3.2 Credit Availability and Credit Crunch

Eckstein and Sinai (1986) define a credit crunch to be a period of tight money and high real interest rates. Credit crunches occur around a cyclical peak in productive activity and span the later months of an expansion, as well as the early months of the ensuing recession.

Crunches arise from a combination of loan demand pressure and reduced supply of funds (Sinai, 1976). Speculative ship lending is the major source of such economic instability. This type of lending gives rise to bubbles (the soaring of prices as investors run and compete with each other to reap the gain from the seeming boom in the sector first); these bubbles always burst; and when they do, shipping markets crash. The pattern is familiar: As ship prices rise, banks feel they can lend more on the basis of the collateral; as investors see prices going up, they want to get in on the game before it is too late. Shipowners see quick profits by putting up newbuildings, until excess capacity results. The problem in this case is that markets can remain irrational longer than the shipowners can remain solvent. According to Keynes (1936) there cannot be liquidity for the community as a whole. The mistake is in thinking that markets have a duty to stay liquid or in other words that buyers will always be present with enough cash to accommodate sellers. If you are not in debt you cannot go broke and cannot be made to sell, in which case liquidity is irrelevant. But a leveraged firm may be forced to sell, while fast accumulating losses put it out of business. Leverage always gives rise to this same brutal dynamic and its dangers cannot be stressed too often. As a result shipping enters recession, the third stage of the cycle.

1.3.3 Recession

A recession covers the period beginning at a business cycle peak and continuing through the interval of absolute decline in the level of physical activity. As the decline begins, businesses curtail spending commitments and adjust inventories or, for shipping in particular, their fleet size. The size of the adjustments depends on the extent of revision in expectations during the period immediately preceding the peak and the forecast of the severity and length of the downturn. In contrast to an expansion, recessions are characterized by low growth rates. As a result, during recession, the shipowners cannot charter their ships, they default on their loans and the bubble bursts. All these are testimony to the risks posed by excessive market exuberance and the pervasive market failures that can arise in the presence of, among others, inadequate government regulation of financial institutions.

In economics, the kind of mistake that banks usually make during a recession by foreclosing on many loans today is called the fallacy of composition (Stiglitz 2002). When only one shipping company has a problem servicing its loan, then insisting on meeting its obligations makes sense. But when many or most banks are in trouble, that policy can be disastrous. If enough firms fail to repay their loans, banks may even collapse or abandon the market. A withdraw or collapse of even a single bank can have disastrous consequences. Financial institutions determine creditworthiness. When a bank goes out of business or retreats, much of the creditworthiness information it has on its borrowers is destroyed, and that information is expensive to recreate. When a bank goes out of business, many of its customers will have difficulty finding an alternative supplier of credit overnight. For small companies in particular, if the bank that the business relies upon fails, finding a new source of funds, especially during an economic downturn, may be nearly impossible. With a large number of banks out and with those managing to survive facing an increasingly large number of loans in distress, and unwilling to take in new customers, more businesses find themselves without access to credit. Without credit, the one glimmer of hope without a recovery is squashed.

1.3.4 Reliquification

Reliquification consists of the financial restructuring that occurs during a business cycle trough. A reliquification typically spans late recession and early recovery periods (Sinai, 1976), hence it is characterized by a low level of economic activity. After a recession begins, firms impose hiring freezes or layoffs, defer capital expenditures, stop ordering new ships and reduce inventories and their fleet size by sending the older units for demolition. As a result, cash inflows increase and financial position improves. In effect, during a reliquification, financial factors have an impact that is the reverse of their influence during credit crunch periods. Financial assets are accumulated and liabilities are reduced. For example, the *Wall Street Journal* (1991) describes reliquification, in the following terms:

"The retirement of debt may set the stage for an economic rebound because it frees up cash for companies to spend and puts them in position for another round of financings which can be plowed directly into capital spending. Indeed, in a disappointing year for the economy, the balance sheet progress of corporations is one of the few bright spots."

Finally, as monetary policy eases and the banking system's reserve position improves, interest rates fall and the stage is set for a new expansion.

The two business cycle stages that represent variation in the aggregate availability of investment opportunities can be characterized by time varying economic growth rates (high in an expansion, low in a recession), and the two business cycle stages that represent variation in the aggregate availability of financing opportunities can be characterized by time variation in the level of economic activity (high in a credit crunch, low in a reliquification).

A recession can be characterized as the absence of networks that make possible the efficiencies associated with high rates of economic growth. In the absence of these networks, it will be more difficult for a firm to capitalize on investment opportunities and, consequently, when these opportunities exist, they will be shorter-lived. Nevertheless, people who spot such opportunities, end up making supernormal profits when markets recover. Earnings provide information about a firm's ability to find profitable investment opportunities. Since it is easier to capitalize on investment opportunities in expansions, earnings will be more persistent in expansionary periods.

Within a business cycle context, Johnson (1999) considers the impact of a cost differential between internal and external funds on the cost of funding a given level of investment expenditures. When the cost of funds is constant across funding sources (i.e., there is no financing hierarchy), a change in the composition of funding sources has no impact on the total cost of financing a given level of investment expenditures. In contrast, when the marginal cost of an additional dollar of investment varies across funding sources, an increase in the pool of lower-cost internal funds allows the firm to substitute out of the higher cost sources, thereby reducing total cost.

In the former situation, the level of investment expenditures is unassociated with the funding source, while in the latter situation, there will be a positive association between the availability of internal funds and investment expenditures. More generally, the greater the cost differential between internal and external funds, the more sensitive investment expenditures will be to a change in the availability of internal funds. The cost differential between internal and external funds is greater during a credit crunch period than during a reliquification period (Johnson 1999).

Overall it can be said that market participants expect strong positive trends to continue uninterrupted disregarding the implications of cycles. Ultimately, however, the gravity of economic reality takes hold, and what went up comes down. Then market participants shift their orientation from the euphoric optimism of never-ending positive conditions to discouraged pessimism that the outlook is forever bleak, as indicated by the expectation of continuing negative performance. But in time, the markets slowly reverse and conditions improve. Parallel patterns apply to capital flows and the ordering of new ships. Although the logical sequence of steps that result in this disappointment can be readily comprehended on an after-the-fact basis, investors seldom consider that their optimistic expectations might be frustrated.

At the heart of all this discussion about shipping markets cyclicality and their determinants is the shipowner who has to optimise his investments both during a good and a bad market. Effective ship investment depends to a very large extent on understanding shipping cycles, transformation forces and structural changes. The essence of ship portfolio management is crafting strategies reflecting insights into and the appropriate differentiation between:

- The cyclic phenomena that may be expected to recur, albeit in perhaps different forms.
- Forces that transform the economic, political and technical environment of the shipping industry.
- Structural change that is both different from what has been before and also long-lived and profound in impact.

Differentiating market cycles, transformation forces and structural change from trends that may reflect a non-recurring, short-lived pattern of preference or activity is basic to shipping portfolio management. Effective shipping portfolio management is an ongoing process of monitoring markets to design investment strategies that distinguish between first-order change within the system and second-order change of the system. The challenge and opportunity are to translate market cycles and trends implications in the context of fundamental change that transforms vessel performance into operational models to forecast estimates of freight rates, capacity utilisation, operating expenses, discount rates and ultimately into calculations of present value and rates of return. Understanding and applying such understanding of ship cycles, change and trends is of utmost value to ship investors.

Comprehending the role of the ship cycle in devising investment strategies is facilitated by consideration of five critical interdependent forces that comprise the shipping market and move in cyclic patterns:

1. Economic structure determined by the emphasis and organisation of economic activity and resulting shipping capacity patterns.
2. Ship demand, defined by the desired amounts and type of ships to support the level of economic activity.
3. Ship supply, reflected by the amount of ships entering the market.
4. Capital flows expressed by investor preferences for ships relative to alternative investments and among different ship types, and investment positions.
5. Investment performance-measured by property returns, risks and value, resulting from the interaction of economic activity, ship supply and demand and capital flows.

1.4 Thesis Aim and Objectives

Although many, including previous researchers on shipping market analysis, believe that shipping cycles are composed solely of the interaction of ship supply and demand, prudent ship sale purchase or employment decisions cannot be made without considering the other three forces of economic structure, investment performance and capital flows.

Therefore the aim of this thesis is to provide an economic analysis of the determinants of bulk shipping markets and the implications for shipping investment and finance.

To achieve this aim, the following objectives have to be met:

- To provide an economic analysis of the major shipping markets (freight, newbuilding, second-hand and scrapping) in bulk shipping
- To identify the determinants of these markets.
- Based on these determinants to develop a theoretical model within a supply-demand framework that quantifies the effects these determinants have, if any, on the shipping markets.
- To apply and utilise modern econometric techniques for the estimation of the models so that statistical inferences can be safely made from them.
- To investigate whether these determinants have different effects on different ship types and sizes thus supporting the need for analysing bulk shipping markets at a desegregate rather than an aggregate level. To achieve this objective, the analysis will be made separately for all ship sizes of the tanker and dry bulk market.
- Based on the results, to analyse the policy and strategic implications for ship investors.
- To compare and contrast the results of the developed model to those of atheoretical models within the context of econometric business cycles research as these were first defined by Tinbergen (1959).
- To apply modern portfolio management techniques to investigate whether investing in a combination of assets reduces risk more effectively compared to an investment in a single market.
- To identify from all possible portfolio combinations the ones where risk reduction based on returns is possible.
- To analyse the integration and efficiency of the bulk shipping markets both in the short and the long-run.
- To try to assess and control Freight Risks in Bulk Shipping within a Value-at-Risk (VaR) and Conditional Value-at-Risk framework.

- To investigate whether ship investors can optimise their investment performance by utilising real option theory and in particular exotic options rather than the traditional discount cashflow model.

The thesis is structured as follows:

Chapter 2 provides the methodological analysis of the thesis, including data collection and analysis as well as problems experienced with data. Chapter 3 describes the econometric methods utilised for analysing the four shipping markets as well as the modelling strategy followed.

Chapter 4 provides an econometric analysis of the freight, both period and spot, market, Chapter 5 of newbuilding prices, Chapter 6 of second-hand ship prices and Chapter 7 of ship demolition prices. Chapter 8 is an investigation into the integration and efficiency of bulk shipping markets, combining modern portfolio theory and econometric techniques, Chapter 9 is an assessment of freight risks in bulk shipping within a Value-at-Risk, Conditional Value-at-Risk framework. Chapter 10 is an application of real option theory and exotic options in particular to different shipping projects in order to enhance financial decision making. Finally, Chapter 11 provides a summary of the thesis and its main conclusions.

1.5 Summary

This Chapter has set the scene by providing a historic analysis of bulk shipping markets over the last 55 years. From this analysis, four shipping markets (freight, newbuilding, second-hand and demolition) were distinguished as well as a fifth one (ship finance) that acts as a facilitator to the other four. Also, with the help of correlation analysis the factors influencing these markets were identified. After that it described how the investment and financing opportunity set varies over time as the shipping markets move through the cycle from expansion, to credit crunch, to recession, to reliquification, and on to the following expansion. The chapter then considered five critical interdependent forces (economic structure, ship supply and demand, capital flows expressed by investor preferences and investment performance) that comprise the shipping market and move in cyclic patterns. This way, it comprehended the role of the shipping cycle in devising investment strategies. Based on this analysis, the chapter ended by defining the thesis aim, objectives and structure.

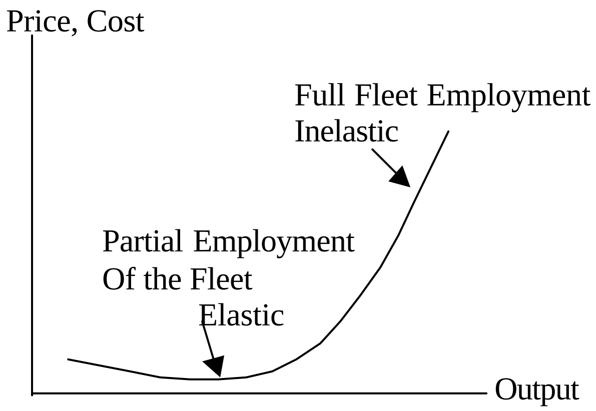
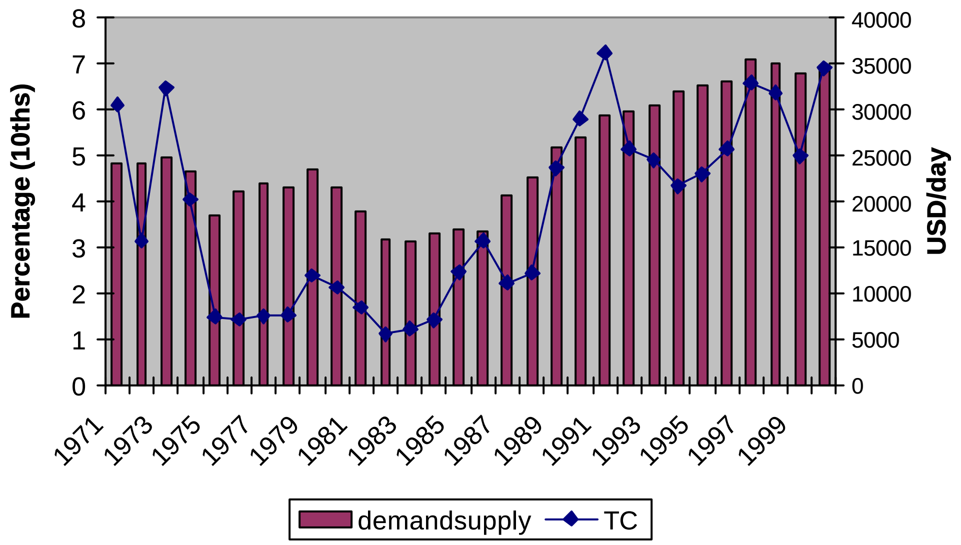


Figure 1.1: The Peculiar Shape of the Supply Curve

Figure 1.2:Correlation between VLCC Timecharter and Supply-Demand Utilisation Rate r=0.814



Source: Compiled by the author from various sources

Figure 1.3: Correlation between Handy Size Bulk Carrier Second-hand Prices and Time charter Rates r=0.908

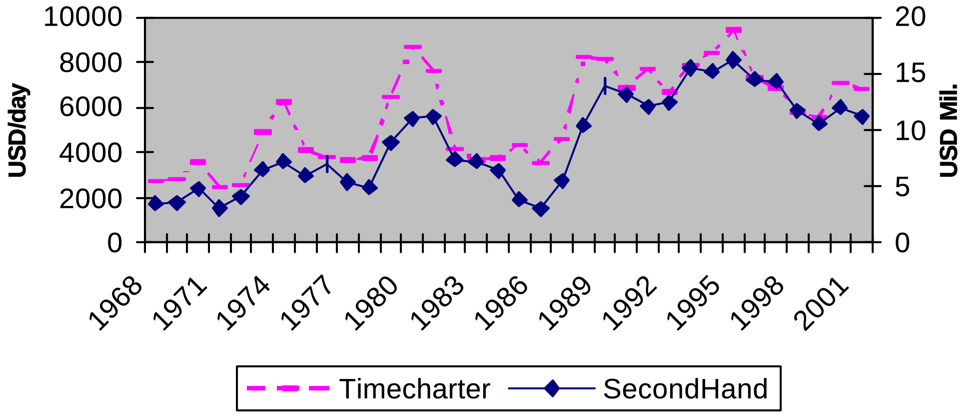


Figure 1.4: VLCC Time Charter Rates versus Fleet Development r=-0.5541

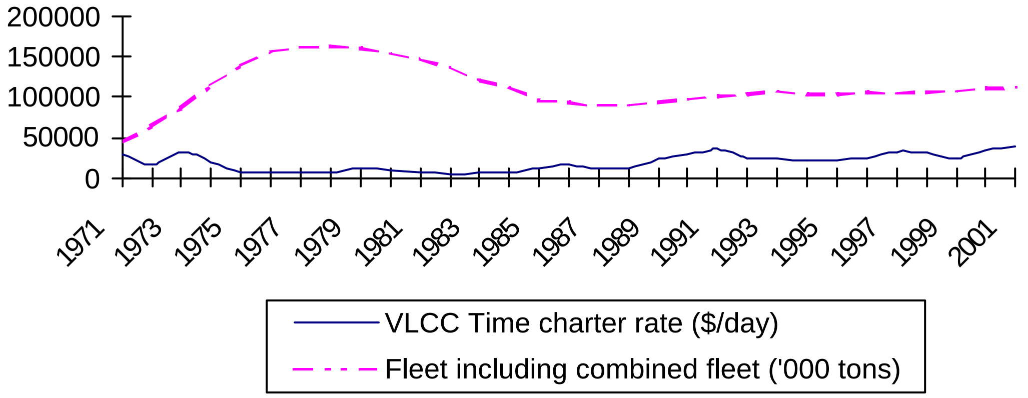


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Figure 1.5: Handy Bulk Carrier correlation between Newbuilding Prices and Orderbook as a percentage of the Fleet r=-0.7541

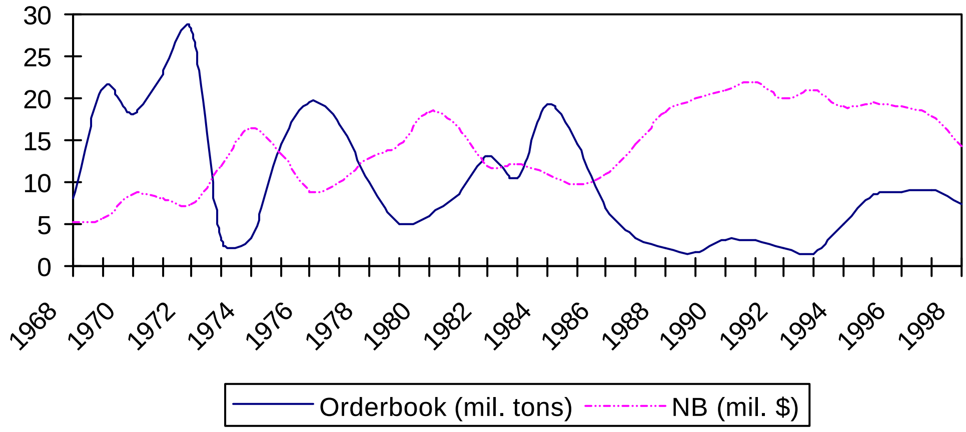

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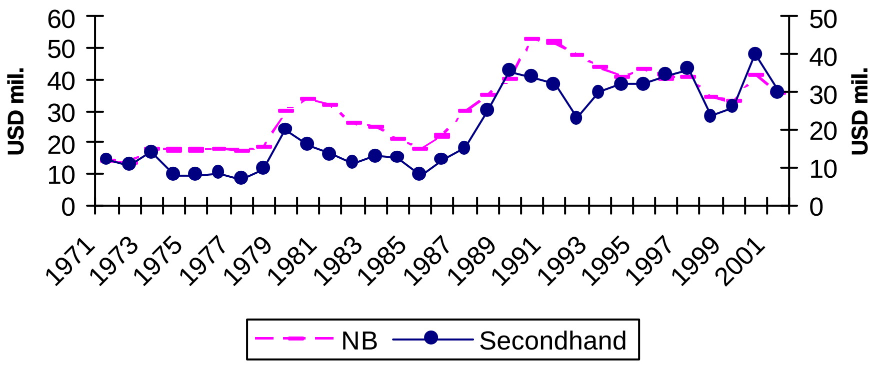
Figure 1.6: Aframax Newbuilding and Second-hand Prices r=0.91



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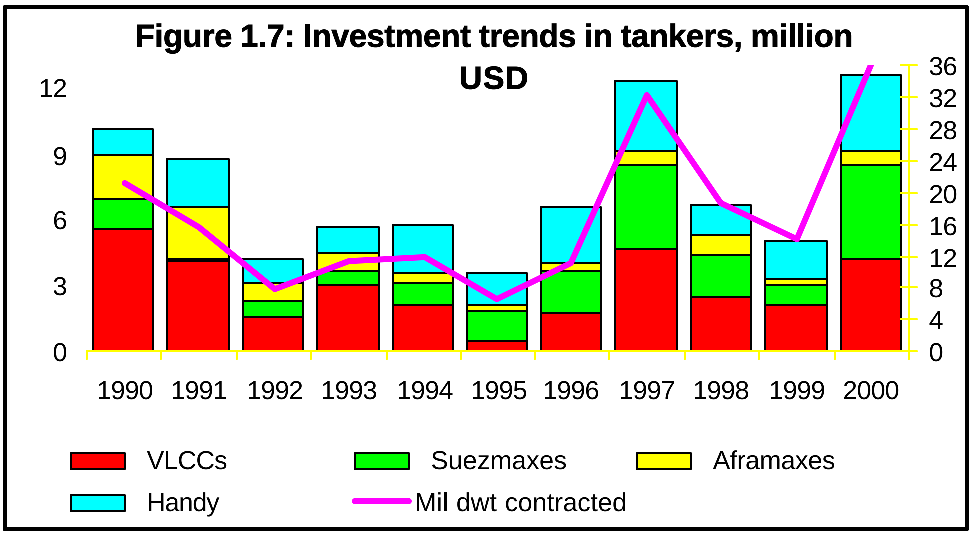
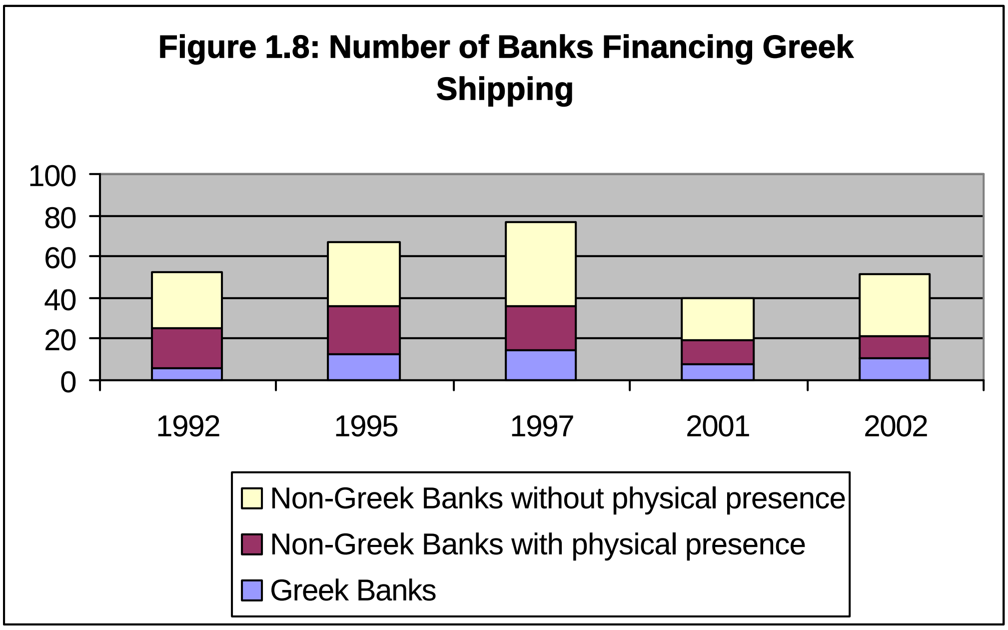


Source: Intertanko (2002)



Source: Petrofin 2003

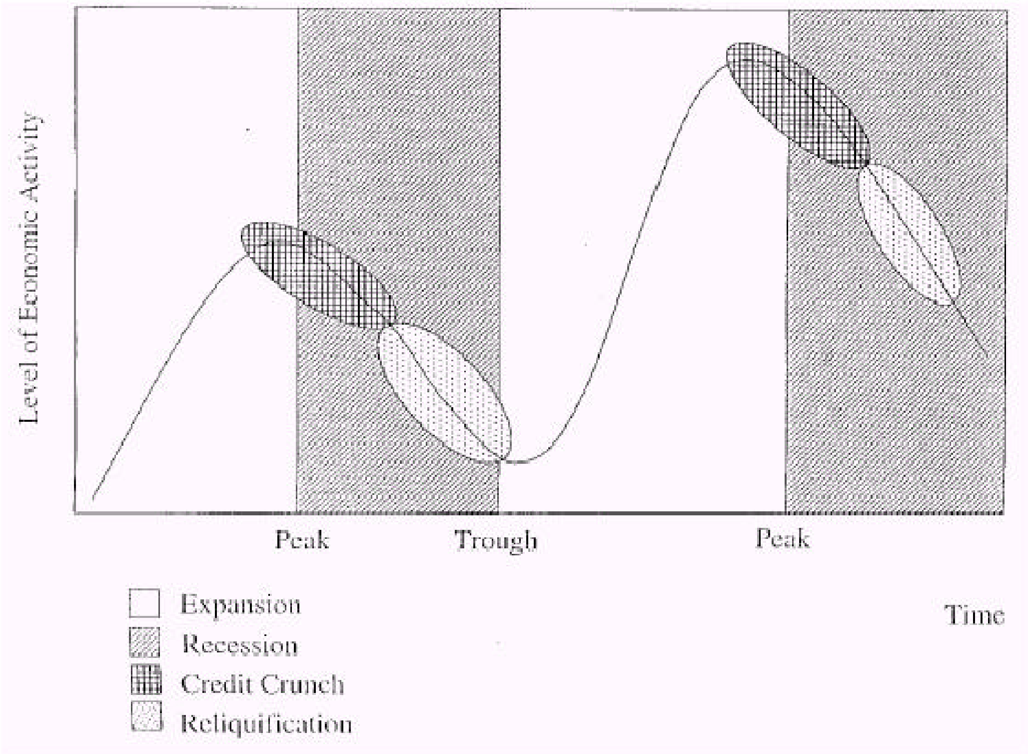


Figure 1.9: A Typical Business Cycle
Source: Johnson (1999)

Chapter 2: Methodology

2.1. Introduction

This chapter deals with the methods employed to achieve the thesis aim and objectives. In other words, it describes when the research began, which methods and why were employed and their limitations

Research began in March 2000, after the research topic was agreed with the two promotors and a broad aim was identified.

In order to achieve the original aim, it was decided as more beneficial to use both qualitative and quantitative methods so that a broader view of the subject would be obtained.

For convenience, the research methodology was divided into three phases. The first phase of the thesis methodology involved secondary research, the second phase involved primary research while the third one involved data compilation, conclusions and recommendations. All phases were subdivided into tasks.

2.2 Phase One: Secondary Research

Secondary Research involves the acquisition of adequate knowledge on the subject, identification of the dominant views regarding the concept, formation of the aim and the objectives.

Secondary research is regarded to be as valuable as primary data. The reason for this is that it is usually gathered using the same primary methods of data collection. The research for this project was carried out mainly in The Netherlands. The information used was provided mainly from shipping related textbooks and market analyses by leading shipbroking firms; several papers presented in conferences; and a variety of articles from different sources analyzing the topic. In addition to these some information was also attained from unpublished University theses of MSc and PhD level in which different aspects of the shipping markets had been analysed.

Phase one comprised two tasks:

2.2.1 Task One: Acquisition of general knowledge regarding the shipping markets

For task one, secondary sources were utilised to collect information on the reasons behind the cyclicality of the shipping markets, and the factors that cause them. In that way a broader understanding of the subject was achieved. Adequate knowledge and understanding of the bulk shipping market was an essential prerequisite in order to proceed with the thesis.

Erasmus and Delft University Libraries provided the information to complete the first task. Beenstock and Vergottis' (1993) Econometric Modelling of World Shipping and Albert Veenstra's (1999) Quantitative Analysis of Shipping Markets, provided a thorough analysis of previous research on the topic thus helping to get a better understanding of the industry as well as a great help in identifying areas for future, complementary research.

2.2.2 Task Two: Identification of the dominant views in bulk shipping markets. Formation of the thesis aim and objectives

In this second task, secondary resources were utilized to collect information on the reasons behind the constant oscillations of freight rates and ship prices. Once more, the Erasmus University Library provided the core information for the completion of this task. During this task the focus was on collecting topic related scientific papers, published in accredited scientific journals. Therefore, papers from researchers like Hawdon (1978), Di Jin (1993), Beenstock and Vergottis (1989), Glen (1990, 1997), Kavussanos (1996a, 1996b) Kavussanos et al. (2002a, 2002b, 2003) were collected and extensively reviewed.

This way, a better insight was gained regarding the dominant views in the world of academia with respect to the factors affecting bulk shipping markets, ship investment and the shipowners' financial decision making process. Furthermore, this task helped to establish lacunae in existing literature and areas where further investigation was necessary.

Finally, the archives of Lloyd's List, Lloyd's Shipping Economist and Tradewinds, along with market reports from the industry's major shipbroking and research firms provided an update on the current issues related to the topic as well as a better insight on the ideas and perceptions of the shipping professionals on it.

After these dominant views were identified, the thesis aim was formed. This aim would be tested through the use of primary research. To achieve this aim, the objectives described in chapter 1 were defined that had to be met first.

2.3 Phase Two: Primary Research

Phase two of the methodology involved primary research. Swetnam (1997) has identified eight different methods of primary research from which someone may choose the one most appropriate to his needs. These are the following:

- Evaluative research
- Correlational research
- Historical research
- Ethnographical research
- Action research
- Case study
- Experimental method
- Survey

After a careful and detailed accession of all the possible research methods available and after taking into account the aim and the objectives of the thesis, correlational research was chosen as a method of research for the parts of this thesis dealing with market analysis.

The limitations of the correlational research methods are recognised in the bias that seeks to isolate and measure narrowly defined variables. However, due to the aim of the thesis, which is to analyse economic relations between variables, it was selected as more suitable than for example the survey method whose limitation lies in the questioning and limited numbers of respondents interviewed can occur (Swetnam 1997). However, in the last two chapters of the thesis that deal primarily with financial decision making in shipping, it made more sense to present our case and arguments by utilising the case study research method.

Phase two (like in the case of phase one) was also divided into two tasks. In the first task research took the form of data collection while in the second that of interviews between the author and people from the shipping industry.

2.3.1 Task One: Data Collection and Analysis

Financial data on the three-month London Interbank Offered rate (3-month LIBOR), was obtained from Datastream International for the years 1960-2001. Commodity prices for oil and iron ore, coal and grain were obtained from ISL annual yearbooks. Steel Prices for roll-plates in Japan were obtained from World Steel Dynamics (2002). Prices of scrap steel were obtained from Kelly and Fenton (2001). Shipping related data (fleet, orderbook, newbuilding, second-hand, scrap prices, scrap volumes, time charter and freight rates) was collected from the annual reviews and the monthly reports of the major shipbroking houses including Clarksons, Fearnley's and SSY. The oldest review found was that of 1965 by Fearnley's including data dating back to 1960. In addition, scrap volumes were obtained from Lloyd's Register. The first step was to distinguish between ship types. Therefore for the bulk carrier market three ship types were distinguished: Handy (15-49,999dwt), Panamax (50-79,999dwt) and Capesize (80,000+) bulk carrier.

By the same token tankers were classified into Handy (15-49,999dwt), Panamax (50-79,999 dwt), Aframax (80-120,000 dwt), Suezmax (120-199,999dwt), and Very Large Crude Carriers (200,000+).

Based on data provided by shipbrokers, for every ship type a specific vessel was taken as benchmark: 30,000 dwt geared, 65,000 dwt and 120,000 dwt ships for bulk carriers and 30,000 dwt, 70,000 dwt, 105,000 dwt, 130,000 dwt and 280,000 dwt ships for the tanker market, all built in Japan. The exception is the tanker market, where from 1985 onwards, Korean built vessels are used. The reason is that Korean shipyards became more competitive price-wise due to massive investment, efficiency and quality improvement as well as due to the currency situation, which clearly disfavoured the Japanese Yen. As a result, prices quoted by Korean shipyards have become the industry’s benchmark.

The reason for this disaggregation is to investigate whether and to what extent the variables influencing second-hand vessel prices affect different ship sizes/segments. Beenstock (1985), Beenstock and Vergottis (1993) have developed models based on aggregate data. Glen (1990) however argues that the traditional assumption that the oil tanker market is homogeneous is no longer valid and it has been replaced by route and size differentiation. According to Glen (1990) size differentiation emerged because of the limited flexibility of the largest oil tankers due to increased supply and lower levels of port capacity growth thus creating severe constraints on port availability and hence route flexibility. Consequently, large vessels became riskier assets to own. This is also supported by the results reported by Kavussanos (1996b and 1997). These results make necessary the analysis of both the bulk carrier and the tanker market at a disaggregate level.

Due to the number of variables and the problems experienced with data collection, it was decided to use annual data for the estimates. Another reason for this decision was the nature of the demolition market. In the long run scrapping and deliveries determine the rate of fleet growth. Since the average economic life of a ship is about 25 years, only a small proportion of the fleet is scrapped each year, so the pace of adjustment to changes in the market is measured in years not months. This way fewer discrepancies with the data occurred and the results were more reliable, particularly for the earlier years where data is scarce and unreliable.

Another issue was the starting date of the observa tions. The 1960s were a time when new types of larger, purpose-built ships were coming on stream on a regular basis to satisfy the increasing demand for sea transport services deriving from the impressive increase in trade volumes. Thus the late 60s saw the introduction of VLCCs and Cape size bulk carriers. Despite the fact that data existed for some ship types from mid 50s it was decided that the starting point of this analysis would be 1968. This year was chosen because for the first time, the world fleet included vessels of all the different types that are analysed in this paper.

Additional information on how chapter-specific data was collected and analysed, is given on the methodological section of each chapter.

The combination carrier effects

Often reported separately from bulk carriers and tankers, combination carriers were developed in order to exploit trade imbalances and demand fluctuations. These vessels primarily offered the potential to maximise laden/ballast ratio and/or switch trades through their greater cargo carrying capabilities. A secondary advantage was the ability to re-position into other markets more easily than straight bulk vessels through carrying backhaul cargoes. They reached their peak in the 70s but their operation-related problems and charterers prejudice did not make them a success with shipowners who steadily abandoned this concept. The result was an ever-decreasing fleet, mainly comprised of old vessels since over the last years only a handful of this type of vessels has been ordered. Nevertheless, these ships pose some pressure, far less significant today than in the 70s, on the supply side of both the tanker and bulk carrier market. To cope with this issue, an investigation into the trade patterns of these ships, their spill between the oil and the dry bulk trades was necessary. Fearnleys and SSY (Jacobs for earlier years) Reviews from 1965 up to 2001 provided the necessary data. The combined carrier fleet and orderbook were divided between dry bulk and oil trades and distributed according to ship sizes based on data from Drewry. This way, a clearer picture of the real size of the fleet employed in both dry and oil trades was obtained and more accurate estimations of the fleet size could be made.

From the data obtained further variables such as the orderbook as a percentage of the total fleet were obtained.

Problems experienced with data

Data collecting proved to be the most time consuming and difficult task. This was not due to the lack of data information sources but due to the consistency and quality of the data itself. One of the major problems incurred during this research was the non-matching of the size class categories. Reported ship sizes change over time. Even when long data series were obtained from a single source, year on year changes with respect to size could be observed. This problem is more intense in the earlier years where not all class size categories were as well developed and well distinguished as today. For example in the early and mid 60s large tankers used to be described as anything above 80,000dwt, something that is certainly not the case today. Such things can create significant problems with the data series, particularly when someone benchmarks against today's size distributions. Take for example newbuilding prices. Until 1975, Fearnleys was reporting newbuilding values based on the prices quoted by European shipyards. From 1976 onwards, prices quoted by

Japanese shipyards became the benchmark. As a result, a price reduction of 10% compared to the previous year in the price of a newbuilding built in Japan may look as a 60% reduction if the price is compared to the 1975 price quoted by a European shipyard for the same ship. Therefore, in some cases, some adjustments had to be made by comparing Fearnleys quotations with that of other shipbroking houses such as Clarksons, and SSY.

Another problem is vessel classification. For example, vessels that some shipbroking houses regard as Aframaxes may be classified as Suezmaxes by others. Also, some shipbrokers may report in their orderbook figures only the deals that go through, whereas others may also include unexercised options. Furthermore, another problem, particularly with tanker vessels, is the inclusion of other ship types in fleet figures. Some for example may report tanker fleet figures including chemical carriers or others include combined carriers when they report the oil tanker orderbook.

In the bulk carrier market some people tend to further distinguishing between handy (up to 35,000dwt) and handymax (35-52,000 dwt), with the latter being in the same size category with some Panamax vessels, rather than sticking to the traditional handy, panamax, cape size classification as described above. However, this classification is flawed for the following reasons. The large handymax vessels, also called superhandymaxes that have been developed over the last four years, are hybrids that have the beam of a Panamax (32.26 m.) and the length of a handy vessel (180 to 190m). This is why many people tend to call them baby Panamaxes. However, for marketing purposes some owners or shipbrokers like to call them either Super Handymaxes or even Ultra Handymaxes. Furthermore, designs have improved over the last three years and these ships are designed to have higher capacity. Therefore, today someone can find ships like the Diamond 53' and 55' designs that are of 53 and 55000 dwt respectively and have replaced the diamond 51 series. Another series is the Tsuneishi built TESS 53, 56 and 58 of 53, 56 and 58000 dwt respectively. Finally, there is Oshima 555 series (55,500 dwt) and the latest Oshima 60,000 dwt design. Therefore, a standard handymax built after 2001 has a capacity between 53and 60000 dwt, with 55000 being the norm. Therefore, the proposed classification of a handymax bulker being between 35 and 52,000 dwt is inaccurate and outdated.

Furthermore, this increase in average handymax size creates another problem from the vessel classification point of view. This has to do with trading patterns. The smaller 35-50,000 dwt have got trading patterns similar to these of the handy size segment while the larger handymaxes in excess of 50,000 have almost identical trading patterns with Panamaxes (US Gulf-JPN 52,000 grain being the most obvious example as well as coal trades). Therefore, it can be said with confidence that a 35,000 dwt ship is different from a 60,000 dwt ship both size and trading pattern wise. Hence putting them together does not make much sense. After all in the 80s and early 90s the standard Panamax design was that of approximately 60-65,000 dwt, with only a few ships larger than 72,000 dwt. This means that if someone's data goes back more than five or ten years your fleet figures are mixed and inaccurate and may affect any estimation results. Therefore, from an analytical point of view it makes more sense and life easier to classify ships up to 49,999 dwt as handies and anything between 50 and 79,999 dwt as Panamaxes. This classification is employed in this thesis.

Such issues create significant discrepancies between the fleet data reported by various shipbroking houses. Therefore, someone has to be careful with such data to avoid discrepancies.

The situation regarding fleet related data became even worse after 1995. Nearly all shipbroking houses use Lloyd's Register to source fleet information.

However, in 1995 Lloyds Register changed the ship type classification for the World Merchant Fleet. This means that some ships previously regarded as bulk carriers are now classified as general cargo vessels. Consequently, fleet statistics pre and after 1995 are even more difficult to compare.

Finally, it is important to note the effect the special relations shipbrokers have with the major players in the market, namely the shipowners and the charterers. It may be the case for shipbrokers, for example in countries where shipowners are the dominant force, to overestimate timecharter rates and underestimate developments on the supply side of the fleet. By the same token, shipbrokers based in charterers' dominated territory, may underestimate timecharter rates and overestimate supply factors such as over-ordering or increasing deliveries.

Again additional information on chapter-specific data problems is given on the methodological section of each chapter.

Transformation into Logarithms

In this chapter time series were transformed by taking natural logarithms. Several reasons can be mentioned to justify this. The first one is that upon certain circumstances, taking logarithms may stabilise a non-stationary variance. Another is that an exponential trend in time series becomes linear after transformation, thus making it easier to analyse it in more detail. Finally, parameters in linear structural models with variables in logarithms can be interpreted as elasticities.

Dummy Variables

During the estimations it occurred that some observations could be considered as outliers. To overcome the problem that these observations had a large impact on the estimation results dummy variables were included in the models.

For all tanker segments dummy variables were used for the years 1971, 1973 and 1979 to make up for the effects on the freight market and subsequently on the second-hand market of unforeseen political events. These are the Tap line closure along with the restrictions on Libya oil production by the new regime in 1971, the Yom Kippur War followed by the first oil crisis in 1973 and the subsequent second oil crisis in 1979. For Bulk carriers dummies were used for 1985 and 1986. These were the years that the ships ordered by Sanko in 1983 were delivered. Sanko, a Japanese company, was facing tremendous financial problems due to the slump in the tanker market in the late 70s and the sharp market fall in the bulk sector in 1982. Instead of looking for a restructuring plan it went on to order secretly 125 handy size bulk carriers. Such behaviour was not justified by market conditions, since the market was showing no signs of recovery but it was due to the company's precarious economic situation and its desire to seek ways to avoid bankruptcy. Furthermore, during these years many banks decided to foreclose on many of the loans they had provided to shipowners in previous years. This caused a record number of ship auctions at very low prices, which had a distorting effect on the value of second-hand vessels.

2.3.2 Task Two: Interviews[1]

[1] The names of the people interviewed can be found in the acknowledgements.

The research for chapters four to seven also included interviews with people from the industry. The scope of the interviews was to obtain specific information regarding the economic analysis and econometric results in chapters four to seven.

These interviews were used both in the beginning in order to get a better insight into the industry and identify the most suitable variables for our models and as a follow-up process to the Ordinary Least Squares (OLS) estimates. It gave the opportunity to various people in the industry coming from different backgrounds to comment on the variables included in the model and the findings of the econometric analysis. This way additional arguments for or against including a variable in the model and further comments for the discussion of the estimates were obtained.

The reason interviews were used sometimes as a follow up process was due to some unexpected results produced by the estimates. Therefore, the interviews were used to check the validity of these results. If there was a valid explanation for such result from an otherwise sound model the estimates were kept. Otherwise the model was specified and estimated again. Therefore, the interviewing process that was used for chapters four to seven, tried to facilitate the possibility of gaining views and additional information which an econometric estimate would not have been capable of doing by itself. Interviewees included shipowners, shipbrokers, market analysts and bankers who were either interviewed face-to-face or via fax and telephone.

Correspondence to various connecting people was also possible, apart from face-to-face interview, via telephone, fax, and e-mail. In this way, people interviewed before or other people from the industry could be contacted whenever additional information or comments on a specific issue were needed. As a consequence, information was collected at low cost and in little time. In this way different views and opinions on the findings stimulated and enriched the discussion section. Speed was also a bonus as the results of phone interviews or e-mail conversations were available straight away without the delay that may be witnessed in, for example, a postal questionnaire.

At this point it is worth noting the input by Colin Cridland, current research director of Braemar-Seascope, whose pertinent and valuable comments, stemming from almost 30 years of market analysis, provided this thesis with a lot of added value. Colin was instrumental in the formation of many of the arguments of this thesis and made the most to breach the gap between academia and business so that this thesis combines the best of both worlds. The chapters on econometric modelling of new and second-hand ship prices are joint efforts that were presented in conferences around the world and found their way in transport journals.

2.4 Phase Three: Analysis

2.4.1 Task: Compilation of findings, discussion, conclusions, recommendations.

The last phase of the research involved firstly the compilation of the findings of both the econometric estimates and the interviews followed by their interpretation and analysis. The final part of the research involved the conclusions and recommendations that arose from the analysis of those findings.

2.5 Summary

This chapter has critically analysed the methods used in the collection of data and the interpretation of it. What needs to be seen now is whether the methods employed were successful in producing adequate findings. Before that however, the next chapter describes the modelling strategy and econometric methods utilised to obtain these results.

Chapter 3: Econometric Methods and Modelling Strategy[1]

3.1 Introduction

This chapter describes the econometric methods and the modelling strategy used in the analysis of the four shipping markets (freight, newbuilding, second-hand, demolition) in the four subsequent chapters. The quantitative methods and modelling strategies utilised in chapters 8 to 10 are analysed in the methodological part of each chapter.

3.2 Regression Analysis

Regression analysis is concerned with describing and evaluating the relationship between a given variable (usually called the dependent variable) and one or more other variables (usually known as the independent variable(s)). The most common method used to fit a line to the data is known as Ordinary Least Squares (OLS). In order to use OLS, we need a model which is linear in the parameters meaning that the parameters are not multiplied together, divided, squared or cubed etc.

The general form of a regression analysis that describes the relation between the dependent and k independent variables has the following form:

$$y = b_0 + b_1 \cdot x_1 + b_2 \cdot x_2 + ... + b_k \cdot x_k + e$$

where y is the dependent variable, x_1, x_2,….x_k are the independent ones, $ß_0$, $ß_1$, $ß_2$, $ß_k$ are the coefficients and e is the error variable.

Regression analysis allows us to use both interval and nominal independent variables. This is very helpful because in many problems the usage of nominal variables is crucial in order to describe the dependent variable. In order to insert nominal parameters to the equation, it is necessary to use indicator variables. The value of indicator or dummy variable varies between two integer numbers usually 0 and 1. One of the values represents the existence of a certain condition and the other indicates the absence of the same condition.

3.3 Results Evaluation

The interpretation starts by examining whether there is enough evidence to infer that there is a linear relationship between each independent parameter and the dependent one. Therefore, the following hypothesis is tested:

$H_0 : b_i = 0$

$H_1 : b_i \neq 0$

for i=1,2,3…k

[1] This section is based on Brooks (2001), *Introductory Econometrics for Finance*, Cambridge University Press, Cambridge, UK

The hypothesis is tested at a significance level usually equal to 5%. Therefore, for the coefficients that p-value is bigger than 5% the null hypothesis is satisfied and for the coefficients that p-value is less than 5% the alternative hypothesis is satisfied. If the null hypothesis is true then there is no linear relationship between y and that variable and if the alternative hypothesis is true then we can infer that a linear relationship exists.

The second parameter used for evaluating a model is the coefficient of determination or R^2. This statistic expresses the percentage of the variation of the dependent variable that is explained by the variation of the independent variables. R^2 unlike the coefficients of the potential predictors, does not have a critical value and therefore cannot be tested. As a general rule though, the higher the R^2 value the better the model fits the data.

In order for the results of the classical linear regression model (CLRM) to hold, we usually make the following set of assumptions about the unobservable error terms:

- The errors have zero mean
- The variance of the errors is constant and finite over all values of x_t
- The errors are statistically independent of one another
- No relationship between the error and corresponding variate
- The error term is normally distributed

The following section describes the problems resulting from the violation of any of these assumptions.

3.4 Problems resulting from the Violations of the Assumptions of the CLRM

3.4.1 Heteroscedasticity

If the errors do not have a constant variance, we say that they are heteroscedastic. Heteroscedasticity can be detected either by Graphical methods or Formal tests. One of the best tests for detecting heteroscedasticity is White's (White 1980) general test for heteroscedasticity.

With Heteroscedasticity present our standard errors are inappropriate and hence any inferences we make may be misleading. Whether the standard errors calculated using the usual formulae are too big or too small will depend upon the form of the heteroscedasticity. Engle's (1982) Auto Regressive Conditional Heteroscedasticity (ARCH) test carries out LaGrange Multiplier (LM) tests for ARCH in the residuals. Ignoring ARCH effects may result in loss of efficiency.

3.4.2 Autocorrelation

If there are patterns in the residuals from an estimated model, we say that they are autocorrelated. A cyclical residual plot indicates positive autocorrelation over time whereas negative autocorrelation is indicated by an alternating pattern where the residuals cross the time axis more frequently than if they were distributed randomly. What we would like to see however is no pattern in residuals at all.

The Durbin-Watson (DW) is a test for first order autocorrelation. However, there are some conditions, which must be fulfilled for DW to be a valid test:

- Constant term in regression
- Regressors are non-stochastic
- No lags of dependent variable

These conditions have made this test less popular today, since in most cases, especially when someone estimates variables in first differences, as is the case with this thesis, it becomes irrelevant. For this reason, another test namely the Breusch-Godfrey test (Breusch (1979), Godfrey (1978)), is employed. The consequences of ignoring autocorrelation is first of all that the coefficient estimates derived using OLS are still unbiased, but they are inefficient even in large sample sizes. Thus, if the standard error estimates are inappropriate, there exists the possibility that we could make the wrong inferences. Also, R^2 is likely to be inflated relative to its "correct" value for positively correlated residuals.

Finally, the Ljung-Box statistic (Ljung and Box (1978)) is very useful as a portmanteau (general) test of linear dependence in time series.

3.4.3 Multicollinearity

This problem occurs when the explanatory variables are very highly correlated with each other. In the case of perfect multicollinearity, it is not possible to estimate any of the coefficients. The problems if near multicollinearity is present but ignored are:

- R^2 will be high but the individual coefficients will have high standard errors.
- The regression becomes very sensitive to small changes in the specification.

As a consequence, confidence intervals for the parameters will be very wide, and significance tests might therefore give inappropriate conclusions. The easiest way to measure the extent of multicollinearity is simply to look at the matrix of correlations between the individual variables. Note that high correlation between y and one of the x's is not multicollinearity.

Some econometricians argue that multicollinearity should be ignored if the model is otherwise statistically adequate and in terms of each coefficient being of plausible magnitude and having an appropriate sign. In this thesis this argument is adopted and where the model is otherwise sound multicollinearity is ignored.

3.5 Statistical Distributions for Diagnostic Tests

In this thesis, an F- and a c^2- version of the above mentioned tests for CLRM violations are available. The F-test version involves estimating a restricted and an unrestricted version of a test regression and comparing the Residual Sum of Squares. The two tests are equivalent since the c^2 is a special case of the F-distribution. For small samples, the F-version is preferable.

3.6 The Exact Significance Level or *p*-value

The p-value gives the plausibility of the null hypothesis. For the purpose of this thesis the critical level for the p-value is 5% as standard practice.

3.7 Stationarity of Time Series

The problems described above stemming from CLRM violations originate from the fact that only non-stationary or both stationary and non-stationary variables are included in the same OLS equation. A stationary series can be defined as one with a constant mean, constant variance and constant autocovariances for each given lag. The model that has been frequently used to characterise non-stationary time series is the random walk model with drift:

$$y_t = \mu + y_{t-1} + u_t$$

The stationarity or not of a series can strongly influence its behaviour and properties. For example, persistence of shocks will be infinite for nonstationary series. Also, the use of non-stationary series can lead to spurious regressions. If two variables are trending over time, a regression of one on the other could have a high R^2 even if the two are totally unrelated. Furthermore, if the variables in the regression model are not stationary, then it can be proved that the standard assumptions for asymptotic analysis will not be valid. In other words, the usual "t-ratios" will not follow a t-distribution, so we cannot validly undertake hypothesis tests about the regression parameters. Therefore, before we start building a model, we must first test for stationarity of the time series.

The statistical methodologies used to test for stationarity were initiated by Dickey and Fuller (1979) and further improved upon by Dickey and Fuller (1981). The latest version of the unit root test, now referred to as the Augmented Dickey Fuller test is done by running a least squares regression on the following equation:

$$\Delta X = \mu_t + \delta_t + \beta_1 X_{T-1} + \beta_2 X_{T-1} + \ldots + \beta_\kappa \Delta X_{T-\kappa+1} + \varepsilon_T$$

$$where: \Delta X_T = (1-L)X_T \quad and \quad \Delta X_{T-\kappa} = (1-L)X_{T-\kappa}$$

The time trend μ_t and the constant δ_t, are included in our estimates to further secure that the residuals are white noise; κ is the number of lagged periods included in the analysis

If a non-stationary series, y_t must be differenced d times before it becomes stationary, then it is said to be integrated of order d. We write y_t ~I(d). So if y_t ~ I(d) then $\Delta^d y_t$~ I(0).

An I(0) series is a stationary series, whereas an I(1) series contains one unit root. An I(2) series contains two unit roots and so would require differencing twice to induce stationarity. The majority of economic, financial as well as shipping related series, as we find out later, contain a single unit root, although some are stationary.
Generally speaking, conventional results and tests in the classical normal regression model are valid only if all variables are I(0). If the variables are I(1) or higher or a mix of I(0) and I(1), the distributional theory is different and so the usual test statistics are no longer valid. This means that no inferences can be made from such models, since among others, most of the assumptions of the classic linear regression model are violated.

3.8 Dealing with the Unit Roots of the Variables. The Error Correction Model Approach

From the analysis of the shipping related variables that follows in the subsequent chapters, it is shown that they are a mixture of I(0) and I(1). This means that if a regression includes such a mixture, as is the case in Beenstock and Vergottis' (1993) work, no inferences can be made from the results since the distribution of t-statistics is not standard.

In order however not to lose the whole framework of regression based statistical inference, we need to deal with the unit root so that standard asymptotics apply again. One way to deal with the unit root is to filter the series so that the unit root is filtered out. Using the error correction or equilibrium correction model, a class of models that utilises a combination of first differenced and lagged levels of cointegrated variables can do this. Provided that the variables constituting the error term are cointegrated then the error term will be I(0) even though the constituents are I(1). It is thus valid to use Ordinary Least Squares (OLS) and standard procedures for statistical inference.

An error correction model has the following form (Brooks 2001):

$$\Delta y_t = \beta_1 \Delta x_t + \beta_2 (y_{t-1} - \gamma x_{t-1}) + u_t$$

where y_{t-1}-γx_{t-1} is known as the error correction term. The variables in lagged levels representing this error correction term must be cointegrated in the long run. This way, an error correction model is able to capture the effects the independent variables have on the dependent one both in the short (less than a year) and the long run (more than a year)[1].

In order to specify such a model, cointegration tests have to be performed so that cointegrating relations are found.

3.9 Cointegration: An Introduction

A group of non-stationary time series is cointegrated if there is a linear combination of them that is stationary; that is the combination does not have a stochastic trend. The linear combination is called the cointegrating equation. Its normal interpretation is as a long-run equilibrium relationship. This allows us to test whether the variables we have chosen to include in our model exhibit such relationships and, consequently, can be used together in the model.

This thesis employs the Johansen (1991) procedure for testing for cointegration among variables. Other less popular and powerful approaches include Engle and Granger (1987) and Engle and Yoo (1987)

The Johansen approach is a statistical method in which all cointegrating relations in a system of variables are found; these equilibrium relationships and the accompanying short-term relationships have to be identified from economic theory.

Since the series may have nonzero means and deterministic trends as well as stochastic trends, similarly, the cointegrating equations may have intercepts and deterministic trends. The asymptotic distribution of the Likelihood Ratio test statistic for cointegration does not have the usual distribution and depends on the assumptions made with respect to deterministic trends. Therefore, in order to carry out the test, assumptions shall be made based on the following five cases with respect to the trend underlying the data (EViews 2002):

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[1] the short run and the long run refer to less and more than a year respectively since our data is annual.

1. The level data have no deterministic trends and the cointegrating equations do not have intercepts:
2. The level data have no deterministic trends and the cointegrating equations have intercepts:
3. The level data have linear trends but the cointegrating equations have only intercepts:
4. The level data and the cointegrating equations have linear trends:
5. The level data have quadratic trends and the cointegrating equations have linear trends:

Cases 2 and 4 do not have the same set of deterministic terms in the two columns. For these two cases, some of the deterministic term is restricted to belong only in the cointegrating relation. For cases 3 and 5, the deterministic terms are common in the two columns and the decomposition of the deterministic effects inside and outside the cointegrating space is not uniquely identified.

In practice, cases 1 and 5 are rarely used. Case 1 is applicable only if all series have zero mean. Case 5 may provide a good fit in-sample but will produce implausible forecasts out-of-sample. As a rough guide, case 2 applies if none of the series appear to have a trend. For trending series, case 3 is more applicable if all trends are stochastic; if some of the series are trend stationary, case 4 is more appropriate. In this thesis, case 2 is used in chapter 5 and case 4 in chapters 4, 6 and 7.

A set of required long-run coefficient values or relationships between the coefficients does not necessarily imply that the cointegrating vectors have to be restricted. This is because any combination of cointegrating vectors is also a cointegrating vector. So it may be possible to combine the cointegrating vectors thus far obtained to provide a new one, or, in general, a new set, having the required properties.

For a detailed treatment of cointegration see Harris (1995) and Franses (2002).

3.10 Building ARMA Models - The Box Jenkins Approach

In chapters four to seven this thesis compares structural models with a-theoretical ARMA family ones, namely the autoregressive (AR), moving average (MA) and autoregressive moving average (ARMA), a few things have to be said on how these models are built. Box and Jenkins (1976) were the first to approach the task of estimating an ARMA model in a systematic manner. There are 3 steps to their approach:

1. Identification
2. Estimation
3. Model diagnostic checking

The first step involves determining the order of the model, the second parameter the estimation of the model either by least squares or maximum likelihood depending on the model while the last one is model checking.

The objective is to choose the number of parameters by minimising the information criterion. The information criteria vary according to how stiff the penalty term is. The two most popular criteria are Akaike's (1974) information criterion (AIC) and Schwarz's (1978) Bayesian information criterion (SBIC), In case the information criteria suggest different model orders then *SBIC* is strongly consistent but (inefficient) but *AIC* is not consistent, and will typically pick "bigger" models.

3.11 Comparison of Theoretical and Atheoretical models within an Econometric Business Cycle Research framework

In addition to estimating a theoretical error correction model, this thesis compares and contrasts this model to ARMA models within an Econometric Business Cycle Research (EBCR) framework (Jacobs 1998). EBCR combines economic theory and measurement of facts in the study of business cycles. It has four goals (Tinbergen 1959):

- To describe cycles.
- To forecast future developments.
- Policy evaluation
- Testing of economic business cycle theories.

For theoretical models, theory guides the specification of the econometric model by relating endogenous and exogenous variables. The model is estimated with observed or refined data. Theories of interest can be tested statistically while the model can be used to describe business cycles, to construct conditional forecasts and to evaluate policies.

ARMA family models on the other hand are data oriented. From pure or refined data a model is specified, in which endogenous variables are explained from their own lags. Estimation and forecasting are straightforward statistical exercises that do not require economic theory. Analysis of ARMA models can be done without economic theory knowledge. They can be used for describing cycles and forecasting without reliance on economic theory. However, analysis and policy evaluation without economic theory is impossible.

Both methods are capable of describing the past. Forecasting with an AR model is easy because little projections for exogenous variables are necessary. Predicting with theoretical models requires skilled model building. Compared to data oriented a-theoretical time series models, preparing forecasts with theoretical models has three advantages:

- The forecasts can be supported by economic arguments.
- The forecasts are based on a consistent accounting framework.
- The forecasts may involve large number of variables.

The limited number of variables that enter a typical ARMA model hampers the possibility for policy evaluation. Moreover, ARMA models only compute final effects of policy changes and therefore cannot disclose underlying contrary developments after a policy shock.

Therefore, theoretical models are the only vehicles for policy evaluation. Despite the Lucas critique (1976) a proper alternative still does not exist. Economic analysts/advisors believe that this type of models is a formal and quantitative framework that is irreplaceable adjunct to the processes of policy thought (Wallis and Whitney 1991).

3.12 Model Forecasting

A major issue is how we can test whether a forecast is accurate or not. Some of the most popular criteria for assessing the accuracy of time series forecasting techniques are the mean square error (MSE), the Mean Absolute Error (MAE) and the Mean absolute percentage error (MAPE).

3.13 The Thesis' Strategy and Approach for Building Econometric Models

Based on the above discussion, our objective is to build a statistically adequate empirical model which:

- Satisfies the assumptions of the Classical Linear regression model *(see p. 26)*
- Is parsimonious.
- Has the appropriate theoretical interpretation
- Has the right "shape" or in other words:
  - All signs on coefficients are "correct"
  - All sizes of coefficients are "correct"
  - Is capable of explaining the results of all competing models

The first step of our modelling approach is to form a "large" model with lots of variables on the right hand side. This is known as a GUM (generalised unrestricted model). Thereafter we need to take the following steps:

- Take logs
- Test for stationarity using the Augmented Dickey Fuller Test
- Make sure all variables in the model are I(0)
- Test for cointegrating relationships among the variables
- Construct an Error Correction Model by taking first differences and developing an error term based on possible combinations of cointegrating and non-stationary variables
- Once we have a model that satisfies the assumptions, estimate it and, if necessary, reparameterise the model by knocking out insignificant regressors.
- Test through various diagnostic tests whether any of the CLRM assumptions is violated.
- Interpret the results, test underlying economic theories
- Make forecast
- Develop AR(MA) models based on the Box Jenkins approach and by using the AIC and the BIC for lag determination.
- Make Forecasts and compare them to the ones of the Error Correction Model by comparing their MSE, MAE and MAPE
- Formulate strategies, analyse policy implications etc.

3.13 Summary

This chapter analysed the various econometric methods used in the subsequent chapters (especially chapters 4-7). It started by analysing the assumptions of the Classical Linear Regression Model and how these are violated, especially when the model is estimated from a combination of stationary and non-stationary variables. It then presented a number of tests for detecting such violations as well as defining the number of unit roots. After that it focused on developing a theoretical error correction model that caters for such problems. This model was then compared to atheoretical time-series models of the ARMA family, namely the autoregressive (AR), moving average (MA) and autoregressive moving average (ARMA) models. Comparison was made within an Econometric Business Cycle Research framework, as it was proposed by Tinbergen (1959). This was followed by a description of how forecasts are made with such models, while the chapter concluded by describing the modelling strategy followed in this thesis. Based on the modelling strategy developed above, the subsequent chapters analyse and interpret the results of the econometric models developed for each shipping market

Chapter 4: Econometric Modelling of Freight Market Rates

4.1 Introduction

The importance of the freight market for determining the level of economic activity in the shipping industry has attracted the interest of many researchers who have developed and estimated theoretical models that explain the behaviour of both spot and period freight rates. However, since these theoretical models were developed in the 30s the 70s and the 80s, they have not kept in pace with the developments in econometric tools and techniques. Over the last decade researchers have applied such techniques in shipping and the freight market in particular (see for example Veenstra (1999), Kavussanos (1996a, 1996b), but by employing a-theoretical models. This chapter develops an error correction model for both the spot and period rate market. Its most significant contribution is that by disaggregating into the different ship types according to size it finds that different variables have different effects on each type thus proving that each ship type has its own distinctive characteristics. Finally, it is the first effort on the topic that analyses, compares and contrasts both the tanker and the dry bulk market at the same time.

The chapter is divided into two parts. Part one is dealing with the analysis of spot freight rates, while part two analyses the period (timecharter) market. The chapter is structured as follows:

The next section provides a review of previous attempts to provide a model for freight rates, followed by methodology, model specification and the analysis of the results for spot rates. Part two analyses previous attempts to model the relationship between spot and time charter rates, provides a specification for a timecharter model and results analysis, followed by conclusions for both parts.

4.2 Part I: Spot Freight Rates

4.2.1 Previous attempts to model spot freight rates

This section analyses previous attempts to model freight rates based on time series analysis. It should be noted that another modelling approach is the hedonic cost function, which can be found in Shimojo(1979) or Oum and Waters (1996) and is based on panel or cross section data. However, an analysis of this approach is beyond the scope of this chapter since it deals with time series analysis. Nevertheless, for a thorough review on the topic see Veenstra (1999).

In one of the earliest econometric applications Tinbergen (1959) investigated the sensitivity of freight rates to changes in the level of demand on the one hand and the factors effecting the supply on the other. The latter include the fleet and the price of bunkers P_B, which at that time was coal. Other factors such as operating costs are also specified to influence rates but since these remain more or less unchanged during the cycle in relation to the other variables their effect is treated as a constant.

A number of decisions that had to be made to enable empirical estimation of the freight rate relation have become industry standards. One of these is the decision to take actual transported quantities as a measure for demand for shipping space. Another decision is that the demand figures are constructed by multiplying the quantities (tonnes) with average transported distance (miles). Therefore, demand is measured in ton-miles.

As in most market models, Tinbergen implicitly considers demand to be perfectly inelastic with respect to the freight rates. Supply on the other side responds positively to freight rates and will shift changes in the fleet size or fuel price. An increase in fleet size increases the supply of freight services. On the other hand an increase in the price of bunkers will cause supply at a given freight rate to contract as ships find that it is now more economical to slow steam while some vessels may even be laid up.

To facilitate comparison with other work, Beenstock and Vergottis (1993) have specified Tinbergen's model to be:

$$Q^S = f_1(FR, P_B, F)$$

Where:

Q^S= Supply

F = Fleet

P_B = price of bunkers (Fuel consumed by the engines of a ship)

FR = Freight rate

Where freight rates move in order to set demand equal to supply.

$$Q^D = Q^S$$

The two expressions imply that equilibrium freight rate can be written as a function of demand, fleet and bunker costs by substituting Eq.1 into Eq.2. The relationship can be written as:

$$FR= f_2 (F, Q^D, P_B)$$

thus depicting the relationship between equilibrium freight rates and the level of demand, the size of the fleet and bunker prices.

Later freight rate econometric models allow for a much richer set of instantaneous or lagged exogenous and endogenous influences. However, the basic forces generating the cyclical behaviour in such models are similar to those analysed by Tinbergen.

Koopmans (1939) investigated the behaviour of tanker freight rates. He is one of the first to note the peculiar shape of the supply curve in tanker shipping. He distinguishes two situations in the supply of tanker shipping:

1. A case of full fleet employment, where the supply curve is steep or inelastic.
2. A partial fleet employment with a flat or elastic curve.

At a very low freight level, supply is extremely elastic so its shape is almost horizontal while at a high freight level rate it becomes very inelastic taking up a vertical shape. When demand meets supply at the elastic region then even wide fluctuations in demand will have little impact on rates. On the other hand when the inelastic demand crosses the supply function at its inelastic region then even small fluctuations in transport requirements on the fleet size can lead to big rate changes (see graph 1.1).

Koopmans assumes that the ton-miles supply is directly proportional to the fleet size, while the supply and demand generated by a unit of capacity depends on the ratio of freight rates to an index of bunker prices and other operating costs. Taking into account that in equilibrium demand must equal supply, the following relationship between rates, fleet, demand and cost is specified:

$$Q^D = F\ (FR/\ P_B)^{\gamma}$$

This is similar to Tinbergen's first equation. The parameter γ is estimated from the data and is found to be equal to a value of about 0.15, suggesting that supply does indeed become very inelastic as lay up (the size of mothballed fleet) falls.

Hawdon's (1978) objective is to determine tanker freight rates in both the short and the long term. The short run model is represented in a single freight rate equation. The long run model is more extensive and includes a representation of the shipbuilding sector. Thus Hawdon's model consists of a freight, scrap and shipbuilding market. He estimates his model based on a collection of data spanning between 1950 and 1973.

Hawdon assumes that the demand for oil freight services is a function of total world trade in oil. Hawdon builds very much on Zannetos (1966) work. His freight rate equation is an extension of Zannetos' equation that according to Hawdon only relates voyage charter rates to be inverse of the lay-up rate. It has to be noted here however that this was not Zannetos intention who used this equation as part of his study of the supply curve rather than to model freight rates. Hawdon argues that a freight rate equation should take into account the relation between tank and dry bulk shipping. His equation includes the dry cargo freight level rates, the tanker newbuilding prices, the ship's payroll, an average ship size and various dummies.

His short-term freight rate determination equations are:

$$FR^t_t = f_3\ (FR^d_t,\ 1/F^t_t,\ q^t_t/F^t_t,\ P_{Bt},\ \text{dum}\ (1957))$$

$$FR^d_t = f_4\ (FR^t_t,\ 1/F^d_t,\ Q^d_t/F^d_t,\ P_{Bt},\ \text{dum}\ (1952,\ 1957,\ \text{Suez}))$$

Where:

FR^t, FR^d = The freight rates for tankers and dry bulk carriers
F = Fleet
^{t}, ^{d} = Superscripts indicating tanker and dry bulk respectively
P_{Bt} = Bunker costs
dum = Indicates dummies to compensate for extraordinary years(1952) and for the Suez Canal closure in 1957 and 1973

1/F, Q/F and P_{Bt}, are variables accounting for the combined influence of demand and supply on the freight rate. The dependent variables are taken in logarithms, which means that the equations have an exponential functional form. This way they are in line with the findings by Koopmans and Zannetos concerning the form of the supply curve.

This model for the tanker market takes into account the influence of the dry bulk market through the freight rate. In the period that Hawdon published this work, a new type of ship, the combined carrier, was gaining in popularity. This ship could be employed to carry both dry bulk and wet cargoes, thus forming an explicit link between the dry bulk and tanker markets. In addition, due to considerable overcapacity in the tanker market in the late 70s, tankers could be observed to carry large dry bulk consignments, especially grain. Hawdon however believes that the cross-over between the oil and dry bulk markets is of minor importance, supported by the low value of particular freight rate variables. Nevertheless, he acknowledges that tankers moving into the dry bulk market is an option for supply adjustment if tanker rates are low enough. This has perhaps persuaded him to introduce this variable in the model.

One of the problems in Tinbergen's, Koopmans and Hawdon's work is that none of them includes an explicit supply and demand framework, where their determinants are clearly separated. As a result, the freight rate equation includes determinants that combine supply and demand elements.

Another problem is that these early models concentrated on modelling supply in the freight market with little focus on the demand side. Norman (1979) who reports on an investigation into the relation between shipping demand and GNP measures in the OECD region draws his attention to this. It turns out that these aggregated measures of economic activity can explain variations in demand for shipping to a very large extent. Based on these findings Norman (1979) claims that shipping market analysis may include an analysis of the relation between freight rates and supply and demand, where aggregate indicators of economic activity connect shipping markets to the environments where their demand originates. This approach is taken in a number of models developed in Norway in the late 70s and early 80s such as Wergeland (1981) who estimated an aggregate model of the world dry bulk freight market (Norbulk). The model consists of a supply function identical to Tinbergen's as well as a demand for ton-miles function that is hypothesised to be related positively to the level of world trade and negatively to freight rates.

In Wergeland's model, the demand for freight is estimated to be very inelastic with respect to freight rates. The supply of freight services is also calculated to be fairly inelastic with respect to freight as well as to fuel prices.

A disadvantage of Wergeland's model is that the output of the voyage market model is a market average rate. This kind of output is too general for shipowners to be of practical use. Another disadvantage is the small number of observations he uses to estimate the model, something that hampers its reliability.

In Beenstock and Vergottis (1993), the freight market is characterised by a supply and demand framework for the voyage charter rate, like the one in Tinbergen. Demand for shipping services is explicitly assumed to be inelastic to freight rates. Beenstock and Vergottis also include the variables Q^D and F in the voyage charter equation(Q^D-F), to incorporate the supply and demand balance. This term reflects the theoretical supply elasticity of the fleet, that is unity.

In addition to the two equations describing voyage and time charter rate, the model contains a lay up equation, where the lay up rate depends on freight rates, costs and the average ship size. All variables are in logarithms. Therefore, the estimates can be directly interpreted as elasticities. The model is estimated by the use of a simultaneous equation estimation method (3SLS)

However, despite the fact that all these studies have a sound theoretical basis, their estimates are based on a combination of stationary and non-stationarity variables in the same equation, since their results are drawn from raw data in levels. Therefore most of the CLRM assumptions are violated resulting in either one or a mix of the following problems: autocorrelation, multicollinearity, heteroscedasticity. The effect is that no statistical inferences can be made from the results (see Chapter 3).

Zannetos (1966) observed that voyage charter rates follow a random walk model. Therefore, for Zannetos, the analysis of freight rates should give attention to the statistical process that governs the freight rate series. Furthermore, such analysis should not focus only on the freight rate but also include other variables. Even if freight rates behave as a random walk, their interaction with other variables will enable the modelling of their joint behaviour in a meaningful way. This characteristic of a set of time series is called co-integration (Veenstra 1999).

Recent studies by Kavussanos, Kavussanos et al. and Veenstra employ atheoretical models (Vector Autoregressive (VAR), Autoregressive Conditional Heteroscedasticity (ARCH), and Autoregressive (Integrated) Moving Average (AR(I)MA) models) that cater for such problems and produce reliable results.

4.2.2 Chapter's Contribution

By developing a theoretical (Error Correction) model for the shipping freight market, both for spot and time charter rates that gives reliable results from which economic inferences can be made confidently, this chapter aims at filling a gap in maritime economics literature. Furthermore, existing theories and models follow different approaches. These are summarised in table 4.1.

This thesis takes an integrated approach incorporating elements of all three different approaches (asset pricing, cost based and supply-demand). This way it develops a model that gives the whole picture with respect to the effects different variables have on the determination of spot and period freight rates.

Insert Table 4.1 somewhere here

Finally, this analysis disaggregates into different ship sizes and compares and contrasts the results in and among tanker and bulk carrier markets. This way, a better understanding of the different characteristics of the different bulk types and sizes is obtained.

4.2.3 Methodology

Variable Identification

Demand for shipping services can be expressed as a function of seaborne trade volume(T), freight rates (FR), commodity prices (CP) and political events.

$$Q_{FR}^{D} = f(T, FR, CP, political \quad events)$$

By the same token, supply of shipping services can be expressed as a function of fleet (F) and the price of bunkers, as the major component of voyage costs.

$$Q_{FR}^{S} = f(F, P_B)$$

Since

$$Q_{FR}^{D} = Q_{FR}^{S}$$

This function can be inverted to obtain an expression of the freight rate:

$$FR = f_5(\overset{+}{T}, \overset{+}{CP}, \overset{+}{P_B}, \overset{-}{F}, Pol.\overset{+/-}{Events})$$

Shipping is a derived demand, acting as a facilitator of world trade. Therefore, seaborne trade determines to a great extent the demand for shipping services. This means that the higher the increases in seaborne trade from period to period, the higher the demand for shipping services and as a result the higher the freight rate. Consequently, a positive sign is expected for this variable.

An indicator of economic activity is the price of major commodities since an increase in prices for commodities such as oil, iron ore, coal or grain will indicate a stronger demand for these commodities. Since most of them are produced or extracted in areas where their utility is lower than the areas where they are consumed, they have to be transported by ships. Consequently, an increase in demand for shipping services will occur followed by an increase in freight rates. As a result a positive sign is expected for this variable.

It has to be noted here that in many models other variables are used to indicate economic activity. Many models use GDP growth, while others commodity production levels. While both variables are good indicators of world state economy and affect trade levels, they suffer from serious shortcomings. Sources and data for these variables are constantly changing and need adjustments thus hampering their reliability. GDP levels for example are readjusted many times a year or even some years after their publication for a particular year. By the same token production levels may not be reliable since countries may have to understate or overstate their production of a commodity in order to serve their political and/or economic aims and objectives. An example is OPEC, where many members tend to produce more oil to increase money ending up in their treasury but have to understate the official quantity they produce so that they comply with the pre-agreed quotas on production posed by OPEC. In this case, using such a variable in our model may hamper our results since, while there may be an actual increase in the amount of oil produced and sold, the official figure used in our model may say the opposite. On the other hand however, commodity prices are determined by supply and demand balance in international trade and consequently, they depict the situation of world economy better, thus being more reliable indicators.

Justifying the use of two demand variables in the model

The reason we use two demand variables (seaborne trade and commodity prices) instead of one as it has been the practice in previous models has to do with the fact that commodity prices represent the demand stemming from economic activity whereas seaborne trade volume represents demand affected from other transport and route specific related factors, such as port congestion, strikes, terminal facilities, political or civil unrest (especially for oil) etc.. To justify our point we need to prove that there is no perfect linear relationship between the two variables. Therefore, in order to investigate whether seaborne trade volume is determined by commodity prices we developed an error correction model with trade volume the dependent and commodity prices the explanatory variables respectively. Results are reported in table 4.2. For tankers the models were found to have very low explanatory power (R^2 from 4 to 31%). Also only in Aframax and VLCCs were commodity prices found to have a statistically significant (and negative) effect on the determination of trade volume. However, even there R^2 was very low. For Panamax bulk carriers commodity prices were also found to have a statistically significant effect. However, R^2 was still extremely low at 19%. Only in cape size bulk carriers R^2 is high enough (70%) for the model to have any significant explanatory power.

This means that trade or route specific factors such as port congestion, labour strikes, port facilities, terminal productivity, weather effects, trade embargoes-restrictions, credit-financial facilitation, political and civil unrest affect much more the determination of seaborne trade volumes, especially the route specific ones, than commodity prices. As a result, the use of two demand variables, one depicting general economic conditions/demand (commodity prices) and the other route or trade specific conditions/demand (seaborne trade volume) are used in the model.

Insert Table 4.2 somewhere here

Of course, there are cases where commodity prices, most notably oil, are influenced by unforeseen events, such as wars, political instability or technical problems creating supply distortions. Such events can be depicted in our model as dummy variables and are expected to have either a positive or negative sign, depending on the situation. An example of the former is the Suez Canal closure in 1967 that increased average distance, thus ton-miles, thus demand for shipping services and resulted in some of the highest freight rates in history. An example of a negative effect has to do with demand limitations arising from embargoes such as the embargo of the Arab countries to Western ones supporting Israel after the October 1973 Yom-Kippur war. This embargo created a technical shortage of cargoes that had a devastating effect on tanker shipping.

An increase in freight rates, stemming from an increase in demand for shipping services, will make shipowners optimistic about the future. The most common reason behind this is that there are few ships chasing a lot of cargoes and as a result charterers are eager to pay more to get their services. This optimism, along with an increase in the value of their fleet that is highly profitable, makes shipowners eager to keep their old but profitable ships trading and avoid scrapping. Furthermore, they are eager to expand, either through second-hand vessel purchases, or by ordering new ships. At the same time, other investors are attracted by shipping's high profitability and enter the market either by second-hand vessels, or by ordering even more new ships. The medium to long run effect of this activity is a fleet increase.

However, due to the time it takes the shipyards to build and deliver the ships, about two to three years after contracting, these deliveries may occur at periods where world seaborne trade is stagnant, contracting or increasing at a slower pace than the fleet does. Consequently, a reverse situation than the one described before arises, where too many ships chase few cargoes. As a result, a fleet increase exceeding the increase in demand for shipping services will make freight rates fall. Freight rates will recover, only after demand can keep up with supply through a combination of increased scrapping activity that will remove older ships from the fleet and/or a recovery in demand for shipping services. Therefore, a negative sign is expected for the fleet variable.

Finally, a variable affecting freight rate levels is the level of voyage costs. Voyage costs include the price of bunkers, port disbursements, cargo handling, canal transits where applicable, as well as freight taxes and commissions paid to shipbrokers. Shipowners will compensate any increases in voyage costs with a higher freight rate. In many cases, a higher freight rate may reflect such an increase rather than higher profitability. In this case, ship bunkers are used as an indicator of voyage costs. The reason is that bunkers account for approximately 50% of voyage costs, in some cases even more and they are the most volatile of all voyage costs components. As a result a positive sign is expected for this variable.

Data Collection and Analysis

The following paragraphs analyse chapter specific data collection and analysis as well as problems experienced with such data. For information on how general shipping data was collected and analysed see chapter 2.

In chapter 2 it was argued that an analysis of both the bulk carrier and the tanker market differentiating into various sizes is required. Therefore, instead of focusing on a single index, the focus must shift on identifying the route that represents economic activity in a particular ship type/size the best way. The routes were chosen on the basis of trade volume, importance and data availability for each vessel size. A novelty of this thesis is that a number of brokers were contacted in order to provide the data. The reason is that such data is so scarce that there is not one broker that has route specific long series for all vessel types. For this reason, most of the data analysed below was provided upon confidentiality agreements. The following data was collected for both tankers and bulk carriers (data in parentheses indicate the cargo size and type, route and source):

- Panamax Bulk Carriers (52,000mt grain, US Gulf to Japan, Clarksons (2002))
- Cape Size Bulk Carrier (150,000mt iron ore, Tubarao (Brazil) to Rotterdam, Clarksons(2002))
- Handy Tankers (30,000, clean, Caribbean to US North of Cape Haterras, Worldscale, Worldscale Flat, Clarksons(2002))
- Panamax Tankers (50,000 dirty, Caribbean to US North of Cape Haterras, Worldscale, Worldscale Flat, Clarksons(2002)/Braemar Seascope (2002))
- Aframax Tankers (80,000 Cross Med. WS Drewry, WS Flat, SSY(2002), E.A. Gibsons(2002))
- Suezmax Tankers (120,000 West Africa to US, WS (Drewry(2002)), WS flat(SSY(2002)).
- VLCC (280,000 Arab Gulf to UK/Continent, WS, WS flat, Braemar Seascope(2002))

No broker was able to provide route specific data for Handy size bulk carriers. This has to do with the versatility of these vessels that allows them to trade in many different routes rather than having a steady trade. This constant change in their pattern of trade does not allow for long time series on a particular route to exist.

Collecting tanker freight rate data was the most challenging and difficult task. The reason is that while in bulk carriers, prices are quoted on a dollar per tonne basis, in tankers they are quoted in Worldscale rates. Worldscale is an abbreviation of the Worldwide tanker nominal freight scale. A function of Worldscale is to make fixtures in different trades and vessel sizes directly comparable. The original war time (1939-1945) ones were designed to give the same net return per day irrespective of the voyage performed and subsequent schedules seek a similar aim. However, such an aim can only be achieved absolutely only when a vessel corresponding to the standard vessel at WS100 incurring the same expenses is taken into account.

The fact that Worldscale is a cost based schedule means that it is re-calculated on an annual basis for a full cargo for the standard vessel based upon a round voyage from loading port to discharging port and return. This simply means that when changes occur in the bunker prices, the port dues or the exchange rate of the currency of the States included in this route, WS100 for this year will be different in dollar terms than WS100 for the same route the previous year.

Consequently, as graph 4.1 shows discrepancies will occur between the WS and the actual rates obtained by the vessels over the years thus distorting the final results.

Insert Graph 4.1 somewhere here

Furthermore, while in Worldscale terms one year may look better than another, a different story may appear if the Worldscale flat rate (WS100) is adjusted for increases in voyage costs. In this case, as graph 4.2 shows, while the WS rate may be higher, the actual dollar per tonne rate may be lower, thus depicting worse rather than improving market conditions. For this reason it was decided that dollar per tonne rates are a more reliable indicator than Worldscale rates and all worldscale rates collected were converted into dollars per tonne.

Insert Graph 4.2 somewhere here

This was done the following way: All worldscale rates were multiplied by the Worldscale flat rate for every year and for every particular route. This way, the dollars per tonne equivalent was obtained. Nevertheless, another problem needing adjustment was that until 1989 all WS flat rates were quoted in long rather than metric tonnes. Therefore, in order to be consistent and accurate, the dollars per ton until 1989, were converted into dollars per metric tonne by multiplying them by 1.0161, which is the ton (2240 lb) to metric tonne (2204,6 lb) ratio.

In other words:

$$USD/tonne = W_R \times (W_F \times \frac{L_T}{M_T})$$

where:

W_R = The Worldscale rate for a year
W_F = The Worldscale Flat rate for a year
L_T = The Long Ton
M_T = The Metric Tonne

The price of bunkers as an indicator of voyage costs was obtained from Clarksons based on the price of International Fuel Oil (IFO) in Rotterdam. The reason is that Rotterdam is the world's major bunkering port with the longest data series available. Commodity prices for oil and iron ore, coal and grain were obtained from ISL annual yearbooks. Fleet data was provided by Braemar Seascope (2002).

Seaborne trade volume data was obtained from Fearnley's World Bulk Trades. The challenge and the novelty here was that instead of focusing on total volumes as previous researchers had done, we focused on the actual amount of the major commodities each ship type and size carried. This way a more accurate determination of the effect developments on seaborne trade have on each ship type and size could be obtained due to better and more specific data than by basing our results on aggregate data. The only exception is oil products, which are mostly carried by Handy tankers and no desegregated data exists. However, since we used freight rates for oil products only for Handy tankers, the oil products trade as an aggregate figure was used for this vessel size.

As a result, seaborne trade volumes for grain, iron ore, coal and grain were obtained both in total and for each major exporting area. After that, and based on Fearnley's estimates, all these figures were multiplied by the percentage of trade that was carried by each ship size. This way, annual trade volumes for each major commodity and total trade were obtained per ship type and size both in total and by exporting area.

Finally, dummy variables were used for oil tanker estimations for the two oil crises in 1973 and 1979.

4.2.4 Model Specification

From the previous section we saw that the main determinants of freight rates, our dependent variables are commodity prices, volume of trade, fleet size, bunker prices and political events. The series of all these variables for both tankers and bulk carriers in natural logarithms are plotted in graph 4.3. From these it is clear that almost all series are nonstationary although their order of integration is less clearcut. The exact order of integration can be determined by performing a sequence of unit root tests, in this case the Augmented Dickey Fuller unit root tests.

Insert Graph 4.3 somewhere here.
Testing for a Unit Root

The Augmented Dickey Fuller Test was applied in order to test for a unit root in shipping related variables. An analysis on the number of lags we chose as well as the reasons for including both a trend and an intercept in our estimates are given in Chapter 3 and table 4.3.

Insert table 4.3 somewhere here

The results in table 4.3 indicate that log-levels of most variables are non-stationary, while their log-first differences are stationary. This suggests that these variables are in fact integrated of first order, I(1). The exceptions are the price of grain and the trade volume for Panamax bulk carriers and Handy tankers, which are stationary I(0).

From the analysis of the shipping related variables above it is shown that they are a mixture of I(0) and I(1). This means that if a regression includes such a mixture, as is the case in Beenstock and Vergottis', Norship, Tinbergen's and Hawdon's work, no inferences can be made from the results (see chapter 3 for a discussion on the topic).

In order however not to lose the whole framework of regression-based statistical inference, we need to deal with the unit root so that standard asymptotics do apply again. One way to deal with the unit root is to filter the series so that the unit root is filtered out. One way to do this is to use a class of models that can overcome this problem by using a combination of first differenced and lagged levels of cointegrated variables. This model is known as the error correction model or an equilibrium correction model and was extensively discussed in Chapter 3.

A simple version of the error correction model looks like:

$$\Delta y_t = \beta_1 \Delta x_t + \beta_2 (y_{t-1} - \gamma x_{t-1}) + u_t$$

where $y_{t-1}-\gamma x_{t-1}$ is known as the error correction term.

In our case the model looks like:

$$\Delta \ln FR_t = \alpha_1 + \alpha_2 \Delta \ln P_{Bt} + \alpha_3 \Delta \ln CP_t + \alpha_4 \Delta \ln Trade_t + \alpha_5 \Delta \ln Fleet_t + \alpha_6 DUMMY_{Pol}$$
$$+ \alpha_7 (\ln FR_{t-1} - \ln P_{bt-1} - \ln CP_{t-1} - \ln Trade_{t-1} - \ln Fleet_{t-1})$$

In order to specify such a model cointegration tests have to be performed so that cointegrating relations are found. It has to be noted here that an assumption is made that only one cointegrating relationship exists between the variables with the spot freight rate being the dependent one. This thesis will not analyse whether more than one cointegrating relationship exist between the variables, and especially between variables that do not include the dependent one since it is beyond its scope.

Testing for Cointegration

To test for cointegration the Johansen (1991) approach was taken. Since, based on graph 4.3 most of the variables display trending patterns, the following version of the Johansen approach, corresponding with Option 4 in the relevant routine in EViews, was estimated[1]:

$$\Delta_1 \ln Y_t = \mu_0 + \alpha(\beta' Y_{t-1} - \mu_1 - \delta_1 t) + \varepsilon_t$$
$$where:$$
$$Y_t = \begin{pmatrix} \ln FR_t \\ \ln P_{Bt} \\ \ln Fleet_t \\ \ln CP_t \\ \ln Trade_t \end{pmatrix}$$

Where α and β' are *(m X r)* full rank matrices, the first one *(α)* of the adjustment factors while the second one (β') of the cointegrating vectors *lnFR*, *lnCP, lnP_b, lnTrade, lnFleet*. This model also allows the individual time series to have trends by not restricting μ_0 to zero, while the cointegrating relations attain their equilibrium values at $\mu_1+\delta_1 t$. Based on this approach, it was found that for all ship types there is at least one cointegrating relation in our models. What is reported in table 4.4 for every ship type rejects the hypothesis that there is no cointegration among our variables at 5% level. Where applicable, different combinations of cointegrated variables based on theory and the robustness of the model (based on diagnostic tests), were used as error terms in our model according to the characteristics of each ship type. The various combinations of the cointegrating variables are also reported in table 4.4

Insert Table 4.4 somewhere here

4.2.5 Output of estimations and test results

The output of estimations and test results contain the following statistics:

- The parameter values

[1] For a discussion on Cointegration see Chapter 3 p. 32-35.

- The standard error of estimate with the corresponding t-values.
- The coefficient of determination (R^2),
- The adjusted R-squared
- The Durbin-Watson statistic (DW)
- The standard error of regression.

Results were estimated with OLS by using the statistical package EViews 4.0.

Diagnostic Tests

In order to test whether inferences can be made from the model, the following tests were performed:

- White (1980) and ARCH (Engle 1982) tests for heteroscedasticity.
- Ljung-Box (Ljung and Box 1978) Q Statistic and Breusch-Godfrey (Breusch 1979, Godfrey 1978) tests for autocorrelation.

The results are summarised in table 4.6 and indicate that neither autocorrelation nor Heteroscedasticity exists. Therefore our OLS estimation is consistent or maximum likelihood.

4.2.6 Model Results

The results for all ship types and reports on the standard errors, t-statistics, R-squared, adjusted R-squared and the Durbin Watson statistic are summarised in table 4.5. In all models R^2 is high and ranges from 0.76 (Aframaxes) to 0.85 (Handy tankers) with the rest ranging between 0.79 and 0.82. The fit of all equations is good as indicated by the SE of regressions ranging from 0.13 to 0.219.

Bulk Carrier Results

Commodity price, the price of iron ore, was found statistically significant for both Panamax and Cape size bulk carriers in the short run. A 10% increase in the price of iron ore will make freight rates increase by about 28%. For Panamax bulk carriers, iron ore price is significant also in the long run. A 10% increase in the price of iron ore in a period will make freight rates increase by 11.6% the following period in order to reach equilibrium. The reason for this difference may be that Capes rely more on iron ore than Panamaxes that are more versatile and can also carry coal and grain. Therefore, freight rate reaction to iron ore price increases is not as instant in Panamaxes than in Capes.

Fleet changes are also significant for both ship types. For Capes, fleet changes are significant in the long run, while for Panamaxes in the short run. A 10% change in Panamax vessel fleet size will make freight rates fall by 18.2%. By the same token, a 10% increase in the size of Cape size vessel fleet in one year will make freight rates fall by 18.5% the next year to reach equilibrium. A reason for this difference may be that most Cape sizes operate under long-term time charters or contracts of affreightment compared to the more spot oriented Panamaxes. As a result, fleet changes in the former will take some time to have an effect, whereas in the later the effect will be almost instant.

Bunker prices as an indicator of voyage costs is significant only for Panamaxes. The reason for this is distance, since the Panamax route under investigation (US Gulf to Japan) is much longer than Tubarao to Rotterdam.

Changes in seaborne trade volume in the long run were found to have the greatest effect on changes in Cape size freight rates. A 10% increase in seaborne trade volume of iron ore from Brazil in one year will make freight rates increase by almost 29% the following year. Volume of trade of grain from the US was not found significant in the determination of Panamax freight rates. This may be due to the fact that trade volumes in this particular route have been rather stable over the years without significant volatility. On the other hand, the effect trade volume has on Panamax bulk carrier freight rate determination is reflected on the effect fluctuations in commodity prices have, since a price increase will be mainly created by higher demand for the commodity, thus higher trade volume.

Tanker Results

Trade volume is significant for all ships carrying crude oil in the long run, while for handy tankers that carry oil products in the short run. Political/unforeseen events seem to have a significant effect in all sectors. Bunker prices are significant in the long run only for large tankers (VLCCs and Suezmaxes). This is attributed to the fact that these ships travel longer distances than smaller tankers. Consequently, their income's reliance on voyage costs fluctuations is greater. Fleet changes are significant for handy, aframax and VLCC freight rates. Changes in fleet size have the greatest effect on Handy tankers where a 10% increase in fleet will make freight rates fall by almost 35%. For Panamax and Suezmax tankers this variable was found to be statistically insignificant. For Panamax tankers the reason may be that newer vessels may opt to work in the oil products trades so the effect on fleet trading on crude oil is lower. As far as Suezmax tankers are concerned, this can be attributed to the special nature of such vessels. Suezmax tankers are not natural products for shipyards to build as the demand for them is relatively limited. This is because the foot print of a Suezmax is not considerably smaller than a VLCC in a building dock and offers shipbuilders little opportunity to maximise output – rather to build a VLCC or two aframaxes than one Suezmax. Finally, oil price changes are significant only for Panamax and Aframax tankers. For Aframax tankers this can be attributed to the fact that they are the workhorse of the industry and, consequently, freight rate changes in this sector may be more dependent on changes in oil prices. For Panamax tankers, the reason may be that crude oil prices will determine whether to work in clean or dirty trades.

Overall

Overall it can be said that long run relations are more important in the determination of freight rates rather than short run ones. Trade volume and fleet changes are the most important determinants of freight rates for both bulk carriers and tankers. Bunker prices on the other hand are significant only where long distances are involved. However, it is proven that independent variables have different and varying effects on the determination of spot rates of different ship types.

Finally commodity price developments are far more important in the bulk sector than in the tanker one. According to MSI (1997) the reason for this is that oil trade is now relatively insensitive to the ups and downs of the general macroeconomic business cycle. Imports of industrial dry bulks are, however, more closely linked to the economic cycle. More diversified in composition and end use, these raw material cargoes largely end up in investment goods or consumer durables, which are highly sensitive to the state of the economic cycle. Consequently, whereas the predominant cause of variations in tonne-mile employment in the dry bulk sector has been economic and cargo demand cycles (the ‘tonne’ component), in the tanker sector it has been shifts in regional oil production and refinery capacity (the ‘mile’ component). Even within the energy sector, bulkers and tankers no longer compete in the same marketplace. Despite the growth of steam coal trade, coal and oil are no longer substitutes. Steam coal plays an insignificant role in the transportation sector, while oil’s global share of electric power generation has waned to below 10%.

Overall it can be said that tankers and bulkers now serve different end use markets with different sensitivities to the overall state of the business cycle, which is itself far less sensitive to the cost and availability of energy. Hence there is no reason for their freight rates to be affected to the same extent by the same variables.

Insert Table 4.5 somewhere here

Insert Table 4.6 somewhere here

4.2.5 Forecasts-Comparison between Error Correction and Autoregressive models

Based on the model estimated above, forecasts were made for all ship types for the period 1999-2000. In addition to that an Autoregressive (AR) model was fitted for all ship types and forecasts were made for the same period. The Akaike and Bayesian Information criteria were used in all cases to determine the lag of the model, which for VLCCs and Cape Size vessels is 1. Therefore, our Auto Regressive model for these two types has the following form:

$$\ln FR_{t+1} = \mu + \rho \ln FR_t + \eta_{t+1}$$

Where μ is the mean $\eta(t)$ denotes the shock at time t and ρ is the autoregressive coefficient.

The other five ship types however follow an Autoregressive Mean Average process. Such ARMA processes are combinations of Auto Regressive and Mean Average models and state that the current value of some series y depends linearly on its own previous values plus a combination of current and previous values of a white noise error term (Brooks 2001). Generally speaking an ARMA model will take the following form (Dewachter 2001):

$$X_t = \mu + \sum_{j=1}^{p} \rho_j X_{t-j} + \varepsilon_t + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j}$$

Allowing the order of the AR and MA part to vary we can fit any type of linear dynamic structure in the series. By utilising both the Bayesian and the Akaike information criteria it was found that Aframax tankers follow an ARMA (1,1) process, handy tankers and Panamax bulk carriers an ARMA (1,2) one, Panamax tankers an ARMA (1,3) and Suezmax tankers an ARMA (5,5) process.

Table 4.7 compares the forecasting capabilities of these two different econometric methods. The size of the errors of the model for the Error Correction Model (ECM) and the AR or ARMA models are demonstrated with absolute errors, percentage errors and the root mean squared error. The root-mean squared error is used to compare the performance of the forecasts of the ECM and AR or ARMA models.

From this table, it can be seen that ECMs outperform AR and ARMA models in all cases but the Panamax tanker segment. In principle, these results show that the ECM model is to be preferred if one wants to achieve the classical objectives of Econometric Business Cycle Research as defined by Tinbergen simultaneously, which are to describe and forecast cycles and to evaluate policies. However, if not all goals have to be met with a single vehicle, other methods might serve the purpose equally well or even better as is the case with the Auto Regressive Mean Average process method whose forecasts outperform those of the ECM in Panamax tankers.

Insert Table 4.7 somewhere here

4.3 Part II: Term structure and Timecharter rates

In addition to analysing the spot rate, this thesis also analyses the determinants of the time charter rate.

4.3.1 Introduction

Time charter rates can represent two things. The first one is to reflect the equivalent of currency unit (normally dollars) paid per tonne of cargo loaded in the equivalent currency unit per day. This term is known as time charter equivalent. Time charter equivalent is derived if we subtract the voyage costs from net freight (that is freight rate per tonne of cargo loaded minus commissions) and we divide it by the voyage days:

$$TCE = \frac{(FR * T_c) - (VC + COM + Ft)}{d_v}$$

where:
TCE= The Time Charter Equivalent Rate
FR= Freight rate per tonne of cargo
T_c = Tonnes of cargo loaded
VC= Voyage Costs
COM= Commission
Ft = Freight Tax (if applicable)
d_v= Voyage days

The Time Charter Equivalent (TCE) rate is normally used for short periods of charter, normally one voyage or a number of consecutive voyages and provides comparable results for the vessel's earnings over a period of time. However, in many cases both shipowners and charterers may prefer to charter or commit a ship for one voyage on a timecharter equivalent basis. In this case, the charterer may sublet the vessel to another charterer from whom he/she will be paid on a dollar per tonne basis immediately or shortly after the vessel's completion, while he will only have to pay the shipowner every fifteen days on a dollar per day basis. This will benefit his/her cashflow since he/she will receive the whole amount of money for the voyage almost immediately upon vessel's completion of loading and departure from the port, while he/she will not have to pay back the shipowner in full up until the completion of the voyage.

On the other hand, by agreeing to enter into a timecharter single voyage, the shipowner passes the risk of an increase in voyage costs to the charterer. For example, if the vessel has to take on bunkers half way through the voyage and an unexpected event (war, supplying problems, strike) occurs that increases fuel prices, this increase will be paid by the charterer without affecting the shipowner's profit.

Also timecharter rates reflect expectations of shipowners and charterers with regard to future developments in the voyage charter market. This is the case where the vessel is chartered out for long periods of time, anything from 3 months and above. A model for time charter rates should therefore reflect this. According to Veenstra (1999, p.54), this structure can be justified on the basis of the assumption that expected returns are equal for all contracts of different duration. This amounts to a structure where long term rates are some weighted-average of expected future voyage charter rates model. The rule that describes this relationship is called the term structure of ocean freight rates.

For Veenstra, a term structure model is also a pricing model because it describes the way in which a long-term rate is formed, in terms of short term rates. This can be found in both Beenstock and Vergottis (1993) and Wergeland (1981). The only difference is the way they treat expectations. Wergeland assumes adaptive expectations while Beenstock and Vergottis rational.

Zannetos was the first to extensively investigate the determination of what he calls the long rate, both in the long and the short run. Zannetos suggested that spot tanker rates should be related to the long run marginal cost of providing tanker services, but could be above or below the level in the short run. Lengthening the period of charter fixture, it was argued, could mean that the rate itself would have to converge towards this long-run marginal cost, from above in booms to below in slumps. After allowing for differences in the risk levels between different durations of charters, a term structure relation between the time charter equivalent and spot rates can be arrived at.

Zannetos performed some quantitative analysis but his results are mixed and as a result he is unable to prove the validity of this relationship (1966, 244).

Strandenes (1984) investigated the relation of time and voyage charter rates, in a way similar to Zannetos. A difference is in the way they treat expectations. Strandenes suggests that expectations are formed semi-rationally while Zannetos assumes adaptive expectations for his analysis. Time charter rate is explained as a function of the freight rate and a hypothetical long-term equilibrium freight rate, taking into account a risk premium. This term reflects that Strandenes follows the semi-rational hypothesis.

The model is:

$$TC = \lambda(a_1 FR_t + a_2 FR^{Lt})$$

where:
TC = Time charter rate
FR= The current freight rate
λ= The risk factor depending on the duration of the contract
FR^{Lt}= the long-run equilibrium freight rate

Strandenes (1984) constructs measurements of the short term and long term expected TCE of the spot market by OLS. The model is estimated separately for bulk carriers, medium-sized tankers and large tankers. Data cover the period from the late 1960s to the early 1980s.

The evidence for the term structure in the rates lies in the development of the estimates with the increase in the duration of the timecharter contract. If duration increases, the relative effect of the current freight rate decreases and the effect of equilibrium rate increases.

In addition, the sum of weights decreases with duration. This according to Strandenes indicates that shipowners are risk averse. The positive difference between the time charter rate and the combined influence of the voyage charter and equilibrium rate can be seen as a risk premium that increases with duration. The longer the timecharter contract, the more certain the shipowner is about the revenue. A risk-averse shipowner would therefore have a greater preference for a longer timecharter contract compared to a voyage charter one, than for a short-term time charter compared to a voyage charter contract.

A present value term structure model for the tanker industry was developed and analysed in Glen et al. (1981). They deal with expectations in a fully rational way, by defining a relation that explains the expected voyage charter rates as a weighted-average of past voyage charter rates and some cost components. Mathematically, they replace the expectations operator by an infinite sum of past rates. These rates are based on profit benchmarks, and include market rates and costs. Thus the unobservable future terms in the models of Veenstra(1999) and Kavussanos and Alizadeh (2002a), are replaced by observable past rates. The resulting present value model is:

$$TC = \sum_{t=0}^{\infty} \alpha^{i} FR_{t-1} + \lambda + u_{t}$$

Here all freight rates are assumed in Worldscale and λ is a risk premium.

Glen et al estimate quadratic and cubic polynomial structures of the voyage charter rates showing a gradual decline in the estimated parameters. They find this to be in contrast with Zannetos hypothesis of elastic expectations, which would have led to a cyclical development in the parameters. However, explanations of the difference in slope should not only be sought in the validity of the elastic expectations hypothesis but also in the quality of the estimation results of Glen et al. (Veenstra 1999, p. 57). Moreover, since Glen et al find that the estimated coefficients in the lag structure add up to a sum greater than unity, this in itself is a confirmation of the elastic hypothesis confirmation.

Finally, despite the differences in the two approaches, Glen et al's results are comparable to the results of Strandenes for the one-year duration contracts. In both cases, the model coefficients add up to more than unity for tankers. Also, both authors conclude that shipowners are risk averse.

Another approach to modelling timecharter rates is that they depend on a type of weighted-average expected future voyage charter rates. Thus a model for time charter rates should not contain one expected voyage charter rate but a sequence of them. This leads to the following relation:

$$TC = \theta \sum_{i=0}^{\infty} \delta^{i} E_{t} FR_{t+1} + \lambda$$

Where θ is a proportionality constant, δ is a discount factor and λ a risk premium. This is called a present value model since it expresses the period rate as the net present value of expected future voyage charter rates. Models like this are extensively used in finance, particularly for modelling the relation of interest rates with different maturities.

This is the model employed by Veenstra (1999) to model the term structure of freight and time charter rates.

According to Veenstra, if the risk premium is positive, the shipowner will prefer to be in the voyage charter market instead of the time charter one. This may be a preference for liquidity (ibid. p.178). On the other hand, if the risk premium is negative, the shipowner prefers to be in the time charter market. It is not immediately clear which risk premium value indicates the shipowner's risk-averse attitude.

In a declining market, shipowners prefer to fix a time charter contract for as long as possible to postpone the impact of the lower freight rates. On the other hand, when the market increases, shipowners prefer to stay liquid. Consequently, according to Veenstra, the term risk premium associated with the liquidity preference is inappropriate if the model is applied to shipping. The risk premium is just a liquidity premium that can be either positive or negative, depending on market developments.

Kavussanos and Alizadeh (2002a) examine the validity of the Expectations Hypothesis of the Term Structure (EHTS) in the formation of period rates in dry bulk shipping markets. According to Kavussanos and Alizadeh, while Zannetos (1966), Glen *et al.* (1981), and Strandenes (1984), recognised that there is a term structure relationship between spot and time charter rates, did not test for the validity of the relationship, as we have seen it being tested in bond and money markets in the finance literature. The only studies attempting to test for the EHTS are those of Hale and Vanags (1989) and Veenstra (1999) for the dry bulk market, who broadly reject the validity of the relationship (Kavussanos and Alizadeh 2002a).

Their results do not support the Expectations Hypothesis of the Term Structure either. This failure is attributed to shipowners' perceptions of risk regarding their decision to operate in spot or time charter markets, which is found to vary proportionally with the volatility of the excess return between the spot and time charter rates. Existence of these negative time varying risk premiums in the formation of period rates suggests that shipowners take into account the future uncertainty in the spot and time charter markets and are prepared to incur a loss in order to secure a contract with longer duration. For Kavussanos and Alizadeh, the higher spot market uncertainty over time charter contracts is thought to emanate from higher freight rate volatilities in spot markets, relocation costs, risk of unemployment, and fluctuations in voyage costs. Comparison of risk premiums across contracts of different duration suggests that larger premiums are required for longer-term contracts.

Adland(2003) however, proposes a new methodology for estimating the implied risk premium in the market, where the expectations about future spot freight rates are based on a non-parametric stochastic multi-factor model of the spot freight rate. He finds that the risk premium in the freight markets should not only be time varying but also depend on the level of the TCE spot freight rate in a systematic fashion.

Adland also points to several potential sources of bias in the data and challenges in the market structure that generally preclude robust conclusions about the empirical risk premium and market efficiency in the freight markets. According to Adland actual market fixtures usually cannot provide sufficient data to determine the detailed shape of the term structure of freight rates or its development over time. The main reason is that the market for period charters is very illiquid and can be inactive for long periods of time. Moreover, the reported period time charters can range in duration from a few days to the full life of a ship. Typically, the number of observations decreases with the time charter duration. Hence, the number of observations for a given duration will be very low, if any transactions have been recorded at all, even for a relatively long sample period of ten years or more. To make matters worse, many time charter contracts are private bilateral agreements where the particulars may not be disclosed in full to the public. Consequently, quotes are more often than not based on the shipbroker's best estimate of what a representative vessel would fetch had there been any transactions (Adland 2003).

From the econometric point of view, Kavussanos and Alizadeh findings suggest that in modelling and forecasting shipping period rates on the basis of the Pure Expectations Hypothesis and the Expectations Hypothesis of the Term Structure(EHTS) it is appropriate to incorporate factors that account for agents' perception of risk and future market conditions.

Adland (2003) adds up to that by claiming that it is impossible to use an arbitrage argument to assert that the term structure equation must always hold. Without a transparent, liquid, and organized market for forward freight or futures contracts in bulk shipping, it is the illiquid and heterogeneous physical period charter market that defines the term structure of freight rates. A period charter is therefore not a redundant contract in the financial economics sense, and the market is dynamically incomplete. Hence, no true arbitrage opportunities can exist. This implies that the link between the spot freight market and the period market, as proposed by the term structure equation and variations thereof in earlier research (Hale and Vanags 1989, Veenstra 1999), may be weaker than assumed. However, Adland argues that large deviations from the proposed relationship are not very likely, as this would imply that investors have very different opinions as to the prevailing market price for a ship.

4.3.2 Thesis's contribution

Based on the findings and observations of Kavussanos and Alizadeh (2002a) and Adland (2003) in addition to the spot rate, the model proposed by this chapter also incorporates changes in fleet size, a variable that accounts for the agents' perception of risk and future market conditions.

Also, instead of using a present value model, an error correction model is developed. The benefit of this approach is its simplicity and that it takes into account both short and long run relations between variables. Therefore, it is more appropriate for the shipping industry, where decisions are based on the situation prevailing both in the long and the short run, compared to present value models. These are mostly used in finance and are based on expected future earnings discounted by a discount factor, which makes things more complicated. Adland (2003) refers to this issue as well by arguing that while the term structure of interest rates is clearly defined by the prices of standardized traded assets in a liquid market (zero-coupon bills, notes, and bonds), the term structure of freight rates is a rather vague concept in practice. The reason is that period charter rates cannot be deduced from the prices of actively traded and identical assets. Thanks to the error correction model approach, this chapter is also able to quantify the extent to which changes in spot rates or other variables affect timecharter rates. Furthermore, while both Kavussanos and Alizadeh (2002a) and Adland (2003) investigate only the dry bulk market, this chapter analyses the tanker market as well and compares and contrasts the findings in both sectors. Finally, this chapter tests the forecasting ability of its models and compares it to that of Autoregressive ones.

4.3.3 Testing for Cointegration

In order to test for long run relations between the variables we use in our model we have to check for cointegrating equations among our variables. By taking the Johansen (1991) approach, we find that for all ship types there are at most three relations in our models, which makes us confident with estimating them. What is reported in table 4.8 for every ship type rejects the hypothesis that there is no cointegration among our variables at 5% level.

Based on the above, different combinations of cointegrated variables were made according to the particularities of each ship market.

Insert Table 4.8 somewhere here

4.3.4 Timecharter Estimation Output

The parameters in the models were estimated with the Ordinary Least Squares method. The diagnostic test results reported in table 4.10 provide us with confidence that our results are not hampered by problems such as heteroscedasticity, ARCH effects or autocorrelation and that inferences form the model we estimated can be made safely.

The estimation results are summarised in table 4.9. In all cases R^2 is high ranging from 0.655 (Suezmax tankers) to 0.92 (Panamax Bulk Carriers) with the rest lying between 0.75 and 0.86. Standard errors are rather low ranging from 0.11 to 0.28 thus indicating a good fit for the equations.

The results indicate that the spot rate is highly statistically significant for all ship types both in the long and the short run. The effect of a 10% increase in the spot rate on the timecharter rate in the short run ranges from 7.3% (Handy Tankers) to 11.4% (Cape Size Bulk carriers) with the rest lying between 8 and 9.5%. By the same token, if the spot rate increases by 10% one period, then timecharter rates will increase by 7.85% (Capes) to 28% (VLCCs), with the rest lying between 10-19% the following one, in order to reach equilibrium. These results may be interpreted as proof that long run relations in shipping have a higher effect than short run ones.

In five out of the seven ship types under investigation, the spot rate is the only determinant that is statistically significant for the determination of time charter rates, proving that EHTS is valid

However, in Panamax bulk carriers and Aframax tankers we see that fleet changes are statistically significant in the long run, having a negative effect on time charter rates. This supports the view of Kavussanos and Alizadeh (2002a) and Adland (2003), who claim that EHTS is not valid and that it is appropriate to incorporate factors that account for agents' perception of risk and future market conditions.

These results provide inconclusive evidence with respect to the validity of the expectations hypothesis of the term structure relationship in bulk shipping markets overall and needs further investigation.

Insert Table 4.9 somewhere here
Insert Table 4.10 somewhere here

4.3.5 Forecasts

Forecasts for the timecharter rate for each ship size were performed and compared to forecasts made by utilising AR and/or ARMA models. The results are summarised in table 4.11. It can be seen from the results that error correction models outperform the autoregressive ones in all markets except Aframax tankers, where again however the results are too close.

Another interesting finding is that the forecasting ability of the timecharter models is far better than that of the spot rates one. This can be attributed to the dominance of the stochastic component of freight rates over its deterministic one, which makes their accurate forecast a very difficult task.

Insert Table 4.11 here

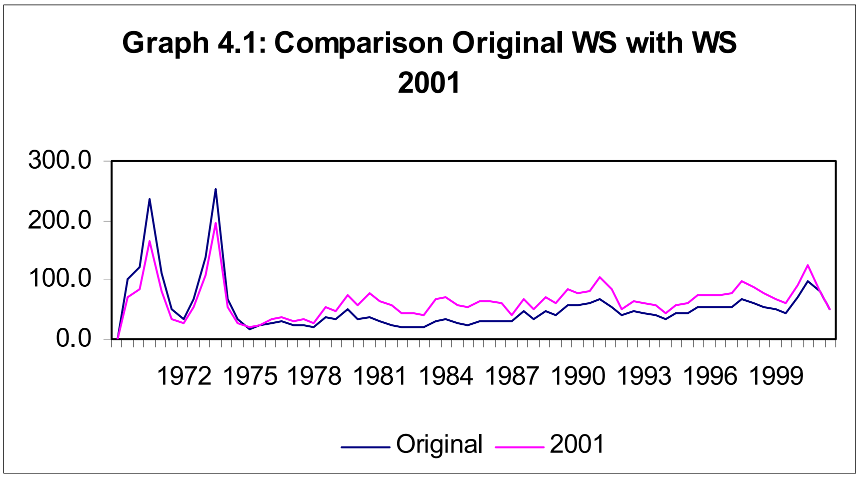
4.4 Conclusion

This chapter developed an error correction model for both the spot and the period rates. This way it fills a gap in the economic literature by estimating a theoretical model where none of the CLRM assumptions are violated. Consequently, statistical inferences from this model can be made safely. Furthermore, by disaggregating into the different ship types according to size, this chapter found that different variables have different effects on each type, thus proving that each ship type has its own distinctive characteristics.

With respect to the period or time charter market, the chapter found that spot rates are the major determinant for period rates, thus the validity of the expectations hypothesis of the term structure relationship between spot and period rates. This hypothesis however is not always valid since on two occasions (Panamax bulk carriers and Aframax tankers), fleet changes, a variable incorporated in the model to depict market changes and risks was found to be statistically significant. This leads to inconclusive evidence that requires further investigation.

Furthermore, by comparing the forecasting abilities of the error correction model with those of the autoregressive or autoregressive moving average (ARMA) models, it was found that the error correction model outperformed the others in six out of seven cases in both the spot and the period markets. Finally, it was found that the forecasting ability of the models for the timecharter market was superior to that for the freight market. This was attributed to the dominance of the stochastic component over the deterministic one in the spot rate market that makes its accurate forecasting a very difficult task.

Table 4.1: Different Approaches in analysing Freight Rates	
Tinbergen	Supply-Demand implicit-cost based
Koopmans	Supply-Demand implicit- cost based
Hawdon	Supply-demand implicit - Political effects
Wergeland	Supply Demand explicit (includes variables indicative of the general economic activity)
Beenstock and Vergottis	Supply Demand explicit - Cost based
Kavussanos	Autoregression
Veenstra	Autoregression



Graph 4.2 VLCC rates in Worldscale and US dollars per tonne

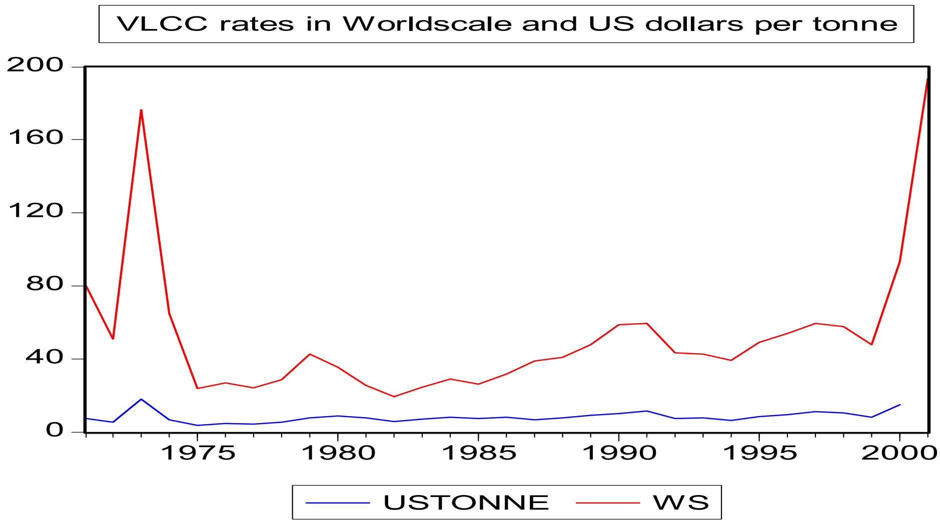


Table 4.2: Relationship between Seaborne Trade Volume and Commodity Prices							
	Bulkers		Tankers				
	Panamax	Capes	Handy	Panamax	Aframax	Suezmax	VLCC
C(1)	-0.31 (1.6)	1.92* (0.33)	0.08 (0.26)	0.07 (0.16)	0.30 (0.47)	0.64* (0.23)	0.62 (0.46)
D(LNCP)	0.44* (0.18)	0.49* (0.18)	-0.04 (0.04)	-0.01 (0.05)	-0.10* (0.04)	0.00 (0.12)	-0.09* (0.04)
LNTRADE(-1)	0.00 (0.15)	-0.20* (0.07)	0.00 (0.03)	-0.04 (0.03)	0.00 (0.06)	-0.11* (0.05)	-0.04 (0.06)
LNIRONORE(-1)	-350.02 (257707)	0.73 (0.72)	-1.28 (12.5)	1.03 (0.97)	250.83 (56536)	-0.32 (0.78)	-1.63 (2.39)
R-squared	0.195	0.71	0.04	0.11	0.37	0.31	0.38
Adj. R-squared	0.098	0.67	0.07	0	0.3	0.23	0.31
S.E. of regression	0.09	0.08	0.05	0.08	0.06	0.18	0.06
Sum squared resid	0.181	0.18	0.07	0.14	0.09	0.84	0.09
* = Denotes significance at 5% level , Std. Errors in parentheses, Series in logarithms							

Table 4.3: ADF Test Results for Stationarity														
	Bulkers				Tankers									
	Panamax		Capes		Handy		Panamax		Aframax		Suezmax		VLCC	
	Level	1st Dif	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.
LnTC	-4.24*	-5.55*	-4.12*	-5.84*	-3.56	-5.07*	-3.49	-4.93*	-3.03	-5.10*	-3.13	-4.51*	-2.32	-4.88*
Lnfr	-2.47	-6.33*	-2.73	-3.92*	-2.78	-4.98*	-2.49	-6.48*	-3.31	-3.61*	-3.31	-5.75*	-3.53	-6.21*
Lnfleet	-1.89	-4.34*	-1.96	-5.69*	-2.94	-4.30*	-0.47	-3.58*	-2.39	-4.74*	-3.41	-5.15*	-3.09	-3.63*
LnTrade	-3.81	-4.45*	-2.58	-5.73*	-3.60*	-4.72*	-2.59	-4.61*	-2.01	-3.66*	-1.08	-3.68*	-1.48	-3.66*
	Levels		1st Dif.											
LnBunkers	-3.56		-4.17*											
LnOil	-3.38		-4.25*											
LnIronOre	-3.46		-6.00*											
LnGrain	-4.34*		-5.29*											
LnCoal	-2.43		-3.63*											
ADF test models contain an intercept and a trend. The null hypothesis is that the series is non-stationary. This hypothesis is rejected if the statistics are larger in absolute values than the critical values. Number of lagged first difference terms added to the regression: One(1).														
*, Denotes variable stationarity based on MacKinnon's critical value of -3.5731 at 5% level														

Table 4.4 Johansen Cointegration Tests Spot Rates (std. Errors in parentheses)														
	Bulkers				Tankers									
	Panamax		Capes		Handy		Panamax		Aframax		Suezmax		VLCC	
Lnfr	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Lnfleet	1.93 (0.61)	-	10.56 (2.62)	2.46 (1.16)	1.34 (0.19)	8.42 (2.1)	1.22 (0.44)	-	-1.28 (0.7)	-	2.95 (0.53)	-	27.1 (3.42)	4.9 (0.49)
LnTrade	5.33 (0.49)	-	5.1 (3.77)	-6.01 (1.03)	-1.28 (0.57)	-	-0.15 (0.18)	-0.68 (0.21)	1.08 (0.33)	0.15 (0.32)	-1.66 (0.28)	0.83 (0.68)	-30.5 (4.1)	-4.76 (0.58)
LnIronOre	1.94 (0.4)	-0.7 (0.28)	-1.83 (2.27)	-	-	-	-	-	-	-	-	-	-	-
LnOil	-	-	-	-	-0.84 (0.2)	-	-0.05 (0.23)	-0.01 (0.03)	-0.47 (0.2)	-0.4 (0.1)	5.04 (0.68)	-	-2.96 (1.82)	-

LnBunkers	-0.26 (0.18)	-	-1.68 (0.8)	-	0.42 (0.19)	-	0.49 (0.23)	-	0.89 (0.23)	-	-5.16 (0.11)	0.8 (0.42)	-12.16 (2.23)	-1.89 (0.22)
Trend	-0.2 (0.03)	-0.01 (0.01)	-0.78 (0.13)	0.88 (0.04)	0.02 (0.02)	0.13 (0.05)	-0.02 (0.01)	0 (0.01)	-0.04 (0)	-0.05 (0.01)	0.1 (0.02)	0 (0.07)	0.73 (0.1)	0.09 (0.01)
Eigenvalue	0.94	0.49	0.76	0.58	0.84	0.6	0.87	0.76	0.85	0.77	0.82	0.68	0.91	0.8
λ trace	87.31	25.32	87.31	42.44	87.31	25.32	87.31	42.44	87.31	42.44	87.31	42.44	87.31	62.99
λ max for 1 coint. Eq.	149.6	37.2	110.5	56.86	114.63	37.66	128.5	59.8	138.8	60.01	126.4	56.8	133.5	111.5
log likelihood	166.9	41	140.45	75.5	178.05	78.5	155.2	50.03	151.2	44.44	104.9	16.25	147.27	121

Table 4.5: Regression Results OLS Spot Rates

	Bulkers		**Tankers**				
	Panamax	**Capes**	**Handy**	**Panamax**	**Aframax**	**Suezmax**	**VLCC**
C(1)	-1.57 (1.13)	-13.47* (3.12)	-10.90* (4.16)	-2.22* (0.55)	-6.74* (1.47)	-1.15* (0.52)	6.19 (3.36)
D(LNBUNKERS)	0.27* (0.12)	-0.04 (0.15)	-0.28 (0.2)	0.05 (0.27)	-0.46 (0.34)	0.02 (0.3)	1.02* (0.4)
D(LNFLEET)	-1.83* (0.78)	0.63 (0.6)	-3.46 (0.85)	1.53 (1.11)	-2.35* (1.2)	-0.22 (0.83)	0.31 (0.3)
D(LNIRONORE)	2.31* (0.51)	2.78* (0.5)	-	-	-	-	-
D(LNOIL)	-	-	0.18 (0.2)	0.34 (0.28)	0.70* (0.34)	0.10 (0.28)	-0.48 (0.34)
D(LNTRADE)	-0.5 (0.41)	-1.08 (0.57)	2.39* (0.55)	0.89 (0.52)	0.23 (0.47)	0.39 (0.22)	2.91* (0.82)
LNFR(-1)	-0.71* (0.16)	-0.90* (0.14)	-0.54* (0.14)	-1.02* (0.19)	-0.70* (0.16)	-0.93* (0.19)	-0.90* (0.19)
LNIRONORE(-1)	1.16* (0.27)	-	-	-	-	-	-
LNOIL(-1)	-	-	-	0.21* (0.07)	0.57* (0.12)	-	-
LNFLEET(-1)	-	-1.85* (0.48)	-1.71* (0.46)	-	-	-	-1.39* (0.29)
LNTRADE(-1)	-	2.88* (0.57)	-	0.59* (0.1)	1.44* (0.28)	0.47* (0.07)	0.96* (0.31)
LNBUNKERS(-1)	-	-	-	-	-	0.23* (0.11)	0.98* (0.3)
DUMMY	-	-	0.53* (0.13)	0.59* (0.18)	1.00* (0.2)	0.78* (0.14)	0.84* (0.17)
R-squared	0.82	0.81	0.85	0.79	0.76	0.81	0.82
Adj. R-squared	0.77	0.75	0.8	0.71	0.66	0.74	0.74
S.E. of regres.	0.17	0.19	0.13	0.17	0.22	0.2	0.2
Sum sqd resid	0.63	0.79	0.36	0.56	0.94	0.77	0.79
Durbin Watson	2.32	2.38	1.46	2.48	2.04	2.3	2.23
* = Denotes significance at 5% level , Std. Errors in parentheses, Series in logarithms							

Table 4.6: Diagnostic Tests (p-values in parentheses) Spot Rates								
	Correlogram Q Statistic (1 lag)	Correlogram Squared Residuals (1 lag)	Serial Correlation LM Test (2 lags)		ARCH LM Test (1 lag)		White Heteroscedasticity Test (no cross terms)	
Ship Type			F Statistic	Obs*R-Squared	F Statistic	Obs*R-Squared	F Statistic	Obs*R-Squared
Panamax Bulk Carrier	0.81 (0.37)	3.53 (0.06)	0.47 (0.63)	1.3 (0.5)	0.06 (0.08)	3.24 (0.07)	0.71 (0.75)	16.26 (0.57)
Cape Size Bulk Carrier	1.28 (0.26)	0.07 (0.79)	0.8 (0.47)	2.2 (0.33)	0.45 (0.81)	0.06 (0.8)	1.45 (0.28)	20.97 (0.28)
Handy Tanker	1.81 (0.18)	0.1 (0.75)	1 (0.37)	2.8 (0.25)	0.08 (0.78)	0.09 (0.76)	0.58 (0.84)	16.27 (0.64)
Panamax Tanker	2.68 (0.1)	0.03 (0.87)	2.1 (0.15)	5.49 (0.06)	0.02 (0.88)	0.02 (0.88)	2.32 (0.1)	24.09 (0.19)
Aframax tanker	0.17 (0.69)	0.23 (0.63)	0.68 (0.52)	1.06 (0.59)	0.28 (0.6)	0.3 (0.59)	1.05 (0.5)	19.97 (0.4)
Suezmax Tanker	0.73 (0.39)	0.33 (0.56)	0.62 (0.55)	1.87 (0.39)	0.28 (0.6)	0.3 (0.59)	2.8 (0.06)	24.8 (0.17)
VLCC	0.59 (0.44)	0.18 (0.67)	0.68 (0.52)	2.15 (0.34)	0.15 (0.7)	0.16 (0.69)	1.04 (0.5)	19.9 (0.4)

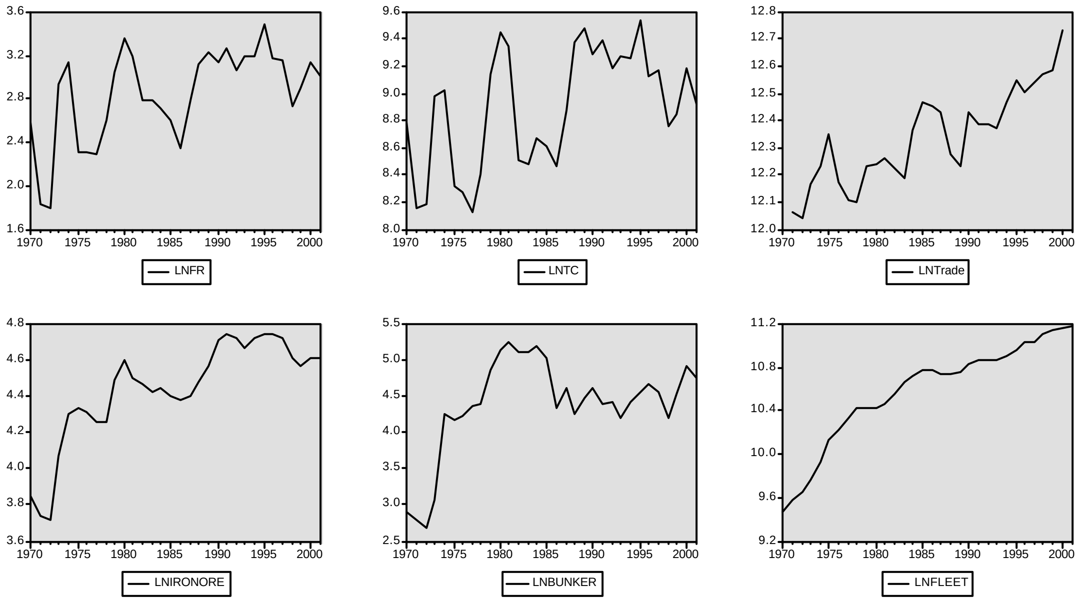
Table 4.7: ECM-AR(MA) Forecast Comparison Spot Rates (1999-2000)	Panamax B/C	Cape B/C	Handy Tanker	Panamax Tanker	Aframax Tanker	Suezmax Tanker	VLCC Tanker
ECM							
Absolute errors	**0.01**	**0.07**	**0.1**	0.31	**0.32**	**0.04**	**0.17**
Percentage errors	**0.32**	**3.01**	**4.38**	17.5	**18.46**	**1.4**	**6.46**
Mean squared errors	**0.01**	**0.07**	**0.12**	0.33	**0.42**	**0.05**	**0.21**
AR (MA)							
Absolute errors	0.19	0.27	0.11	**0.33**	0.37	0.41	0.35
Percentage errors	6.03	11.7	4.94	**14.95**	21.91	15.7	13.27
Mean squared errors	0.26	0.32	0.14	**0.42**	0.44	0.57	0.46

Table 4.8 Cointegrating Relations: Timecharters (std. Errors in parentheses)												
	Bulkers			Tankers								
	Panamax	Capes		Handy		Panamax		Aframax		Suezmax	VLCC	
LnTC	1	1	1	1	1	1	1	1	1	1	1	1
LnFR	0.45 (0.76)	-11.38 (2.52)	0.92 (0.53)	-0.71 (2.17)	0.06 (0.18)	-0.54 (0.28)	-0.48 (0.27)	-9.03 (2.01)	2.45 (0.62)	0.4 (0.21)	0.49 (0.34)	4.12 (0.96)
LnFleet	8.36 (1.31)	-14.98 (3.02)	-	-16.76 (3.62)	-	0.57 (0.52)	-	12.34 (5.24)	-	-1.83 (0.59)	-2.02 (0.39)	-
Trend	-0.25 (0.06)	188.08 (37.8)	-10.99 (1.12)	0.23 (0.06)	-0.04 (0.01)	-0.02 (0.01)	-0.03 (0.01)	0.16 (0.12)	-0.17 (0.03)	-0.05 (0.02)	-0.09 (0.01)	-0.17 (0.03)
Eigenvalue	0.74	0.56	0.37	0.78	0.55	0.66	0.61	0.6	0.53	0.62	0.8	0.67
λ trace.	61.48	35.9	20.76	76.1	26.1	49.35	40.2	52.1	25.48	45.47	69.8	35.36
λ max for 1 coint. Eq.	42.44	34.91	19.96	42.44	25.32	42.44	25.32	42.44	25.32	42.44	42.44	25.32
log likelihood	96.7	63.12	-0.88	117.56	39.4	78.78	14.39	79.25	16	52.06	85.6	18.6
All cointegrating equations contain a trend and an intercept trend except Capesize bulkers where series do not contain trend												

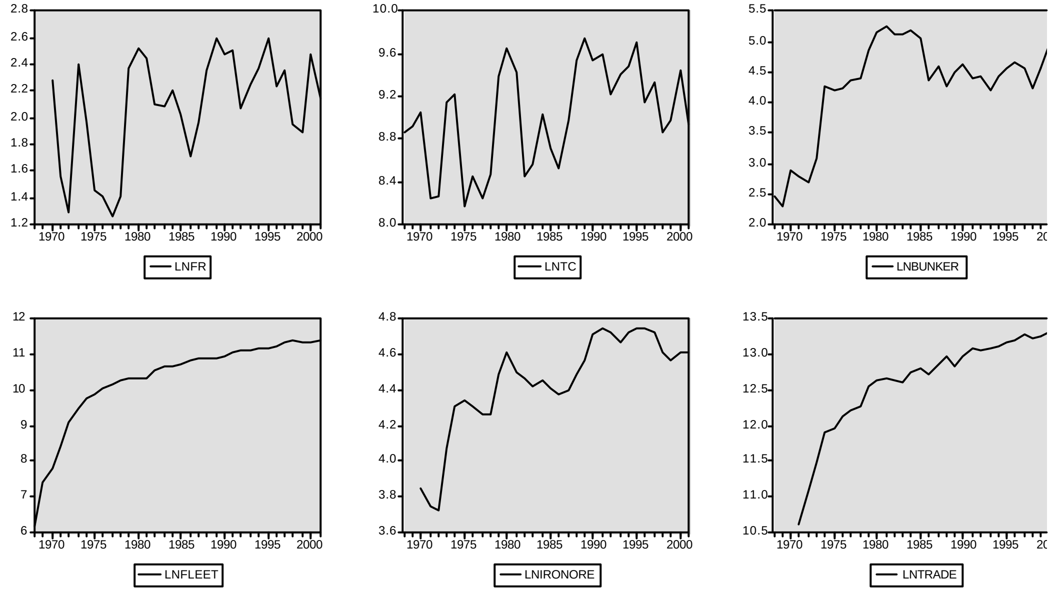
Table 4.9: Timecharter Regression Results OLS							
	Bulkers		**Tankers**				
	Panamax	**Capes**	**Handy**	**Panamax**	**Aframax**	**Suezmax**	**VLCC**
C(1)	5.51* (1.4)	3.10* (0.82)	3.77* (1.34)	4.55* (1.35)	5.24* (1.07)	16.32* (5.93)	0.83 (0.79)
D(LNFR)	0.87* (0.07)	1.14* (0.13)	0.73* (0.11)	0.95* (0.17)	0.82* (0.11)	0.88* (0.16)	0.91* (0.12)
LNTC(-1)	-0.58* (0.15)	-0.42* (0.12)	-0.54* (0.17)	-0.65* (0.16)	-0.65* (0.13)	-0.45* (0.15)	-0.21 (0.11)
LNFR(-1)	1.00* (0.13)	0.79* (0.18)	1.05* (0.26)	1.47* (0.26)	1.23* (0.15)	1.89* (0.43)	2.78* (1)
LNFLEET(-1)	-0.31* (0.13)	-	-	-	-	-2.82* (0.94)	-
D(LNFLEET)	-2.22* (0.6)	-0.9 (0.7)	-1.01 (1.24)	-0.36 (1.4)	1.73 (0.9)	-0.52 (1.2)	-0.30 (0.4)
R-squared	0.92	0.86	0.77	0.75	0.79	0.66	0.75
Adj. R-sqred	0.91	0.85	0.73	0.71	0.76	0.58	0.71
S.E. of regres.	0.11	0.16	0.12	0.23	0.18	0.28	0.21
Sum squared resid	0.32	0.58	0.31	1.29	0.81	1.86	1.03
Durbin Watson	1.81	1.7	1.7	2.27	1.72	1.81	1.58
* = Denotes significance at 5% level , Std. Errors in parentheses, Series in logarithms							

Graph 4.3: Variables included in the freight market model

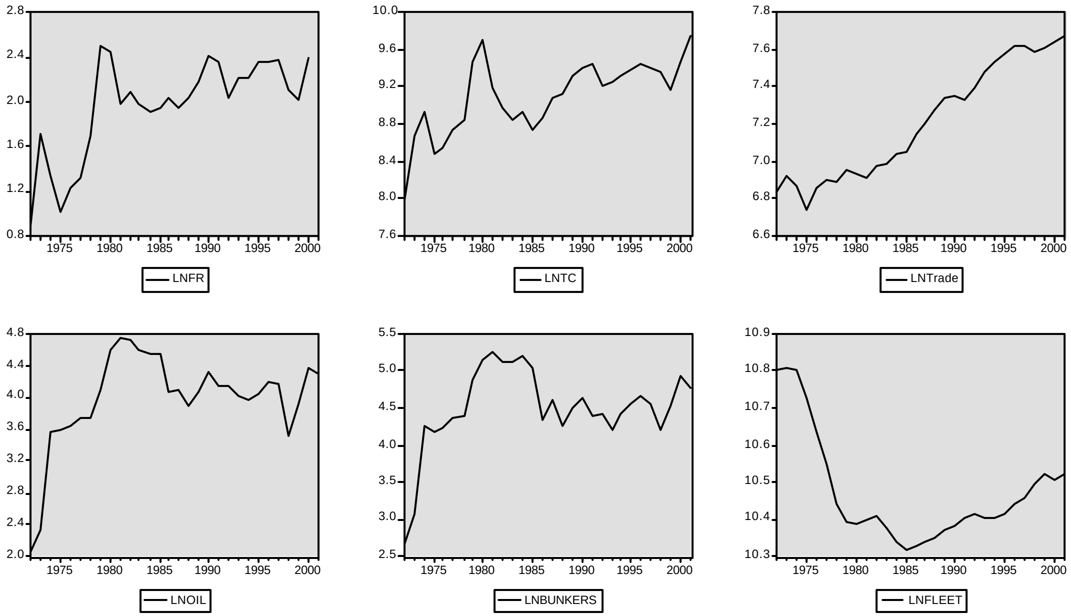
Panamax Bulk Carriers



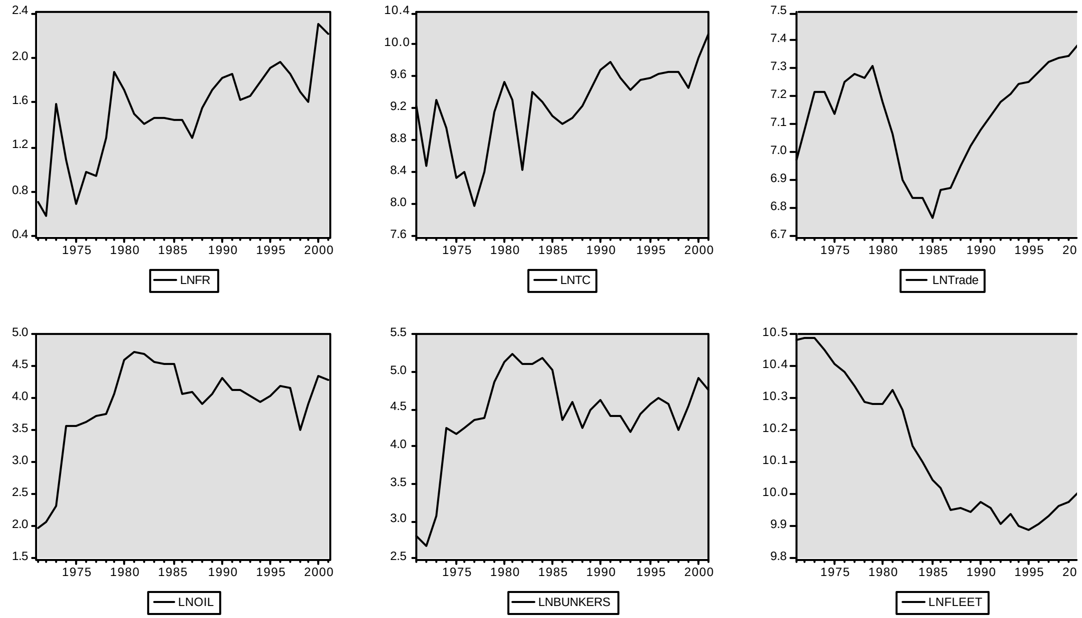
FREIGHT MODEL VARIABLES CAPE SIZE BULK CARRIERS



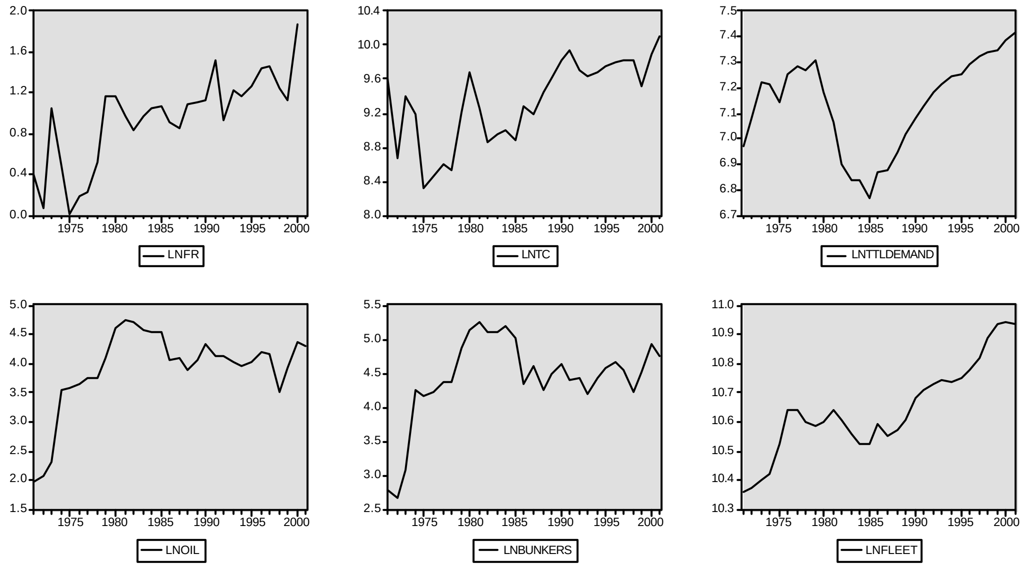
Handy Tankers



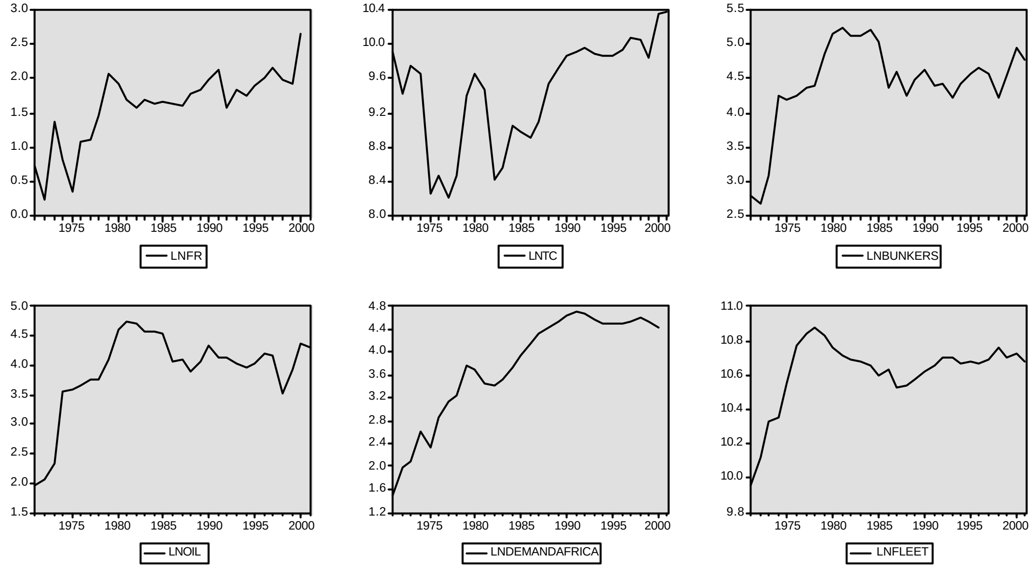
Panamax Tankers



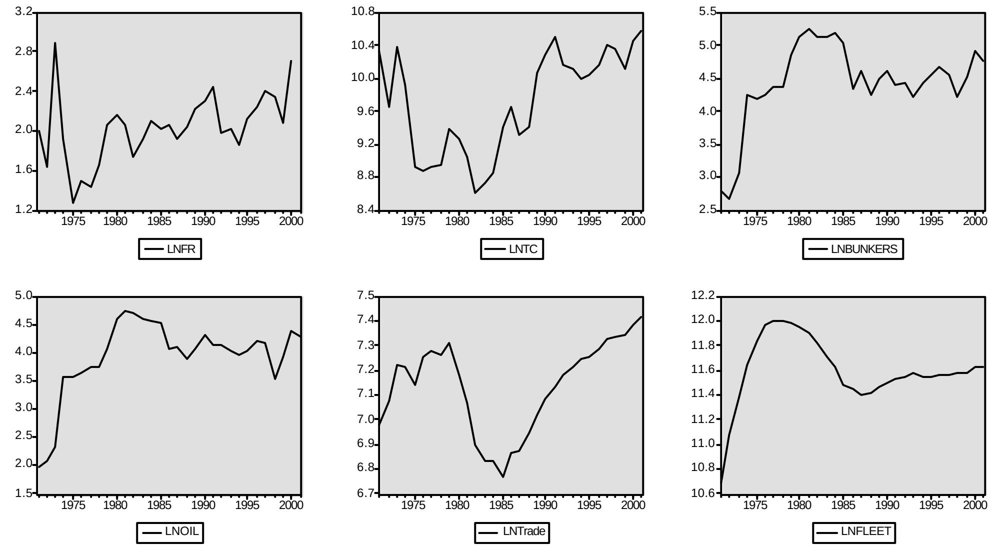
Aframax



Suezmax



VLCC



Chapter 5: Econometric Modelling of Newbuilding Prices

5.1 Introduction

5.1.1 The Market for New Ships

Shipbuilding is a market where variables, demand-supply related and prices, are subject to distinct cyclical fluctuations. Such price volatility has led repeatedly to collapses in newbuilding prices leading to disturbances in production output and consequently, to severe financial problems, even bankruptcy, for shipyards and shipowners.

Therefore, understanding the supply and demand of new vessels, as well as, the determinants of new vessel prices is important not only to shipowners, but also to shipbuilders, bankers and public officials for their investment and management decisions.

This thesis aims at filling a gap in the literature by developing a theoretical error correction model from which statistical inferences can be made.

The chapter is structured as follows. The following section provides a literature review of the most important work done on the field and identifies the most important variables influencing new vessel prices. Focus then shifts on previous econometric attempts on the topic and their shortcomings, while the subsequent section focuses on the development of this chapter's modelling strategy. Methodological analysis is then followed by model estimation and results discussion. Finally, the chapter compares the forecasting abilities of the developed model with that of an Autoregressive model for all ship types under investigation.

5.2 Literature Review

The first researcher to observe the cyclicality of the newbuilding market was Tinbergen (1931). Tinbergen (1931) supported that the condition of the shipbuilding market is very much dependent on the amount of freight offered for shipping. The freight rate is then in its turn dependent on the shipping tonnage present in the market. This leads to an endogenous shipbuilding market cycle, which is caused by the time lag between the demand for shipping capacity and the actual availability of shipping capacity. In addition to this, he comments that there is also evidence of exogenous disruptions causing the cycle to act unpredictably at different periods of time.

Tinbergen takes a supply-demand approach to analysing the newbuilding market based on the cobweb theorem. In other words, Tinbergen describes a model where supply adjusts to price with a specific time lag. More specifically, low total tonnage leads to high freight rates. Ships ordered during a prosperous market period will be delivered about one year later, thus increasing the total amount of tonnage. The cobweb theorem approach is subsequently followed by Koopmans (1939).

For Koopmans (1939) the shipbuilding market is influenced by expectations concerning the degree of equilibrium between the transportation capacity of the world fleet and the aggregate demand for its services. The main reason behind this reliance on expectations is the time lag that is evident between ordering and delivery of new tonnage, since the market situation is shaped according to orders placed several years earlier.

As part of his Tankship Building Model, Hawdon (1978) estimates a tanker newbuilding price equation by including both cost related (steel price) and asset pricing (freight levels) variables in his approach.

For Hawdon (1978) the price per dwt of new tankers is assumed to be linearly related to rates, rates lagged, the size of the fleet, the average size of tankers and the price of steel sections. He estimates a linear relationship employing both the Ordinary Least Squares (OLS) and the 2 Stage-Least Squares (2SLS) method.

He finds that current levels of freight rates have a significant impact on newbuilding price, while lagged freight rates are non-significant. Steel Prices as indicators of shipbuilding costs are also found to be highly significant. He also finds a statistically negative coefficient for fleet size. This result according to Hawdon (1978), reflects the depressing influences of overcapacity on ship prices. Finally average size of tankers has no significant effect on newbuilding prices due to its high correlation with freight rates. The problem in Hawdon's research is that his analysis is not based along simple demand/supply terms. As a result, there is a lack of capturing causality relationships. For example, it is not fleet oversupply that directly impacts prices but rather the effect of oversupply on orderbook, which in its turn distorts the supply/demand equilibrium for newbuildings and then prices.

By taking an asset pricing model approach, Beenstock (1985) observes that second-hand prices are flexible whereas newbuilding prices are relatively sticky. This implies that newbuilding prices adjust to second-hand prices over time. This statement however is open to criticism since newbuildings are cost driven whereas second-hand vessels are market driven. Newbuilding prices cannot possibly adjust to something that is so volatile and speculative. By the same token, no country would adjust its shipbuilding capacity, involving a lot of heavy investment and sunk costs, to speculative movement of prices. After all, the drivers of newbuilding prices, as discussed later in the chapter, are competition among shipyards, excess shipbuilding capacity and subsidies (i.e. industrial sectional policies). These are the important variables in a supply driven industry like shipbuilding with the rest being of secondary importance.

Beenstock and Vergottis (1989) distinguish between the market for new-built ships and second-hand ships and take an asset pricing model approach. At the time of their contracting, new-built ships will typically be sold for prices that can differ from the prices of identical existing new ships by a larger or smaller amount. The main reason for this difference in price, they state, stems from the fact that a new ship is immediately available to trade, while a contracted new-building ship only becomes available after the construction period has elapsed. Because new built ships are for forward delivery, the market for them should resemble a forward market. Prices arranged should reflect market expectations, at the time of contracting, regarding the value of new ships at the time of delivery. This statement is partly true however since on many occasions today in some countries it is national policy, i.e. subsidies or aggressive pricing to grab market share, that is reflected in newbuilding prices rather than market expectations.

Their newbuilding model is:

$$\text{Ln NB} = E(\ln P_{t+1}) + k$$
$$k = k_1 + k_2$$

Where:

NB = price of new-built ships
k = premium

Beenstock and Vergottis have assumed here that the prices of new existing ships move in line with expected prices in the second-hand market. The parameter k reflecting a number of factors $k_1 > 0$ is a premium that reflects the fact that the new-built ships may embody superior technology, while $k_2 < 0$ represents a risk premium, required to attract investors into taking forward positions in tankers. This means that the demand side of the newbuilding market is one of the factors determining newbuilding prices.

The Beenstock and Vergottis model for newbuilding prices is a case of an asset pricing model. They assume that newbuilding and second-hand ships are practically perfect substitutes. Although it seems plausible that demand for newbuildings has a high price elasticity, because second-hand prices are a close substitute, it is unlikely that newbuilding and second-hand vessels are perfect substitutes. This is due to several reasons:

1) Second-hand and new ships are available in different time frames
2) Different trading conditions apply as a result of timing
3) Different costs apply as a result of timing
4) Different risks apply as a result of timing
5) Second-hand ships have shorter remaining trading life than the newly-built ones
6) There may be technological advantages of one over the other

Jin (1993) takes a supply and demand approach to analysing the newbuilding tanker market. However, her analysis also incorporates elements of the cost based approach such as shipyard labour costs. The study provides a framework to analyse quantitatively the relationship among market factors, such as newbuilding prices and orders, and other exogenous factors, such as, technological change in the shipbuilding industry and changes in shipping distances. The study also identifies the impacts of these factors on tanker supply and demand.

For Jin (1993) shipbuilding is both a capital and labour intensive industry, in terms of absolute uses of factor inputs. There are high fixed costs associated with shipyard operations. Ship construction creates a large number of jobs, which generate important regional and national economic impacts. Shipbuilding capacity is reflected by the capital and labour in the industry. Shipbuilding capacity is the most important factor determining the supply of new tankers, and higher capacity is associated with greater supply. Technological change is another important factor influencing new tanker supply.

According to Jin (1993) shipbuilding cost should be a decisive factor in a supply function, but in the short run, cost may be less influential than capacity. Furthermore, it is difficult to measure world shipbuilding cost, since there is great variation in labour costs among different suppliers; costs of shipbuilding materials and energy in different countries are also different. For this reason Jin uses the average number of employees in the Japanese shipbuilding industry at *t-1* as a cost indicator. This is not a very convincing argument since there are many reasons for labour force numbers to fluctuate. Therefore, it is labour force costs that someone is interested in rather than number of workers. On the other hand, shipbuilding costs can either be approximated by an index or, an approach this paper employs, take the price of rolled steel plates that are used in shipbuilding as a cost indicator.

The inverse supply function can be specified as:

$$NB = f_s(Orderbook, Cap, EMP_{t-1} Steel, T_{i,} e_{2i})$$

Where for observation i:

NB = The price of new ships (in this case tankers)
Orderbook = The quantity of tanker newbuilding supplied which is equal to the quantity of tanker newbuilding demanded
Cap = Shipbuilding capacity
Steel = The steel price
EMP_{t-1}= Average number of employees in the Japanese shipbuilding industry at t-1.
T_i = Technological change
e_{2i} = A stochastic error term

The expected sign of orderbook is positive, as an increase in quantity supplied is generally caused by a rise in new tanker price. The validity of this argument is questionable since shipowners and their financiers will be reluctant to invest in new ships when there is the fear of oversupply, unless they are offered rock bottom prices, with negative effects on newbuilding prices. The expected sign of *Cap* is negative, since a capacity increase induces an outward shift of the new tanker supply curve. For a given downward sloping demand curve, such a shift leads to a decline in equilibrium price. The expected sign of *Steel* is positive, because a cost rise will make the supply curve shift in, inducing a price increase. The expected sign of T is negative, as technical change will improve shipbuilding productivity and reduce costs, leading to a price reduction.

In order to estimate her model, Jin drops the steel price variable because it has a low t-statistic and is highly correlated with time. The results indicate a positive relationship between new tanker price and newbuilding supply and shipbuilding costs. Finally, the model reveals that the mean of tanker prices has a downward trend over time, mainly effected by technological changes

By combining the asset pricing model with the cost based model approach, Volk (1994) attempts to explain the shipping and shipbuilding market cycle through the development of shipping freight rates, shipping innovation, psychological and speculative factors in shippers' behaviour and a limited endogenous influence of replacement orders. It should be noted however that of these factors only freight rates are quantifiable, thus making the other 'stochastic' variables difficult to quantify and use them in a model.

Summing up we could say that the major determinants of newbuilding prices are:

- Shipbuilding costs
- Exchange rates
- Shipyard capacity
- Vessel orderbook
- Freight rates
- Sector dwt demand that advocates desegregation into different ship sizes and
- Second-hand prices.

5.3 Chapter's Contribution

Existing theories and models follow different approaches. These are summarised in table 5.1. However none of them gives the whole picture. For example, despite the fact that exchange rates play a key role in the volatility of newbuilding prices, none of the above models include it as a variable. Furthermore, Beenstock and Vergottis assume that newbuilding prices are not affected by shipbuilding costs whereas Di Jin does not include any market or asset pricing variables such as freight rates or second-hand prices, a proxy for asset speculation in her model. Also, all three models take an aggregate approach to modelling, which causes the loss of lots of information regarding the various ship sizes and their characteristics. Moreover, none of the researchers is dealing with dry bulk carriers and the effects these variables have on the formation of dry bulk carrier newbuilding prices.

Insert Table 5.1 somewhere here

This chapter incorporates elements of all three different approaches (asset pricing, cost based and supply-demand) to develop a model that gives the whole picture with respect to the effects different variables have on the determination of new ship prices.

By developing a theoretical (Error Correction) model for the newbuilding market that gives reliable results from which economic inferences can be made confidently, this chapter aims at filling a gap in maritime economics literature. Another contribution is that by disaggregating into the different ship types according to size it finds that different variables have different effects on each type thus proving that each ship type has its own distinctive characteristics. Furthermore, it analyses, compares and contrasts both the tanker and the dry bulk market simultaneously. Another contribution is that it compares the forecasting ability of the developed theoretical model with that of an atheoretical Autoregressive one. The final contribution of this chapter to existing literature has to do with the company's sale and purchase strategy. The three major driving forces behind a ship purchase are replacement, speculation and trading/fleet expansion. Depending on the purpose, the buyers will require differing motives and have different priorities. However, these three motives are not easily identifiable in practice, since it is very difficult to know the rationale behind every ship purchase. A product of this process is the development of a useful tool that the market players may utilise before designing and implementing their sale and purchase strategies.

5.4 Methodology: Model Specification, Data collection and analysis

5.4.1 Variable Identification

This section analyses the effects the variables representing the three different approaches have on determining newbuilding prices.

These variables are:

- Cost based related: Shipbuilding costs, Exchange rates
- Asset Pricing Related: Second-hand ship prices, timecharter rates
- Supply demand Related: Orderbook as a percentage of the fleet, shipyard capacity

At the end of the section these variables are integrated in a supply-demand model. This way all different approaches are integrated into one model thus providing a better picture of the newbuilding prices determinants.

Cost based Related Variables

Shipbuilding Costs

High yard competition has ensured that the most influential factor in determining Newbuilding Prices is shipbuilding cost. This statement is made upon the assumption that these costs are not subsidised as may be the case with a few countries today. However, a discussion on shipbuilding subsidies and how they affect yard competitiveness is beyond the scope of this chapter.

Newbuilding Prices in key Sectors and Segments are mostly set by those yards with the lowest costs that normally have the greatest efficiency and output and therefore the competitive advantage over other yards. Therefore, it can be assumed that, other things being equal, the higher the costs of ship construction, the higher the price of the final product.

Due to the fact that shipbuilding costs are difficult to measure, for the purpose of this thesis the price of steel plates in Japan is taken as a newbuilding cost indicator. The reason is that steel plates account for approximately 30% of newbuilding prices and their fluctuations provide a reliable indicator for fluctuation in shipbuilding costs.

Exchange Rates

Exchange rates can help shipbuilding nations to become more competitive by offering lower prices for new ships. Since most shipbuilding costs are incurred in local currency but the final product is quoted in dollars, a devaluation of the currencies of the major shipbuilding nations against the US dollar will have a negative effect on newbuilding prices, thus making them tempting for shipowners to order, even if the market fundamentals are not there. An example can be Korean yards whose competitiveness may be traced among others to the weakness of their domestic currency. Figure 5.1 shows the price of a new VLCC built in Korea quoted in both US dollars and Korean Won. We can see that despite the fact that after the depreciation of the Won against the US dollar in 1999, the Koreans were quoting prices in Won that were much higher than the 1997 levels. However, in US dollar terms they were quoting a lower price that made them more competitive and kept newbuilding prices low. As a result a negative sign is expected for this variable.

Insert Figure 5.1 somewhere here

Asset Pricing Related Variables

Timecharter Rates

Fluctuations in newbuilding prices may also be a function of the vessel's revenue. This revenue is expressed as the average timecharter equivalent rate per day. The reason for this is that timecharter rates denote the shipowners' and the charterers' expectations of the things to come. Therefore, it is assumed that the higher the time charter rate, the higher the ships profitability and as a result, the more eager the shipowners to invest in new ships are, with a positive effect on their prices. This way, timecharter rates determine Sector Dwt Demand or a sector's orderbook, since shipowners will be eager to build more ships of the ship size or type yielding the highest returns. Therefore, Shipping Dwt Demand determines which type of vessel yards will build. An overall fall in the dwt demand within one specific sector or segment will prompt a shipbuilder to move or increase its production to another sector or segment. For the large yards that are able to switch their production from one sector/segment to another, their order of preference in descending order is:

- Containerships
- LNG carriers
- Tankers
- Bulk Carriers and always the larger the better.

Therefore, for most large shipbuilders the bulk carrier is the vessel of last resort. The building of bulk carriers in large shipyards implies a softer demand for the preferred vessel types and a lowering of newbuilding prices to stimulate ordering in a sector where vessel earnings are restricted by low cargo values. In other words, the newbuilding market for different ship types and sizes is not homogeneous and different ship types and sizes exhibit different characteristics with respect to the determinants of their new ship price. However, while sector dwt demand or ship orderbook is a demand variable, the orderbook as a percentage of the fleet variable that is used in the model is a supply variable since it refers to the amount of new ships that will enter the market in the next few years. This way, as we see later, it can be used as a capacity utilisation proxy.

Based on the analysis above, a positive sign is expected for the coefficient of this variable.

Apart from denoting expectations, the time charter rate is also a much better market indicator than the freight rate, which is route specific, and more importantly in the tanker market, the Worldscale. Apart from denoting expectations, the time charter rate is also a much better market indicator than the freight rate, which is route specific, and more importantly in the tanker market, the Worldscale (see discussion in Chapter 4 for problems associated with Worldscale). There are several reasons for this. A timecharter by definition is the result of an owner and a charterer agreeing to a given hire rate over future period of time and it can be assumed that this in some way reflects the parties market expectations in the period ahead. Timecharter rates are much less volatile than spot rates and therefore do not reflect the highs or the lows of the spot market. Shipowners also like to project their income in terms of being net of operating costs and in this the timecharter rate is perfect whereas the spot rate only provides a gross income position. Spot rates also reflect only a snap shot in time, give no indication of forward expectation and are notoriously difficult to forecast by the nature of their volatility. For all of these reasons spot rates are seldom a driver to newbuilding ordering and it would be unwise by owners to place too much faith in their measurement. By contrast, timecharter rates display greater stability and are easier to understand. It is often a condition of ordering that owners cover their initial forward position with a timecharter.

Second-hand Prices

Second-hand and new ships are substitutes since an increase for example in the price of second-hand ship prices will lead to an increase in the demand for new ships. Moreover, since it is easy for shipowners to switch from second-hand ships to newbuildings, the demand is more elastic thus making these goods close substitutes. In other words, a freight rate increase will increase demand for ships with an immediate positive effect on second-hand ship values, which in effect will make shipowners more eager to order new ships thus pushing newbuilding prices up as well. On top of replacement and substitution however, the driving force connecting second-hand and newbuilding markets is speculation. Speculative orders of a new ship take place only because either the buyer expects the value of the ship to increase in a relatively short period of time, ideally before the vessel's delivery date or because the seller tries to take advantage of a value increase of a ship he has recently ordered. Although the extent of speculative ship sales is unclear, it is certain and evident that this type of activity exists and takes place in shipping. Therefore, the shipowner/speculator continuously compares the price of a new ship with that of a second-hand. If second-hand prices increase substantially he will be eager to pay more for a newbuilding whereas if they decrease he will ask for a lower price from the shipyard.

As a result, second-hand ship prices are used as a proxy for asset speculation and a positive sign is expected for this variable.

Supply-Demand related variables

Shipyard Capacity Utilisation and Orderbook as a percentage of the Fleet

One of the most important variables affecting shipbuilding prices is capacity. Excessive and growing yard capacity ensures that despite substantial increases in Shipyard Output in recent years that have been driven by increase sector dwt demand there has been little or no corresponding increase in new ship prices. In other words, an increase in vessel ordering whether or not prompted by vessel revenue increases may not translate into an increase in newbuilding price if the shipbuilding capacity far outweighs demand. The key factor for shipyards is how full their orderbook is compared to their capacity over time. Therefore, it does not matter how big the world suezmax tanker orderbook is if yards have many slots to fill. If their preferred vessel is Suezmax and they have spare slots they will price accordingly. This brings into perspective the influence of shipyard capacity and competition on newbuilding prices. Therefore, it can be said that the greater the shipbuilding capacity available, the lower the newbuilding prices the yards are eager to offer. In other words, the higher the shipbuilding capacity utilisation, the higher the price the shipyards charge for a new ship will be. Thus, the sign for this variable is expected to be negative. Nevertheless, due to data discrepancies and lack of long enough time series, this variable is excluded from the final model. Discussion regarding this issue follows on the section dealing with problems experienced with data. However, a variable that can be used as a proxy for shipbuilding capacity utilisation is orderbook as a percentage of the fleet. The reason is that a large orderbook compared to existing fleet (capacity) will make shipowners and capital providers like banks unwilling to invest or support investment in a potentially oversupplied sector thus leading to a slide in newbuilding prices. Therefore, a negative effect is also expected for this variable while its relationship to shipyard capacity makes it a good proxy for this variable.

5.4.2 Integrating the variables of the three different approaches

The previous paragraphs have identified the different approaches in modelling newbuilding prices and analysed the variables representing each approach.

These variables affecting the newbuilding market can be represented in terms of a supply and demand framework.

Demand for new ships can be expressed as a function of the timecharter rate and second-hand ship prices.

$$Q_{NB}^{D} = f(tc, \sec ondhand, NB)$$

By the same token supply of second-hand vessels is a function of the orderbook as a percentage of the fleet (used as a proxy for shipyard capacity changes), shipbuilding costs, exchange rate fluctuations and newbuilding prices:

$$Q_{NB}^{S} = f(\frac{Orderbook}{Fleet}, NB, XRATE, NB\cos ts)$$

Since Q^{D}_{NB}=Q^{S}_{NB}, the function can be inverted to obtain newbuilding prices expressed as a function of:

$$NB = f(\overset{+}{tc}, \sec \overset{+}{o}ndhand, \overset{+/-}{\frac{Orderbook}{Fleet}}, NB\overset{+}{\cos} ts, XR\overset{-}{A}TE)$$

Where:

NB = Newbuilding price
Secondhand = Second-hand price of a vessel
tc = The vessel's average timecharter rate per day for the year
Orderbook/fleet = Orderbook as a percentage of the total fleet (including combined carriers) used as an indicator of shipyard capacity availability and utilisation
NBcosts = Shipbuilding costs expressed as the price of rolling steel plates in Japan
XRATE = The USD/Yen and USD/Won exchange rate

On top of each variable, the expected sign is given.

5.5 Data Collection and Analysis

Data collecting proved to be the most time consuming and difficult task. This was not due to the lack of data sources but due to the consistency and quality of the data itself.

5.5.1 Problems Associated With Quoted Newbuilding Prices

As a general rule the main problem with public information is that it is based on reported prices. These may be subject to a margin of error, depending in part on the source they emerge from. However, they seldom (if ever) reveal vital elements such as payment terms. In most business areas, there is likely to be a discount for cash or prompt payment. It may be that, typically, payments are staged (contract signing, keel laying, launching, delivery – with various permutations available). Some deals have payments which are end-loaded, in which case a higher reported price would seem a reasonable expectation. Payment terms may have implications for issues such as refund guarantees. Even for vessels of similar outline specifications, there are valid reasons for price differentials between and within yards. Some of these are listed below (Drewry 2001):

- Reported prices may not be accurate.
- The vessel may or may not be of a standard design, and the degree of changes from the standard specifications demanded by the customer will vary.
- It may be a single ship order, or part of a series, or the order may include future options.
- The vessels may have differing levels of 'bought in' equipment such as engines or containment systems.
- Existing customers may be offered a more competitive price as some yards place customers relations above the level of profit on each individual contract.
- Differing financing terms will alter the final cost.

The Shipyard Capacity Measurement Problem

Shipyard capacity was proven to be the most difficult variable to find data for. The reason behind this is that it is difficult to measure shipbuilding capacity and different sources quote different figures, thus making it very difficult for someone to obtain long series of reliable, widely approved data. The two major sources of information in this area are the Organisation for Economic Cooperation and Development (OECD) and the Association of Western European Shipbuilders (AWES). In many cases on an OECD report, annual output seems to exceed actual capacity, something that cannot happen in reality, while AWES statistics do not make a clear division between available capacity and annual output. Table 5.2 compares the OECD shipyard capacity figures, in CGT (000s), with the delivered ship output in CGT from AWES statistics. In Japan and EU output has substantially exceeded the capacity, whereas no capacity figures are reported for Korea and the US. Furthermore, AWES provides statistics on shipyard capacity from 1975 onwards.

Insert Table 5.2 somewhere here

These examples raise significant doubts of the accuracy and reliability of the above information as a measure of merchant shipbuilding capacity, and hence the supply/demand imbalance in shipbuilding. Therefore, in order to avoid data that could affect the results of the models, it was decided to exclude this variable from the model and use orderbook as a percentage of the fleet as a proxy for shipyard capacity availability and utilisation.

5.6 Model Specification

From the above we saw that the main determinants of newbuilding prices, our dependent variables are shipbuilding costs, second-hand prices, time charter rates, exchange rates and shipbuilding capacity availability and utilisation represented by orderbook as a percentage of the fleet. The series of all these variables for both tankers and bulk carriers in natural logarithms are plotted in graph 5.2. From these it is clear that almost all series are nonstationary although their order of integration is less clearcut. The exact order of integration can be determined by performing a sequence of unit root tests, in this case the Augmented Dickey Fuller unit root tests.

Insert graph 5.2 somewhere here

5.6.1 Testing for a Unit Root

The Augmented Dickey Fuller Test was applied in order to test for a unit root in shipping related variables. An analysis on the number of lags we chose as well as the reasons for including both a trend and an intercept in our estimates are given in Chapter 3. The results in table 5.3 indicate that log-levels of most variables are non-stationary, while their log-first differences are stationary. This suggests that these variables are in fact integrated of first order, I(1). The exceptions are the timecharter variable for all bulk carriers as well as Handy bulk carrier newbuilding and orderbook as a percentage of the fleet variables, which are stationary I(0).

From the analysis of the shipping related variables above it is shown that they are a mixture of I(0) and I(1). This means that if a regression includes such a mixture, no inferences can be made from the results.

In order however not to lose the whole framework of regression based statistical inference, we need to deal with the unit root so that standard assymptotics do apply again. One way to deal with the unit root is to filter the series so that the unit root is filtered out. Therefore an error correction model or an equilibrium correction model is developed.

In our case the error correction model looks like:

$$\Delta \ln NB_t = \alpha_1 + \alpha_2 \Delta \ln Costs_t + \alpha_3 \Delta \ln TC_t + \alpha_4 \Delta \ln XRate_t + \alpha_5 \Delta \ln \frac{Orderbook}{Fleet}_t + \alpha_6 \Delta \ln Secondhand_t$$

$$+ \alpha_7 Dummy + \alpha_8 (\ln NB_{t-1} - \ln TC_{t-1} - \ln XRate_{t-1} - \ln Secondhand_{t-1} - \ln Costs_{t-1} - \ln \frac{Orderbook}{Fleet}_{t-1})$$

In order to specify such a model cointegration tests have to be performed so that cointegrating relations are found. It has to be noted here that an assumption is made that only one cointegrating relationship exists between the variables with the newbuilding price being the dependent one. This thesis will not analyse whether more than one cointegrating relationship exist between the variables, and especially between variables that do not include the dependent one since it is beyond its scope.

Insert Table 5.3 somewhere here

5.6.2 Testing for Cointegration

To test for cointegration the following version of the Johansen approach, corresponding with Option 2 in the relevant routine in EViews, was estimated.

$$\Delta_1 Y_t = \alpha(\beta' Y_{t-1} - \mu_1) + \varepsilon_t$$
$$where:$$
$$Y_t = \begin{pmatrix} \ln NB_t \\ \ln Costs_t \\ \ln TC_t \\ \ln Xrate_t \\ \ln Secondhand_t \\ \ln \dfrac{Orderbook}{Fleet}_t \end{pmatrix}$$

Where α and β' are *(m X r)* full rank matrices, the first one *(α)* of the adjustment factors while the second one (β') of the cointegrating vectors *lnNB. lnTC, lnCosts, lnSecondhand, lnOrderbook/Fleet and lnXRate*.

What is reported in table 5.4 for every ship type rejects the hypothesis that there is no cointegration among our variables at 5% level Based on this approach, it was found that for all ship types there is at least one cointegrating relation in our models. What is reported in table 5.4 for every ship type rejects the hypothesis that there is no cointegration among our variables at 5% level. Where applicable, different combinations of cointegrated variables based on theory and the robustness of the model (based on diagnostic tests), were used as error terms in our model according to the characteristics of each ship type. The various combinations of the cointegrating variables are also reported in table 5.4

Insert Table 5.4 somewhere here

5.7 Output of estimations and test results

The results for all ship types and reports on the standard errors, t-statistics, R-squared, adjusted R-squared and the Durbin Watson statistic are summarised in table 5.5.

In all models R^2 is high and ranges from 0.74 (VLCCs) to 0.92 (Suezmax tankers) with the rest ranging between 0.80 and 0.83. The fit of all equations is good as indicated by the SE of regressions ranging from 0.065 to 0.09.

5.7.1 Tanker Results

Shipbuilding costs were found to have a significant effect for all ship types both in the long and the short run. For example, in the short run, a 10% increase in shipbuilding costs will make newbuilding prices rise by 3.5% in the Handy sector, 5.2% in the Suezmax and 4.3% in the VLCC sector respectively. This was expected since shipbuilders usually filter any increase in shipbuilding costs into the final product, with a positive impact on the vessel’s price. For suezmaxes in particular, this important influence of shipbuilding costs on newbuilding prices can be attributed to the special nature of such vessels. It should be understood that Suezmax tankers are not natural products for shipyards to build as the demand for them is relatively limited. This is because the foot print of a Suezmax is not considerably smaller than a VLCC in a building dock and offers shipbuilders little opportunity to maximise output

– rather to build a VLCC or two aframaxes than one Suezmax. Consequently, Suezmax prices have been closely pegged to VLCCs with a discount but not proportional to the size. In other words Suezmaxes are rarely bargain vessels. Newbuilding prices of Suezmaxes could therefore be more closely tied to shipbuilding costs than for other tanker sizes.

Orderbook as a percentage of the fleet fluctuations used as a proxy for the effects of shipyard capacity availability and utilisation on newbuilding prices, were found statistically significant for all tankers except Panamax. The results indicate the important role shipyard capacity plays in the determination of newbuilding prices.

Exchange rate fluctuations were found not to have an impact in newbuilding prices. However, the fact that shipbuilding costs found to affect newbuilding prices significantly along with the fact that most of shipbuilding materials are purchased by the shipyard in local currency but quoted to the buyer in dollars shows that exchange rate fluctuations still have an important, although less direct and visible at first sight effect on the determination of newbuilding vessel prices.

Freight rates, expressed as time charter rates, fluctuations were found not to affect newbuilding prices in the short run but in the cases of VLCCs, Suezmax and Handy tankers they had a long run effect.

The dummies were found to be significant in large tankers. However, the dummy variable exercises higher influence in the Suezmax and VLCC segments. The reason is that the dummies included in the model are related to political events affecting the Middle East in particular, where most loadings for these types of ships take place.

5.7.2 Bulk Carrier Results

For bulk carriers, like tankers, shipbuilding costs were found to be statistically significant for all ship types. However, the orderbook as a percentage of the fleet and the exchange rate fluctuations were found to have no significant effect on the price of a new vessel.

Freight rate fluctuations seem to affect Handy and Cape size newbuilding prices in the short run. For example, a 10% in freight rates for Handy Bulk carriers will make handy newbuilding prices increase by approximately 4.5%. However, newbuilding prices for Panamax bulk carriers do not seem to be affected by this variable either in the short or the long run.

5.7.3 Overall Results

Overall, shipbuilding costs were found to have a significant effect on the determination of newbuilding prices for all ship types. Also, this variable has the greatest effect of all variables on the determination of newbuilding prices. The reason behind this is that newbuilding prices do not react as quickly to changing market conditions, as do secondhand values. The exception is Handy size bulk carriers where freight rates seem to have the highest effect on the determination of newbuilding prices. This result can be attributed to the fact that since these vessels are scarcely built any more and since they are the workhorse of the industry, they rely heavily on freight rate fluctuations. These fluctuations will determine whether or not to order such ships, particularly in the 30,000dwt segment, which was our benchmark.

For shipbuilding costs the result is in line with what was expected since, traditionally shipbuilding has shifted to countries that could build a ship at the lowest cost. In other words, newbuilding prices are primarily cost driven rather than market driven as second-hand ship prices are. What is interesting however, is that for bulk carriers, such fluctuations are statistically significant in the long rather than the short run. The reason may lie with the fact that being cheaper to build than tankers, bulk carriers are not the first choice of construction in a shipyard where both tankers and bulkers are constructed. This is because a shipyard has a need to get the maximum value from the available space. New contract prices for dry bulk carriers may therefore be driven by the demand and price of alternative vessels like tankers. The timing of the dry bulk carrier order is more crucial than in tankers and often takes place when demand for new tankers has fallen and shipbuilding prices have fallen. Hence, the effect of fluctuations in shipbuilding costs in the long rather than the short run.

Orderbook as a percentage of the fleet used as a proxy for shipyard capacity availability and utilisation, was found statistically significant only for tankers. This is also in line with theory, which says that shipyards increase their capacity with demand for high value tankers in mind rather than the less preferred bulk carriers that are considered as vessels of last resort for shipyards to build.

Exchange rate fluctuations were found to be insignificant for all ship types both in the long and the short run. This means that actual exchange rates do not have an effect on shipbuilding prices. Based on our conclusions from the shipbuilding costs variable, it is the changes in costs due to exchange rate fluctuations that matter.

Time charter rates were found to be statistically significant in the determination of newbuilding prices in handy and Cape Size bulk carriers and in Handy, Suezmax and VLCC tankers. The fact that timecharter rates were not found to be significant for Panamax bulk carriers and Panamax and Aframax tankers may be attributed to the forward nature of newbuilding ordering. This implies that demand for new vessels reflects an anticipated future trading environment rather than the present market. There are many instances however where increased ordering has been witnessed in anticipation of improved future market conditions that were not realised. There have also been times when rising freight rates have not prompted new ordering. This may be the reason why in the aforementioned markets Newbuilding Prices do not seem to be driven by either freight rates or its close relation timecharter rates.

As far as second-hand prices are concerned, the econometric results indicate that they have a significant effect on the newbuilding price of all ship types except VLCCs and Handy size bulk carriers. This means that apart from being predominantly cost driven, newbuilding prices for some ship types may be driven to a certain extent by asset pricing and speculation.

With all these observations and results in mind it is easier for someone to identify and understand the different effects various market variables have on different ship types and markets.

5.8 Diagnostic Tests

In order to test whether inferences can be made from the model, the following tests were performed:

- White and ARCH tests for heteroscedasticity.
- Ljung-Box Q Statistic and Breusch-Godfrey tests for autocorrelation.

The results are summarised in table 5.6 and indicate that neither autocorrelation nor Heteroscedasticity exists. Therefore our OLS estimation is consistent or maximum likelihood.

Insert Tables 5.5 and 5.6 somewhere here.

5.9 Forecasts-Comparison between Error Correction and Autoregressive models

Based on the model estimated above, forecasts were made for all ship types for the period 2000-2001. In addition to that an Autoregressive (AR) model was calculated for all ship types and forecasts were made for the same period. The Akaike and Bayesian Information criteria were used in all cases in order to determine the lag of the model, which for this case is 1. Therefore, our Auto Regressive model has the following form:

$$\ln NB_{t+1} = \mu + \rho \ln NB_t + \eta_{t+1}$$

Where μ is the mean $\eta(t)$ denotes the shock at time t and ρ is the autoregressive coefficient.

Table 5.7 compares the forecasting capabilities of these two different econometric methods. The size of the errors of the model for the actual levels of both ECM and AR are demonstrated with absolute errors, percentage errors and the root mean squared error. These are used to compare the performance of the forecasts of the ECM and AR models.

From this table, it can be seen that AR forecasts outperform those of ECM in five out of eight cases namely for the Panamax bulk carriers, as well as for the Handy, Panamax, Aframax and Suezmax tankers. The error correction model outperforms AR estimates for Handy and Cape size bulk carriers and VLCC tankers. These results imply that the theoretical Error Correction Model is still to be preferred if one wants to achieve the classical objectives of EBCR simultaneously, which are to describe and forecast cycles and to evaluate policies. However, if not all goals have to be met with a single vehicle, other methods might serve the purpose equally well or even better as is the case with the Autoregressive models whose forecasts outperform those of ECM in most cases.

Insert Table 5.7 somewhere here

5.10 Conclusion

This chapter developed a theoretical model from which, thanks to the employment of modern econometric techniques and various diagnostic tests, statistical inferences can be made, thus filling in a gap in the literature of newbuilding vessel prices.

The variables determining new vessel prices have different effects on different ship types, thus adding validity to the argument that analysis at a deseggregated level is needed in order to understand each market segment better. The results obtained are in line with the economic theory stating that newbuilding prices are primarily cost driven in contrast to second-hand prices that are market driven. Furthermore, orderbook as a percentage of the fleet used as an indicator of shipyard capacity plays an important role in the determination of tankers newbuilding prices rather than bulk carrier ones. The reason is that for shipyards bulk carriers are considered to be the vessels of last resort to build and as a result they increase their capacity with the prospects for more expensive ships in mind such as tankers, containers or LNGs. Moreover, the chapter found that newbuilding prices for some ship types might be driven to a certain extent by asset pricing and speculation.

Finally, the chapter compared different econometric methods, the theoretical error correction model and the atheoretical Auto Regressive (AR) model. Error Correction Models, are still to be preferred if one wants to achieve the classical objectives of EBCR simultaneously (to describe and forecast cycles, to evaluate policies and test economic theories).

However, if not all goals have to be met with a single vehicle, other methods may serve the purpose equally well or even better as is the case with the Auto Regressive method whose forecasts outperform those of ECM in most occasions.

Table 5.1: Different Approaches in analysing New Vessel Prices	
Tinbergen	Supply-Demand (Cobweb)
Koopmans	Supply-Demand (Cobweb)
Hawdon	Asset pricing - Cost Based
Beenstock	Asset pricing
Beenstock and Vergottis	Asset pricing
Di Jin	Supply Demand - Cost Based
Volk	Asset Pricing - Cost Based

Figure 5.1:VLCC price in Korea
Price coverted to Won (Billion)

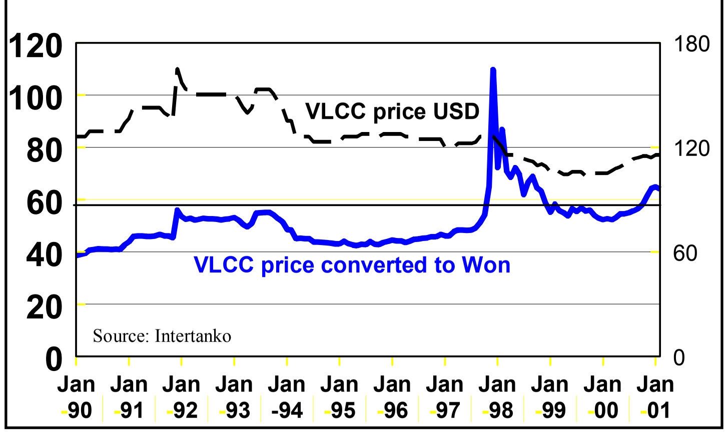


Table 5.2: OECD Shipbuilding Capacity and Output

	1997		1998	
	Capacity	Output	Capacity	Output
EU	3190	3225	3230	3586
Japan	5600	6298	5600	6834
Korea	-	3983	-	3656
USA	-	134	-	360.4

Source: Capacity OECD, Output AWES

Table 5.3: ADF Test Results for Stationarity

	Bulkers						Tankers									
	Handy		Panamax		Capes		Handy		Panamax		Aframax		Suezmax		VLCC	
	Level	1st Dif	Level	1st Dif	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.
LnNB	-3.17	-5.64*	-3.19	-4.06*	-3.22	-5.07*	-2.00	-4.78*	-3.02	-4.50*	-2.51	-3.60*	-2.99	-5.69*	-2.94	-3.57*
LnTC	-3.82*	-5.46*	-4.24*	-5.55*	-4.12	-5.84*	-3.37	-4.41*	-3.49	-4.93*	-3.03	-5.10*	-3.13	-4.51*	-2.32	-4.88*
Lnorderbook/fleet	-3.63*	-5.19*	-2.90	-4.79*	-1.88	-7.67*	-2.79	-3.77*	-3.01	-5.38*	-2.90	-4.37*	-1.85	-4.95*	-3.02	-4.89*
LNSECONDHAND	-3.43	-4.65*	-3.25	-4.50*	-3.37	-5.00*	-2.62	-4.34*	-2.71	-3.98*	-3.00	-4.32*	-2.25	-4.48*	-2.52	-4.61*
	Levels		1st Dif.													

Ship. Costs (Lnnbcosts)	-2.33	-6.46*						
Exch. Rate (lnyen)	-2.09	-4.08*						
Exch. Rate (lnwon)	-2.31	-4.59*						

ADF test models contain an intercept and a trend. The null hypothesis is that the series is non-stationary. This hypothesis is rejected if the statistics are larger in absolute values than the critical values. Number of lagged first difference terms added to the regression: One(1).

*, Denotes variable stationarity based on MacKinnon's critical value of -3.5731 at 5% level

Table 5.4 Johansen Cointegration Tests Newbuilding Prices (std. Errors in parentheses)

	Bulkers						Tankers									
	Handy		Panamax		Capes		Handy		Panamax		Aframax		Suezmax		VLCC	
LnNB	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LnSecondhand	-0.33 (0.4)	-	-0.51 (0.06)	-0.49 (0.05)	-0.18 (0.74)	-	-1.74 (0.25)	-0.8 (0.13)	-0.64 (0.1)	-0.68 (0.05)	0.37 (0.22)	-0.47 (0.06)	-0.55 (0.21)	-	-0.17 (0.05)	-
LnTC	-0.23 (0.06)	-	-0.31 (0.07)	-	-0.89 (0.1)	-	-0.52 (0.38)	-0.34 (0.18)	-0.4 (0.07)	-	-1.03 (0.21)	-	0.07 (0.11)	-0.33 (0.03)	-0.58 (0.07)	-0.18 (0.06)
LnOrderbook/Fleet	0.12 (0.02)	-	0.01 (0.03)	-	0.26 (0.04)	-	2.16 (0.21)	-	-0.29 (0.056)	-	0.01 (0.05)	-	0.02 (0.08)	-	0.21 (0.02)	-
LnXrate	-0.13 (0.03)	-	-0.27 (0.05)	-	-0.31 (0.08)	-	-0.34 (0.148)	-	0.34 (0.07)	-	0.29 (0.12)	-	0.72 (0.15)	-	0.29 (0.05)	-
LnNBCosts	-0.15 (0.04)	-1.48 (0.27)	-0.2 (0.06)	-0.25 (0.04)	0.49 (0.13)	-0.66 (0.11)	1.7 (0.28)	-	-0.07 (0.09)	-	-0.58 (0.19)	-0.33 (0.11)	-0.44 (0.25)	-0.87 (0.08)	-0.51 (0.07)	-1.22 (0.14)
C	1.31 (0.5)	6.1 (1.57)	3.52 (0.73)	-0.35 (0.21)	3.8 (0.85)	0.47 (0.66)	-7.04 (2.65)	2.08 (1.32)	1.02 (0.62)	-1.31 (0.15)	6.49 (2.17)	-0.16 (0.52)	-4.96 (1.89)	4.54 (0.48)	2.74 (0.64)	4.8 (0.86)
Eigenvalue	0.83	0.34	0.82	0.49	0.83	0.32	0.92	0.49	0.76	0.39	0.83	0.57	0.84	0.65	0.86	0.48
λ trace	155.9	20.11	145.8	42.08	157.44	21.7	149.1	37.2	123.12	20.48	132.36	44.5	161.75	44.7	149.57	41.1
λ max for 1 coint. Eq.@5%	102.14	19.96	102.14	34.91	102.14	19.96	102.14	34.91	102.14	19.96	102.14	34.91	102.14	34.91	102.14	34.91
Log Likelihood	109.26	37	105.78	45.7	90.96	34.32	104.08	37.3	58.39	46.67	114.1	46.23	74.67	38.15	70.73	36.4

Table 5.5: Regression Results OLS Newbuilding Prices								
	Bulkers			**Tankers**				
	Handy	**Panamax**	**Capes**	**Handy**	**Panamax**	**Aframax**	**Suezmax**	**VLCC**
C(1)	-2.81* (0.6)	-0.18 (0.64)	-0.47 (0.57)	-1.86 (1.13)	0.33 (0.42)	-0.33 (0.43_	-3.45* (0.43)	-2.58* (0.58)
D(LNSECONDHAND)	0.02 (0.1)	0.28* (0.1)	-0.03 (0.12)	0.37* (0.08)	0.62* (0.11)	0.30* (0.3)	0.14* (0.06)	0.01 (0.06)
D(LNTC)	0.45* (0.1)	0.06 (0.12)	0.10* (0.1)	0.12 (0.06)	0.00 (0.06)	-0.04 (0.07)	0.02 (0.04)	0.03 (0.08)
D(LNORDERBOOK/FLEET)	-0.04 (0.04)	-0.02 (0.04)	0.02 (0.05)	0.14* (0.04)	0.01 (0.04)	-0.10* (0.04)	-0.07* (0.03)	-0.10* (0.05)
D(LNXRATE)	-0.26 (0.16)	-0.12 (0.16)	0.11 (0.17)	-0.26 (0.15)	0.08 (0.14)	0.00 (0.11)	0.52* (0.11)	0.18 (0.16)
D(LNNBCOSTS)	-0.04 (0.13)	0.17 (0.14)	0.26 (0.18)	0.35* (0.1)	0.28* (0.1)	0.08 (0.13)	0.15 (0.11)	0.43 (0.15)
DUMMY	-0.21* (0.09)	-	-0.29* (0.1)	0 (0.06)	0 (0.04)	0.18* (0.05)	0.26* (0.04)	0.14* (0.07)
LNNB(-1)	-0.83* (0.13)	-0.78* (0.19)	-0.34* (0.13)	-0.59* (0.14)	-0.40* (0.17)	-0.57* (0.1)	-0.63* (0.08)	-0.61* (0.11)
LNNBCOSTS(-1)	0.25* (0.1)	0.22* (0.1)	0.83* (0.29)	-	-	0.42* (0.16)	1.09* (0.1)	1.18* (0.16)
LNSECONDHAND(-1)	-	0.49* (0.12)	-	0.60* (0.15)	0.81* (0.2)	0.52* (0.08)	-	-
LNTC(-1)	-	-	-	0.52* (0.22)	-	-	0.28* (0.04)	0.14* (0.06)
R-squared	0.83	0.79	0.8	0.81	0.82	0.8	0.91	0.74
Adj. R-squared	0.77	0.72	0.72	0.73	0.76	0.72	0.88	0.62
S.E. of regres.	0.09	0.09	0.09	0.09	0.08	0.07	0.07	0.1
Sum sqd resid	0.2	0.2	0.15	0.17	0.16	0.09	0.09	0.17
Durbin Watson	1.83	1.91	1.69	2.17	1.53	2.3	2.12	2.07
* = Denotes significance at 5% level , Std. Errors in parentheses, Series in logarithms								

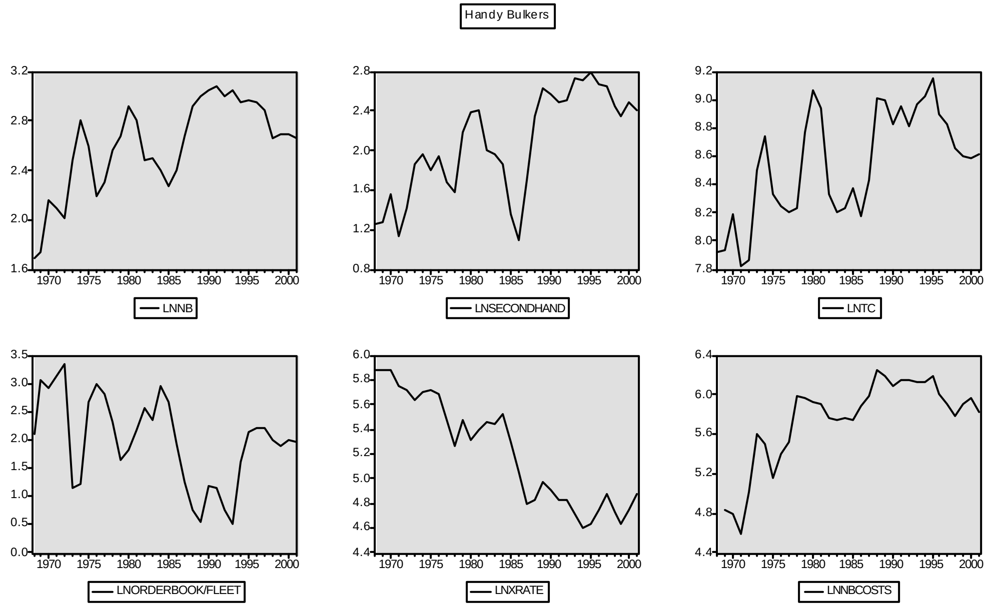
Table 5.6: Diagnostic Tests (p-values in parentheses)

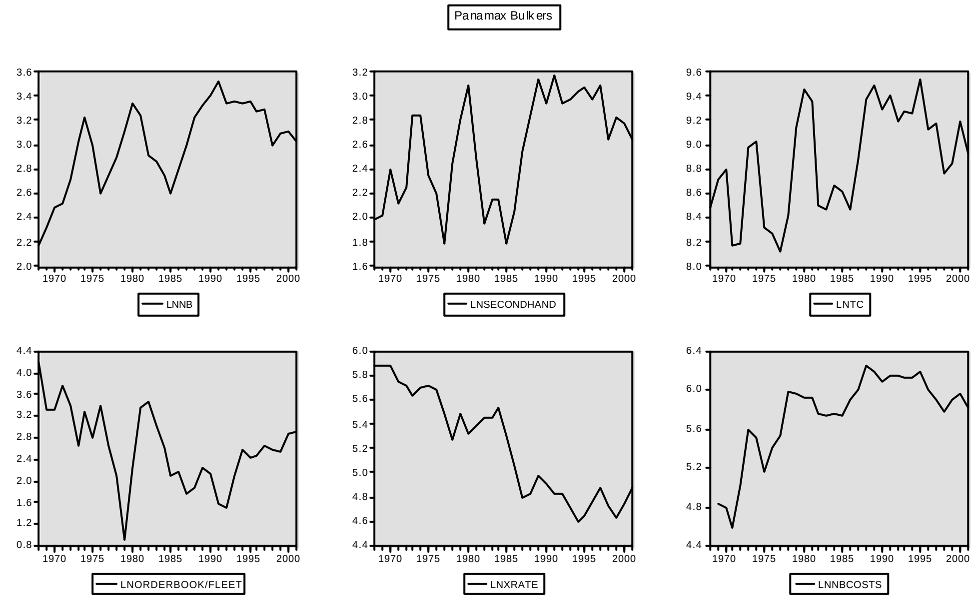
	Correlogram Q Statistic (1 lag)	Correlogram Squared Residuals(1 lag)	Serial Correlation LM Test (2 lags)		ARCH LM Test (1 lag)		White Heteroscedasticity Test (no cross terms)	
Ship Type			**F Statistic**	**Obs*R-Squared**	**F Statistic**	**Obs*R-Squared**	**F Statistic**	**Obs*R-Squared**
Handy Size Bulk Carrier	0.24 (0.62)	1.90 (0.17)	0.78 (0.47)	2.22 (0.33)	1.71 (0.2)	1.73 (0.19)	0.72 (0.75)	19.23 (0.57)
Panamax Bulk Carrier	0.00 (0.999)	0.15 (0.7)	0.00 (0.999)	0.00 (1)	0.13 (0.72)	0.14 (0.71)	1.1 (0.46)	21.3 (0.38)
Cape Size Bulk Carrier	0.7 (0.4)	0.04 (0.85)	0.32 (0.73)	1.05 (0.59)	0.03 (0.86)	0.03 (0.85)	0.99 (0.59)	23.86 (0.41)
Handy Tanker	0.32 (0.57)	0.11 (0.74)	0.45 (0.64)	1.42 (0.49)	0.09 (0.77)	0.1 (0.76)	2.92 (0.12)	25.98 (0.25)
Panamax Tanker	0.79 (0.37)	0.73 (0.39)	0.74 (0.49)	2.1 (0.36)	0.67 (0.42)	0.7 (0.4)	1.54 (0.26)	23.2 (0.28)
Aframax tanker	0.78 (0.38)	0.14 (0.71)	0.63 (0.54)	1.96 (0.38)	0.12 (0.73)	0.128 (0.72)	0.61 (0.82)	20.99 (0.58)
Suezmax Tanker	0.14 (0.71)	1.37 (0.24)	0.68 (0.52)	2.11 (0.35)	1.19 (0.29)	1.22 (0.27)	0.34 (0.97)	16.89 (0.82)
VLCC	0.06 (0.80)	2.25 (0.13)	0.05 (0.96)	0.15 (0.93)	2.1 (0.16)	2.1 (0.15)	0.93 (0.6)	23.52 (0.43)

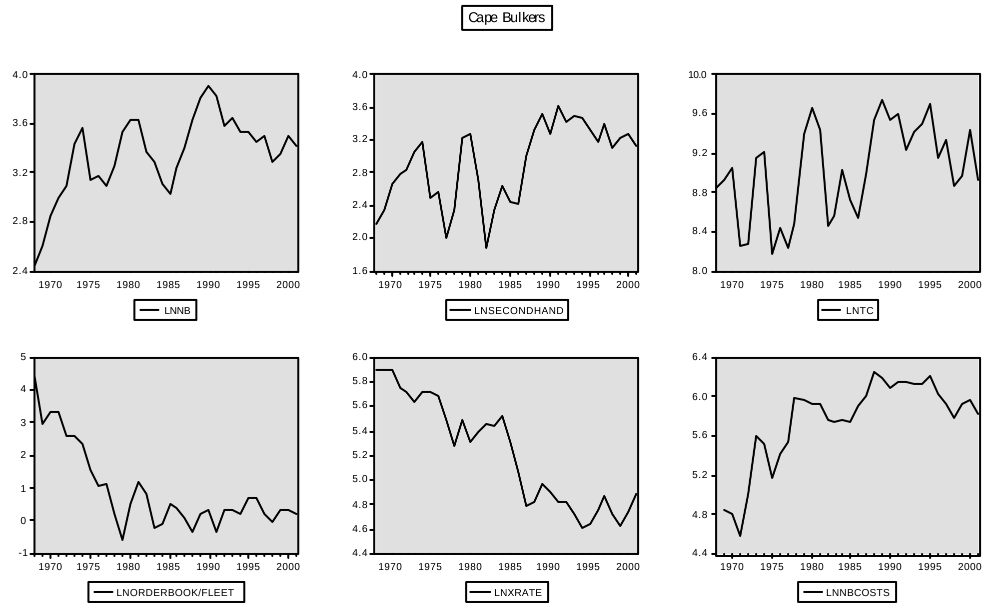
Table 5.7:
ECM-AR Forecast Comparison for 2000-2001

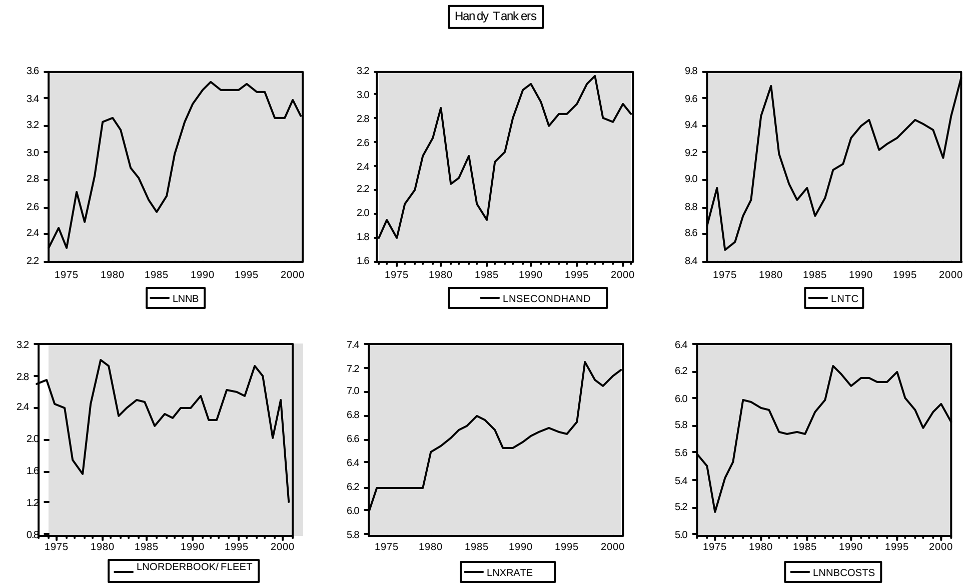
	Handy B/C	Panamax B/C	Cape B/C	Handy Tanker	Panamax Tanker	Aframax Tanker	Suezmax Tanker	VLCC Tanker
ECM								
Absolute errors	**0.03**	0.07	**0.004**	0.1	0.15	0.096	0.09	**0.06**
Percentage errors	**0.96**	2.39	**0.11**	3.	4.29	2.61	2.28	**1.45**
Mean squared errors	**0.03**	0.08	**0.004**	0.12	0.17	0.1	0.10	**0.077**
AR								
Absolute errors	0.04	**0.05**	0.07	**0.07**	**0.07**	**0.05**	**0.05**	0.07
Percentage errors	1.33	**1.62**	2.001	**1.98**	**2.08**	**1.29**	**1.20**	1.58
Mean squared errors	0.04	**0.06**	0.09	**0.09**	**0.07**	**0.05**	**0.07**	0.09

Graph 5.2: Variables included in the newbuilding price model

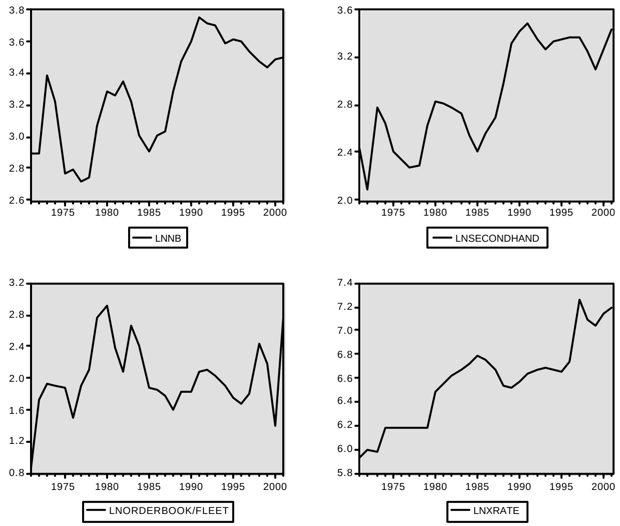




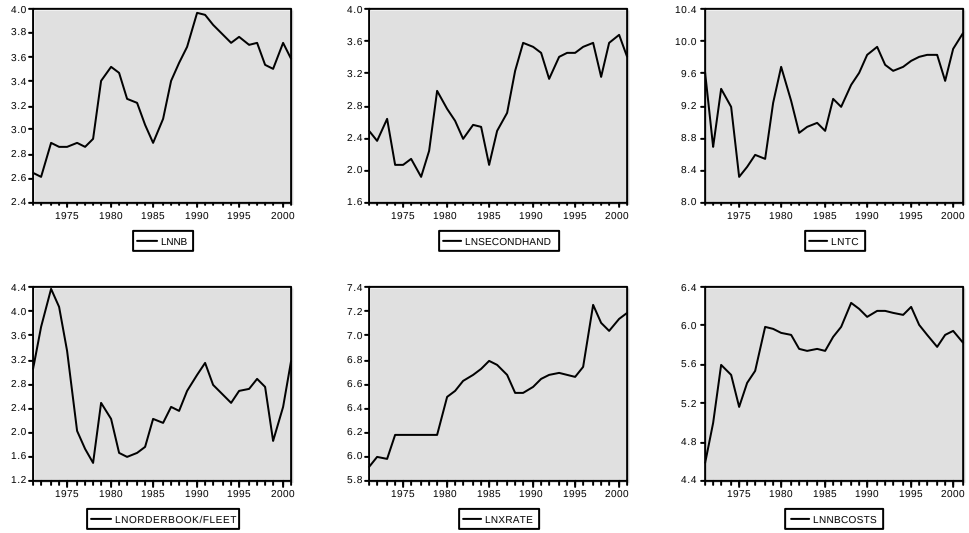




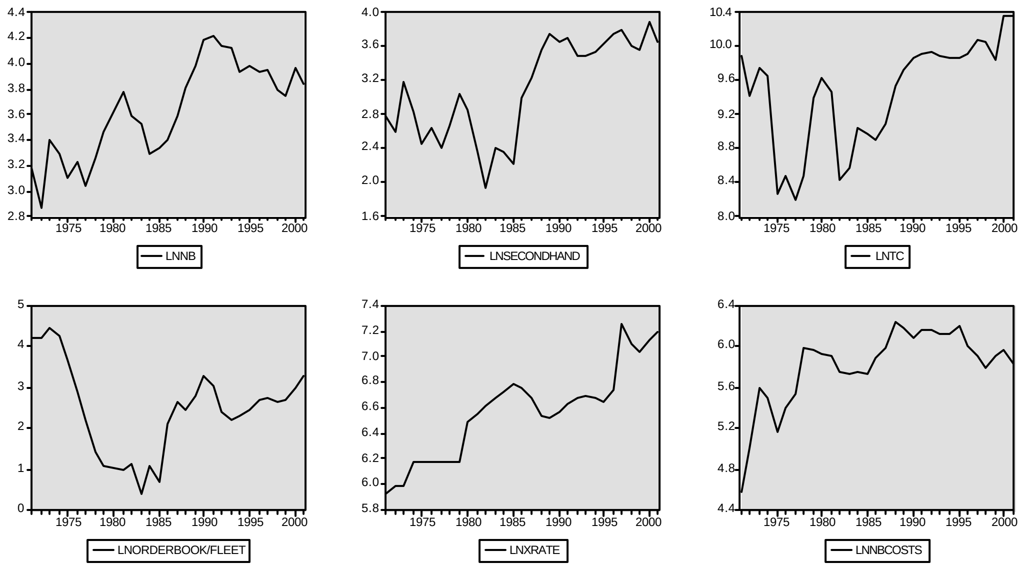
Panamax Tankers



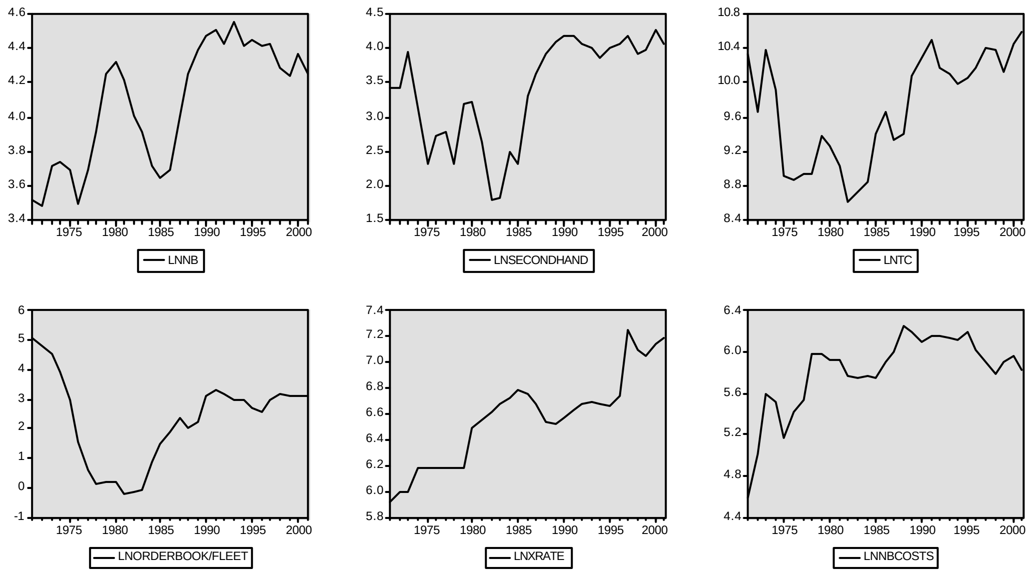
Aframax



Suezmax



VLCC



Chapter 6: Econometric Modelling of Second-hand Ship Prices

6.1 Introduction

6.1.1 The Market for Second-hand Vessels

Shipping is one of the few industries having a separate and active market where the main assets themselves are traded. The market for second-hand ships plays an important economic role in the shipping industry. It gives shipowners and investors the opportunity to buy and sell ships directly, thus allowing easy entry and exit to the freight market. This is a major condition for market competitiveness.

Also, the importance of the second-hand ship market lies with the fact that due to the extreme cyclicality of the markets, considerable profit opportunities exist through asset play, or in other words the ability to buy low and sell high. Timing of the investment is a critical issue here. Instances of low freight rates usually coincide with low vessel values but despite the fact that this is bad news for owners of existing tonnage it provides opportunities for new investors to buy in at a low cost. This can exacerbate the volatility of the market.

These important functions of the second-hand ship market have attracted the interest of many researchers who have developed and estimated theoretical models that explain the fluctuations in second-hand ship values. However, since these theoretical models were developed in the 70s and 80s, they have not kept in pace with the developments in econometric tools and techniques and suffer from problems analysed in chapters 3 and 4. Consequently, their results are biased and no statistical inferences can be made from them. Over the last decade researchers have applied modern econometric techniques in shipping and the second-hand market in particular (see for example Veenstra (1999), Kavussanos (1996a, 1996b, 1997), but by employing atheoretical models. However, there is still a gap for a theoretical model of the second-hand ship market employing modern econometric techniques. This chapter aims at filling this gap in the literature by developing a theoretical error correction model for the second-hand market that caters for all the above problems and from which statistical inferences can be made.

The chapter is structured as follows. The following section provides a literature review of the most important work done on the topic and its shortcomings, while the subsequent section focuses on the development of this chapter's modelling strategy. Methodological analysis is followed by model estimation and results discussion. Finally, the chapter compares the forecasting abilities of the developed model with that of an Autoregressive (AR) one for all ship types under investigation.

6.2 Literature Review

With the exception of Charemza and Gronicki (1981) who report equations in which ship prices adjust to freight and activity rates, Beenstock (1985) is the first one paying attention to ship markets and the determination of ship prices. Beenstock argues that supply and demand analysis is not appropriate for ship prices since a ship is a capital asset of considerable longevity. However, this is a false statement and as it will be shown later in the chapter supply and demand analysis is appropriate for modelling ship prices.

Based on portfolio theory, Beenstock comes up with the following equation:

$$\frac{Fleet * Secondhand_t}{W_t} = f_{Secondhand}\left(\frac{E_t \Pi_{t+1}}{Secondhand_t}, \frac{E_t Secondhand_{t+1}}{Secondhand_t}, i_t\right)$$

Where:
Secondhand: the second-hand price
W: the world wealth
Fleet: The fleet Size (bulk carrier or tanker depending on the circumstances)
$E_t\Pi_{t+1}$= expected ship earnings for the coming year, equal to time charter minus operating costs
E_tSecondhand$_{t+1}$= Expected second-hand price for next year
i: the interest rate

According to his theory the share of ships in world total wealth varies directly with the expected return on ships as capital assets and is inversely related with alternative investments.

This capital asset equation is based on the assumption that the share of ships in the total world wealth behaves like being part of a well-diversified portfolio consisting of all world wealth. In other words, for given rates of return and wealth, the demand for ships varies inversely with the price of ships since the relative return on ships falls as price rises and because of wealth effects induced by relative ship prices changes.

Beenstock and Vergottis (1989a, 1989b, 1992, 1993) follow this approach in all their subsequent research.

A capital asset allocation model is meant to calculate the optimal shares in assets of a portfolio, given certain fixed expected return and risk for all assets. However, Beenstock and Vergottis do not give any arguments why this model can also be applied to calculate ship prices or the reason it can be applied for stock prices or the price of any asset.

Besides that, world wealth is something very hard to measure and it is certainly not equivalent to world GDP, which Beenstock and Vergottis use in their model.

In addition, Beenstock (1985) assumes that new and second hand ship prices are perfectly correlated, thus new and second-hand ships are the same asset, only differing in age. This assumption however is open to criticism. If asset play is an important consideration, these prices should not be very highly correlated. Beenstock himself observes that these conditions are unlikely to be fulfilled because second-hand prices are flexible whereas new prices are relatively sticky. This implies that new prices adjust to second-hand prices over time rather than instantaneously as he assumed. For this reason, in his following work together with Vergottis (1989, 1992 and 1993), he introduces an additional dynamic element into the model, the newbuilding market.

Again however, this argument by Beenstock is open to criticism. Both newbuilding and second-hand prices are supply/demand driven. It is nonetheless true that newbuilding prices are more driven by cost factors (labour, raw materials, equipment, design, supervision, debt, exchange rates etc.) as shown in Chapter 5 whereas second-hand prices are in turn more driven by market forces.

In simple terms newbuilding prices represent a cost plus figure whereas second-hand prices are realisations of values not costs. There is no evidence to support the notion that newbuilding prices fluctuate more than building costs. On the contrary there are many examples where building costs have escalated out of control between agreeing the contract price and delivering the vessel e.g. the construction of large parcel tankers in Denmark and France that caused major losses for the yards. In such instances newbuilding prices have not risen by anywhere near the same degree as costs. It is also the experience of the author during years of market analysis that newbuilding prices do not react as quickly to changing market conditions as second-hand values.

Therefore, newbuilding prices cannot possibly adjust to something that is so volatile and speculative. No country would adjust shipbuilding capacity, involving a lot of heavy investment and sunk costs, to speculative movement of prices.

Overall it can be said that Beenstock and Vergottis' equation is needlessly complicating. A simple present value equation as the ones presented in the Norwegian models would suffice.

Strandenes (1984, 1986) regards second hand values as a weighted average of short and long-term profits. In Strandenes (1986) the second-hand market is integrated with the newbuilding market. The second-hand price depends on expectations concerning future developments in other shipping markets. As a result a present value equation is estimated including the ship's value, its expected cashflow in each period and the number of expected trading days.

Individual cash flows are then substituted by average expected earnings per year. An interesting point is the assumption of infinite economic life and the inclusion of a depreciation factor. The assumption of infinite economic life however is not realistic, as ships have a finite life and a substantial terminal value. Kavussanos and Alizadeh (2002a) show that if this is not taken into account results are different. Expected earnings are then expressed as a weighted sum of current and future expected long-term earnings. Finally by using the real depreciation factor to correct for the ship's age, a general formula for any ship price regardless of age is obtained.

By using the cointegration methodology, Veenstra (1999) establishes that second hand ship prices for various ship sizes in bulk markets are stationary in first differences, thus permitting the search for long-run cointegrating vectors between them. The variables chosen for examination include the second-hand price, a time charter rate, as well as newbuilding and scrap prices. Veenstra distinguishes between replacement and speculative sales. He analyses the data for this different type of sales based on two different ages: 5 year old ships representing the replacement sales and 10 year old ship representing the speculative sales. Veenstra has been criticised for his approach to modelling second hand ship prices. Glen (2001) for example argues that the definition of all second hand ship transactions being replacement driven for 5 year old vessels and all 10 year old vessels transactions being speculative driven seems arbitrary and difficult to defend.

Kavussanos (1996b, 1997) examines the dynamics of volatilities in the dry-bulk and tanker markets. By employing time-series modelling, atheoretical ARCH models, he finds that prices of small vessels are less volatile than larger ones and the nature of this volatility varies across sizes. Glen and Martin (1998) make a similar study on tanker market risk. Their results are in line with Kavussanos, despite differences in data, sample period and modelling technique.

In another application of modern econometrics to second-hand ship market, Glen (1997) examines the dynamic behaviour of second hand prices of tankers and dry cargo vessels over various time periods. He aims to determine whether or not the market for such assets is efficient. He extends and re-analyses the results of an earlier study by Hale and Vanags (1992) by employing the Johanssen method of testing for cointegration. He concludes that the existence of cointegration does not necessarily imply market inefficiency, if the factors that create the common trends are stochastic in nature. Therefore he argues that the evidence put forward in his chapter is consistent with market efficiency in the long run.

In line with Chapters 4 and 5, this chapter develops a theoretical (Error Correction) model for the second-hand vessel market that gives reliable results from which economic inferences can be made confidently. It contributes to the second-hand ship prices literature the same way as the previous two chapters have done for the freight and the newbuilding market respectively.

6.3 Variable Identification

An analysis of the second-hand market can be represented in terms of a supply and demand framework.

Demand for second-hand ships can be expressed as a function of the timecharter rate, newbuilding price, second-hand price and the cost of capital.

$$Q_{SH}^{D} = f(TC, \sec ondhand, NB, LIBOR)$$

By the same token supply of second-hand vessels is a function of the orderbook as a percentage of the fleet and second-hand prices:

$$Q_{SH}^{S} = f(Orderbook / Fleet, \sec ondhand)$$

Since $Q^{D}_{SH}=Q^{S}_{SH}$, the function can be inverted to obtain second-hand ship prices expressed as a function of:

$$\sec ondhand = f(\overset{+}{TC}, \overset{+}{NB}, \overset{+/-}{\frac{Orderbook}{Fleet}}, \overset{-}{LIBOR})$$

Where:

Secondhand= Second-hand price of a vessel
TC = The vessel's average timecharter rate per day for the year
NB= Newbuilding price
Orderbook/Fleet= Orderbook as a percentage of the total fleet (including combined carriers)
LIBOR = Interest Rates (LIBOR)

On top of each variable, the expected effect is given.

According to our model, second-hand prices are a function of the vessel's revenue. This revenue is expressed as the average timecharter equivalent rate per day. The reason for this is that timecharter rates denote the shipowners' and the charterers' expectations of the things to come. Therefore, it is assumed that the higher the time charter rate, the higher the ship's profitability and as a result, the higher its second-hand value. Consequently a positive sign is expected for the coefficient of this variable.

Furthermore, according to a view firstly expressed by Beenstock (1985) second-hand ships are also capital assets. This means that they compete with other investments in terms of profitability. The higher the return on investment in shipping, both through operational and asset play earnings, the more money investors will be willing to pour in the market and as a result the higher the demand for second-hand ships. In principle, this argument is correct but there are exceptions; Norwegian K/S schemes for example have served to illustrate that there have been times when second-hand prices have appeared to move outside of the primary influences of earnings and newbuilding prices. At the height of their popularity there were many K/S schemes in the market to buy tonnage and this pushed the price up for second-hand vessels even though vessel earnings were low. This also supports the comments elsewhere that ships themselves are a tradable commodity that encourages many owners to engage in the practice of asset play.

Apart from denoting expectations, the time charter rate is also a much better market indicator than the freight rate, which is route specific, and more importantly in the tanker market, the Worldscale. There are several reasons for this, that were analysed extensively in Chapters 4 and 5 as well as in Tsolakis, Cridland and Haralambides (2003).

Another variable affecting second-hand ship price is the price of new vessels. Second-hand and newbuilding ships are substitutes since an increase for example in the price of second-hand ship prices will lead to an increase in the demand for new ships. Moreover, since it is easy for shipowners to switch from second-hand ships to newbuildings, the demand is more elastic thus making these goods close substitutes. As a result a positive sign is also expected for this variable.

Fleet size and orderbook have an impact on the value of a second-hand price. This variable is a good market indicator since it catches fluctuations on both fleet size and orderbook. Furthermore, it denotes expectations on how the market will develop. A large orderbook compared to existing fleet may create negative expectations for the future thus leading to a slide in second-hand prices. On the other hand a large orderbook may show that there is a potentially lucrative market segment where there are too few ships unable to satisfy demand. An example is the VLCC orderbook in 1970 that was almost three times the size of the existing fleet or more recently the Super Handy Max bulk carrier and the super post panamax container vessels. This of course will have a positive effect on second-hand prices. As a result this variable may have either a positive or a negative sign, depending on the circumstances.

Finally, the cost of capital, expressed as the average 3-month London Interbank Offered Rate (LIBOR), is assumed to affect the price of second-hand ships negatively, since the higher the interest rate, the higher the cost of capital and as a result the lower the liquidity of most shipowners. This low liquidity limits the shipowners' ability to bid higher for a second-hand vessel. In this case, the availability of finance provided to shipowners on an annual basis would have been a much better indicator of the shipowners' liquidity. Unfortunately, the authors could not find such data. Traces of such information were found in an article by Mr. Newbold of Citibank (1994). However, when Citibank was contacted for more information, they were disappointed to find out that the data contained in this article was nothing more than arbitrary estimations based on assumptions made by Citibank staff rather than real data (Sahni 2002). The reason that this variable is not included in the newbuilding model presented in Chapter 5 as well is that there is always an abundance of sources and levels of capital to finance a newbuilding project, especially government subsidies and shipyard credit schemes that are normally unavailable to second-hand investors. Furthermore, investors opting for newbuildings rather than second-hand ships are in principle more liquid than those investing in second-hand tonnage. This means that this variable does not affect the determination of new ship prices or the decision to buy or build a new ship as much as it does in second-hand ship market.

6.4 Model Specification

6.4.1 Testing for a Unit Root

The Augmented Dickey Fuller Test was applied in order to test for a unit root in shipping related variables. An analysis on the number of lags we chose as well as the reasons for including both a trend and an intercept in our estimates are given in Chapter 3.

Insert Table 6.1 somewhere here

The results in table 6.1 indicate that log-levels of most variables are non-stationary, while their log-first differences are stationary. This suggests that these variables are in fact integrated of first order, I(1). The exceptions are the timecharter variable for all bulk carriers as well as Handy bulk carrier newbuilding and orderbook as a percentage of the fleet variables, which are stationary I(0).

From the analysis of the shipping related variables above it is shown that they are a mixture of I(0) and I(1). This means that if a regression includes such a mixture, no inferences can be made from the results.

In order however not to lose the whole framework of regression based statistical inference, we need to deal with the unit root so that standard assymptotics do apply again. One way to deal with the unit root is to filter the series so that the unit root is filtered out. Therefore an error correction model or an equilibrium correction model is developed.

In our case the error correction model looks like:

$$\Delta \ln secondhand_t = a_1 + a_2 \Delta \ln NB_t + a_3 \Delta \ln TC_t + a_4 \Delta \ln LIBOR_t + a_5 \Delta \ln \frac{Orderbook}{Fleet}_t + a_6 \Delta DUMMY$$
$$+ a_7 (\ln secondhand_{t-1} - \ln TC_{t-1} - \ln LIBOR_{t-1} - \ln NB_{t-1} - \ln \frac{Orderbook}{Fleet}_{t-1})$$

In order to specify such a model cointegration tests have to be performed so that cointegrating relations are found. It has to be noted here that an assumption is made that only one cointegrating relationship exists between the variables with the second-hand price being the dependent one. This thesis will not analyse whether more than one cointegrating relationship exist between the variables, and especially between variables that do not include the dependent one since it is beyond its scope.

6.4.2 Testing for Cointegration

To test for cointegration the Johansen (1991) approach was taken. Since, based on graph 6.1 most of the variables display trending patterns, the following version of the Johansen approach, corresponding with Option 4 in the relevant routine in EViews, was estimated:

$$\Delta_1 Y_t = \mu_0 + \alpha(\beta' Y_{t-1} - \mu_1 - \delta_1 t) + \varepsilon_t$$

where

$$Y_t = \begin{pmatrix} \ln secondhand_t \\ \ln NB_t \\ \ln TC_t \\ \ln LIBOR_t \\ \ln \dfrac{Orderbook}{Fleet}_t \end{pmatrix}$$

Where α and β' are *(m X r)* full rank matrices, the first one *(α)* of the adjustment factors while the second one (β') of the cointegrating vectors *lnsecondhand, lnTC, lnNB, lnLIBOR, lnOrderbook/Fleet*. This model also allows the individual time series to have trends by not restricting μ_0 to zero, while the cointegrating relations attain their equilibrium values at $\mu_1+\delta_1 t$. Based on this approach, it was found that for all ship types there is at least one cointegrating relation in our models. What is reported in table 6.2 for every ship type rejects the hypothesis that there is no cointegration among our variables at 5% level. Where applicable, different combinations of cointegrated variables based on theory and the robustness of the model (based on diagnostic tests), were used as error terms in our model according to the characteristics of each ship type. The various combinations of the cointegrating variables are also reported in table 6.2

Insert Graph 6.1 somewhere here
Insert Table 6.2 somewhere here

6.5 Diagnostic Tests

In order to test whether inferences can be made from the model, the following tests were performed:

- White and ARCH tests for heteroscedasticity.
- Ljung-Box Q Statistic and Breusch-Godfrey tests for autocorrelation.

The results are summarised in table 6.4 and indicate that neither autocorrelation nor Heteroscedasticity exists. Therefore our OLS estimation is consistent or maximum likelihood.

6.6 Model Results

The results for all ship types and reports on the standard errors, t-statistics, R-squared, adjusted R-squared and the Durbin Watson statistic are summarised in table 6.3.

In all models R^2 is high and ranges from 0.74 (VLCCs) to 0.95 (Panamax tankers) with the rest ranging between 0.75 and 0.90. The fit of all equations is good as indicated by the SE of regressions ranging from 0.05 to 0.27.

6.6.1 Tankers Results

Time charter rates were found statistically significant in all market segments in the short run. The effect of a 10% increase in time charter rates ranges from 2% (Panamax tankers) to 7.5% (VLCCs) increase on the price of second-hand vessels, with the rest lying between 3.5 and 6%.

Newbuilding prices were found significant in all market segments both in the long and the short run. Short run effects on second-hand values range from an increase of 6%(Handy tankers) to almost 20% (VLCCs) with the rest of the second-hand values rising between 8 and 10% respectively for a 10% increase in newbuilding prices.

The only exception is the Aframax tanker market, where due to the fact that it is regarded as the workhorse of the industry relies too much on timecharter rates. Therefore, newbuilding price changes are only significant in the long run.

Also, changes in orderbook as a percentage of the fleet are significant in the long rather than the short run with negative effects on the second-hand values of the VLCCs, Suezmax and Panamax tankers respectively. For the other two markets this variable does not seem to have an effect.

The cost of capital was found to be insignificant for all tanker segments. The exception is the Suezmax market.

Finally, the dummy variable included to investigate the effects of the oil crises in 1973 and 1979 and the Tap Line closure in 1971 was found to have significant explanatory power in all markets except Aframax tankers.

6.6.2 Bulk Carriers Results

Newbuilding prices and Timecharter rates are statistically significant in the short run for all types. The only exception is the Handy Bulk Carrier market where newbuilding prices were found to be statistically insignificant. The reason may be that there are not many newbuildings entering the market or on order. Furthermore, handy is the industry's workhorse and relies heavily on timecharter rates (a 10% increase on timecharter rates will make second-hand prices increase by 8%).

While in Handies timecharter rates have a higher effect than newbuilding prices, in capes they have the same effect (about 5% increase in second-hand value from a 10% increase in either of them) while in Panamax bulk carriers it is the newbuilding variable that has the greatest effect.

In the long run, an increase in the cost of capital will have negative effects for all vessel segments.

Orderbook as a percentage of the fleet was found statistically insignificant for all vessel types.

The dummy used for the Sanko deal (1985, 1986) was found significant for Handies and Panamaxes but not for Capes. The reason is that the Sanko deal applied only to Handy and Panamax orderbook.

6.6.3 Overall Results

Newbuilding and Timecharter rates have the greatest effect of all variables on the determination of second-hand values, in most cases both in the short and the long run.

The coefficients for the newbuilding variable are higher than the ones for the timecharter rate ones. A reason behind this may be asset play. It seems as if people looking for making money out of buying and selling ships at the right point in time are more active in these sectors. These people keep an open eye for fluctuations in the prices quoted by shipyards should an opportunity for asset play arise on a continuous basis, thus affecting second-hand ship prices accordingly. A special case is the Suezmax tanker segment. According to our findings, a 10% increase in the newbuilding price of a Suezmax tanker will make a five-year old vessel's price rise by about 8.5%. This can be attributed to the special nature of such vessels. It should be understood that Suezmax tankers are not natural products for shipyards to build, as the demand for them is relatively limited. As it has also been said in Chapter 5, Suezmax prices have been closely pegged to VLCCs with a discount but not proportional to the size. In other words Suezmaxes are rarely bargain vessels. Second-hand prices of Suezmaxes could therefore be more closely tied to newbuilding prices than for other tanker sizes.

In the above circumstances second-hand values for bulkers have become closely related to the cost of building a new ship and owners have placed a greater emphasis upon trading ships as commodities (asset play) than their counterparts in the tanker market.

The cost of capital is only significant for bulk carrier owners, and this only in the long run, rather than tanker owners. The only exception is the Suezmax segment due to its particular characteristics described above. What can be implied from this is that shipowners operating in the tanker sector have more capital than their dry bulk colleagues do. Therefore, an increase in the cost of borrowing money will not affect their investment decisions, as much it will do those of bulk carrier owners. This argument can be further strengthened by the fact that cashflow and revenues are significantly higher in the tanker market than in the bulk carrier one, as well as by the fact that, traditionally, the world's largest and richest shipowners have mostly been active in the tanker sector. After all, for many shipping enterprises, particularly for the Greek ones, entering the tanker market from the bulk carrier one is regarded as a step forward, and a sign of maturity and success.

Finally, orderbook as a percentage of the fleet has a negative effect on the prices of second-hand vessels only in the long run and only in large (Suezmax, VLCCs) and medium size (Panamax) tankers. This may be due to the fact that an already existing large orderbook may make tanker owners reluctant to invest in ships particularly as expensive as large tankers, since for them it is an indication of oversupply. As a result, demand for second-hand ships falls and so do their prices. The exception is the Aframax segment were as it has already been said it is the workhorse of the industry and owners place most of their decision to invest on second-hand ships on timecharter fluctuations.

With respect to bulk carriers the following observations may add up to the above findings:

- The values of the dry cargo commodities carried by bulkers are far lower than the values of the commodities carried by tankers such as crude oil and especially petroleum products. This tends to put greater pressure upon dry bulk carriers than tankers to provide value for money transportation given that transportation costs form a higher proportion of the landed commodity cost in bulkers than in tankers. This tends to limit the upside potential of dry bulk carrier freight rates more than tankers. Dry bulk shipping is therefore more cost driven than revenue driven than tanker shipping.
- The performance of the dry bulk carriers both in terms of absolute earnings and return on investment has traditionally been much lower than for tankers. This is one of the reasons why combined carriers have on average traded predominantly in oil rather than dry cargo (sometimes the ratio has reached 90% wet 10% dry).
- Given the above dry bulk carrier owners have tended to be far more readily attracted by low newbuilding prices than tanker owners as the cost of the vessel is more crucial to the return on investment. Thus dry bulk carrier orders often react much quicker than tanker orders to lower contract prices especially at times when orderbooks are much lower than available shipbuilding capacity.
- Being cheaper to build than tankers, bulk carriers are not the first choice of construction in a shipyard where both tankers and bulkers are constructed. This is because a shipyard has a need to get the maximum value from the available space. The demand and price of alternative vessels like tankers may therefore drive new contract prices for dry bulk carriers. The timing of the dry bulk carrier order is more crucial than in tankers and often takes place when demand for new tankers has fallen and shipbuilding prices have fallen.

With all these observations in mind it is easier for someone to understand the different effects the market variables have on different ship types and markets.

Insert Tables 6.3 and 6.4 somewhere here

6.7 Forecast

Based on the model estimated above, forecasts were made for all ship types for the period 1999-2001. In addition to that an atheoretical Autoregressive (AR) model that can be used solely for forecasts was calculated for all ship types and forecasts were made for the same period. The Bayesian and Akaike Information criteria were used in all cases in order to determine the lag of the model, which for this case is 1. Therefore, our Auto Regressive model has the following form:

$$\ln secondhand_{t+1} = \mu + \rho \ln secondhand_t + \eta_{t+1}$$

Where μ is the mean $\eta(t)$ denotes the shock at time t and ρ is the autoregressive coefficient.

Table 6.5 compares the forecasting capabilities of these two different econometric methods. The absolute, percentage and root mean squared errors are used to compare the performance of the forecasts of the Error Correction Model and the AR models.

From this table, it can be seen that AR forecasts outperform those of the ECM in all three bulk carrier segments as well as in the Handy Tankers sector. The ECM outperforms AR estimates for Panamax, Aframax, Suezmax and VLCC tankers. These results are similar to the ones for the freight and the newbuilding market and indicate that the theoretical Error Correction Models, are to be preferred if one wants to achieve the classical objectives of Econometric Business Cycle Research simultaneously but in some cases other methods might serve the purpose equally well or even better.

Insert Table 6.5 somewhere here

6.8 Conclusion

This chapter developed a theoretical model from which, thanks to the employment of modern econometric techniques and various diagnostic tests, statistical inferences can be made, thus filling in a gap in the literature of second-hand prices.

The variables effecting second-hand ship prices have different effects on different ship types, thus adding validity to the argument that analysis at a disaggregated level is needed in order to understand each market segment better.

Newbuilding and Timecharter rates were found to have the greatest effect of all variables on the determination of second-hand values, in most cases both in the short and the long run.

The coefficients however for the newbuilding variable are higher than the ones for the timecharter rate ones. A reason behind this may be asset play.

The cost of capital is only significant for bulk carrier owners, and this only in the long run, rather than tanker owners. The only exception is the Suezmax segment due to its particular characteristics described above. What can be implied from this is that shipowners operating in the tanker sector possess more capital than their colleagues in the bulk carrier sector do.

Furthermore, orderbook as a percentage of the fleet has a negative effect on the prices of second-hand vessels only in the long run and only in large (Suezmax, VLCCs) and Panamax tankers.

Finally, the chapter compared different econometric methods, the theoretical Error Correction and the atheoretical Auto Regressive models. It was found that theoretical models, are still to be preferred if one wants to achieve the classical objectives of EBCR simultaneously (to describe and forecast cycles and to evaluate policies and test economic theories). However, if not all goals have to be met with a single vehicle, other methods might serve the purpose equally well or even better as is the case with the Auto Regressive method whose forecasts outperform those of the ECM method on many occasions. This result is consistent with the results in the freight and newbuilding market.

Table 6.1: ADF Test Results for Stationarity

	Bulkers						Tankers									
	Handy		Panamax		Capes		Handy		Panamax		Aframax		Suezmax		VLCC	
	Level	1st Dif	Level	1st Dif	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.
LnNB	-3.17	-5.64*	-3.19	-4.06*	-3.22	-5.07*	-2.00	-4.78*	-3.02	-4.50*	-2.51	-3.60*	-2.99	-5.69*	-2.94	-3.57*
LnTC	-3.82*	-5.46*	-4.24*	-5.55*	-4.12*	-5.84*	-3.37	-4.41*	-3.49	-4.93*	-3.03	-5.10*	-3.13	-4.51*	-2.32	-4.88*
Lnorderbook/fleet	-3.63*	-5.19*	-2.90	-4.79*	-1.88	-7.67*	-2.79	-3.77*	-3.01	-5.38*	-2.90	-4.37*	-1.85	-4.95*	-3.02	-4.89*
LNSECONDHAND	-3.43	-4.65*	-3.25	-4.50*	-3.37	-5.00*	-2.62	-4.34*	-2.71	-3.98*	-3.00	-4.32*	-2.25	-4.48*	-2.52	-4.61*
	Levels		1st Dif.													
LnLibor	-2.91		-5.16*													

ADF test models contain an intercept and a trend. The null hypothesis is that the series is non-stationary. This hypothesis is rejected if the statistics are larger in absolute values than the critical values. Number of lagged first difference terms added to the regression: One(1).

*, Denotes variable stationarity based on MacKinnon's critical value of -3.5731 at 5% level

Table 6.2 Johansen Cointegration Tests Second-hand Ship Prices (std. Errors in parentheses)

	Bulkers						Tankers									
	Handy		Panamax		Capes		Handy		Panamax		Aframax		Suezmax		VLCC	
LnSecondhand	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LnNB	-22.13 (2.48)	-	-1.3 (0.16)	-	-1.96 (0.15)	-	-1.48 (0.2)	-0.81 (0.09)	-1.59 (0.16)	0.29 (0.45)	-1.35 (0.13)	-0.96 (0.25)	-0.63 (0.12)	-0.65 (0.1)	-1.17 (0.14)	-1.18 (0.17)
LnTC	19.32 (2.09)	-	0.14 (0.12)	-	0.38 (0.11)	-	0.68 (0.26)	-	0.95 (0.12)	-1.17 (0.34)	0.9 (0.16)	-0.3 (0.17)	-0.07 (0.07)	-	0.06 (0.13)	-
LnOrderbook/Fleet	-1.43 (0.59)	-	-0.13 (0.06)	-	-0.27 (0.05)	-	-1.12 (0.1)	-	-0.08 (0.09)	1.17 (0.21)	-0.56 (0.05)	-	-0.19 (0.03)	-0.21 (0.02)	-0.38 (0.05)	-0.32 (0.06)
LnLIBOR	0.46 (0.75)	1.16 (0.32)	0.37 (0.08)	1.02 (0.27)	0.34 (0.1)	1.15 (0.27)	-0.22 (0.08)	-	0.01 (0.1)	-	-0.69 (0.07)	-	-0.16 (0.1)	0.07 (0.09)	-0.61 (0.1)	-
Trend	-0.05 (0.04)	-4.53 (0.65)	0 0	-4.62 (0.55)	-0.02 (0.01)	-5.21 (0.56)	0 0	0 0	-0.0 (0.01)	0.02 (0.01)	-0.07 (0.01)	-0.05 (0.01)	-0.05 (0.01)	-0.04 (0.01)	-0.04 (0.01)	-0.2 (0.01)
Eigenvalue	0.89	0.46	0.73	0.43	0.83	0.43	0.91	0.53	0.78	0.63	0.88	0.57	0.86	0.77	0.84	0.71
λ trace	136.81	19.98	103.6	21.2	130.76	21.5	121.16	26.16	118.79	78.65	145.37	43.41	127.11	76.14	107.61	72.49

λ max for 1 coint. Eq.@5%	87.31	19.96	87.31	19.96	87.31	19.96	87.31	25.32	87.31	62.99	87.31	42.44	87.31	62.99	87.31	62.99
Log Likelihood	46.05	12.18	49.5	2.86	48.96	-3.66	60.59	26.15	58.39	40.98	51.96	34.26	39.19	26.28	34.12	14.96

Table 6.3: Regression Results OLS Second-hand Ship Prices

	Bulkers			Tankers				
	Handy	Panamax	Capes	Handy	Panamax	Aframax	Suezmax	VLCC
C(1)	-4.3 8* (1.05)	-2.41* (0.88)	-2.77* (0.86)	0.01 (0.27)	-1.16* (0.25)	-5.54* (1.49)	0.85 (0.61)	-6.13* (1.96)
D(LNTC)	0.81* (0.16)	0.43* (0.14)	0.63* (0.11)	0.52* (0.15)	0.14* (0.04)	0.57* (0.19)	0.30* (0.1)	0.73* (0.24)
D(LNNB)	-0.34 (0.24)	0.57* (0.2)	0.57* (0.24)	0.59* (0.23)	0.80* (0.1)	0.48 (1.3)	0.85* (0.22)	1.98* (0.65)
D(LNLIBOR)	-0.06 (0.05)	-0.09 (0.16)	-0.45* (0.18)	-0.03 (0.13)	0.12 (0.05)	0.07 (0.08)	-0.25 (0.16)	0.10 (0.25)
D(LNORDER BOOK/FLEET)	-0.12 (0.09)	0.05 (0.06)	-0.13 (0.08)	0.02 (0.08)	0.00 (0.03)	0.13 (0.08)	0.24* (0.07)	0.13 (0.13)
DUMMY	-0.57* (0.09)	-0.23* (0.11)	-0.36 (0.2)	-0.31* (0.12)	-0.11* (0.06)	-0.11 (0.08)	-0.11* (0.08)	-0.33* (0.16)
LNSECONDHAND(-1)	-0.59* (0.08)	-1.03* (0.13)	-0.74* (0.12)	-0.73* (0.2)	-0.60* (0.12)	-1.13* (0.19)	-0.60* (0.14)	-1.17* (0.22)
LNNB(-1)	-	-	-	0.84* (0.12)	0.79* (0.13)	0.71* (0.2)	0.72* (0.21)	0.92* (0.21)
LNTC(-1)	-	-	-	-	0.31* (0.09)	0.58* (0.15)	-	0.45* (0.23)
LNLIBOR(-1)	-0.20* (0.09)	-0.23* (0.09)	-0.53* (0.13)	-	-	-	-0.62* (0.25)	-
LNORDERBOOK/FLEET(	-	-	-	-	-0.3 (0.07)	-	-0.14* (0.07)	-0.22* (0.07)

-1)								
R-squared	0.9	0.81	0.86	0.77	0.95	0.82	0.81	0.74
Adj. R-squared	0.86	0.75	0.81	0.69	0.92	0.76	0.72	0.62
S.E. of regres.	0.1	0.17	0.17	0.13	0.05	0.14	0.16	0.27
Sum sqd resid	0.24	0.62	0.56	0.36	0.06	0.46	0.51	0.51
Durbin Watson	1.96	1.89	1.86	2.02	1.85	1.62	2.05	2.14
* = Denotes significance at 5% level , Std. Errors in parentheses, Series in logarithms								

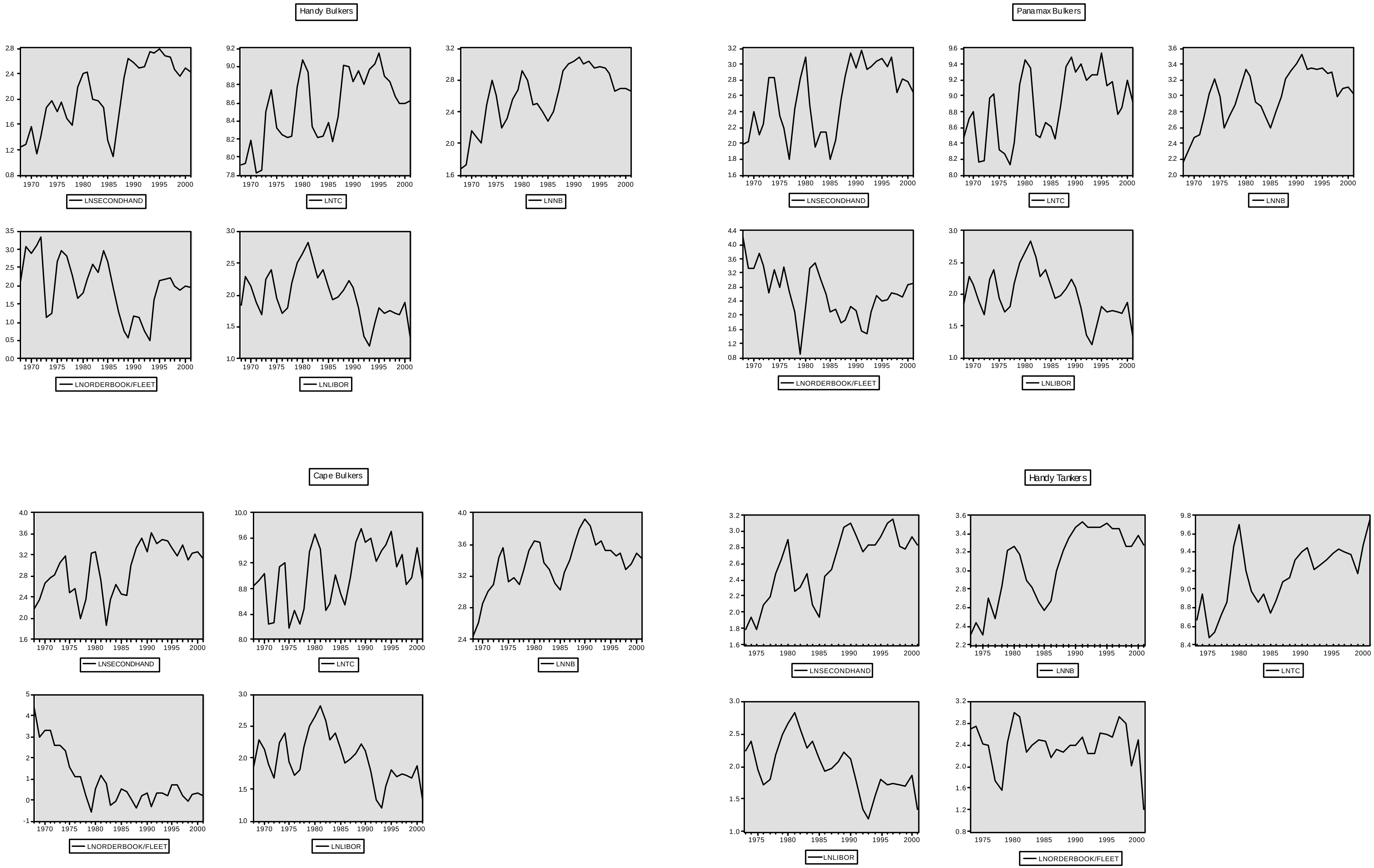
Table 6.4: Diagnostic Tests (p-values in parentheses)

	Correlogram Q Statistic (1 lag)	Correlogram Squared Residuals(1 lag)	Serial Correlation LM Test (2 lags)		ARCH LM Test (1 lag)		White Heteroscedasticity Test (no cross terms)	
Ship Type			F Statistic	Obs*R-Squared	F Statistic	Obs*R-Squared	F Statistic	Obs*R-Squared
Handy Size Bulk Carrier	0.05 (0.95)	0.3 (0.59)	0.8 (0.47)	2.21 (0.33)	0.25 (0.62)	0.27 (0.61)	1 (0.49)	13.44 (0.41)
Panamax Bulk Carrier	0.065 (0.8)	0.25 (0.62)	0.06 (0.94)	0.19 (0.91)	0.20 (0.66)	0.22 (0.64)	1.53 (0.22)	18.64 (0.23)
Cape Size Bulk Carrier	0.00 (0.98)	0.96 (0.33)	0.57 (0.58)	1.67 (0.44)	0.92 (0.35)	0.96 (0.33)	1.04 (0.5)	17.86 (0.4)
Handy Tanker	0.17 (0.68)	2.94 (0.09)	0.31 (0.74)	0.92 (0.632)	2.96 (0.1)	2.86 (0.09)	1 (0.53)	19.72 (0.41)
Panamax Tanker	0.46 (0.5)	2.77 (0.1)	1.1 (0.39)	4.79 (0.09)	2.47 (0.13)	2.44 (0.12)	2.38 (0.09)	24.18 (0.19)
Aframax tanker	0.42 (0.52)	0.73 (0.39)	2.02 (0.16)	5.04 (0.08)	0.74 (0.4)	0.78 (0.38)	2.92 (0.31)	24.8 (0.13)
Suezmax Tanker	0.02 (0.88)	0.65 (0.42)	1.42 (0.27)	4.08 (0.13)	0.58 (0.45)	0.61 (0.44)	2.21 (0.1)	24.24 (0.19)

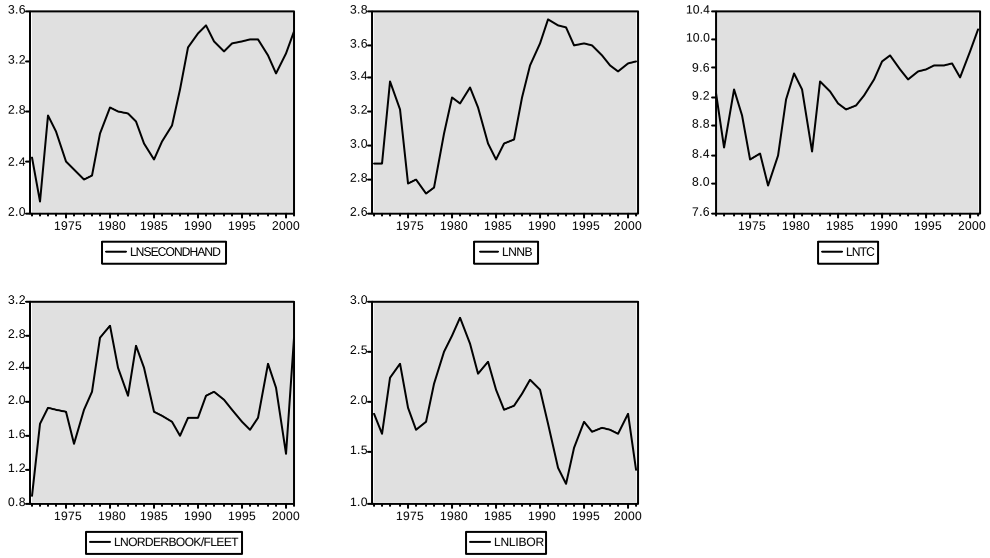
VLCC	0.22 (0.64)	1.01 (0.31)	1.30 (0.3)	3.8 (0.15)	0.87 (0.36)	0.90 (0.34)	1.35 (0.32)	21.56 (0.31)

Table 6.5: ECM-AR Forecast Comparison for 2000-2001	Handy B/C	Panamax B/C	Cape B/C	Handy Tanker	Panamax Tanker	Aframax Tanker	Suezmax Tanker	VLCC Tanker
SEM								
Absolute errors	0.17	0.08	0.15	0.22	**0.19**	**0.06**	**0.25**	**0.17**
Percentage errors	6.76	3.03	4.71	7.71	**5.5**	**1.76**	**6.49**	**4.08**
Mean squared errors	0.19	0.08	0.15	0.26	**0.23**	**0.07**	**0.246**	**0.17**
AR								
Absolute errors	**0.12**	**0.05**	**0.08**	**0.12**	0.27	0.36	0.28	0.32
Percentage errors	**5.01**	**1.8**	**2.09**	**4.27**	7.95	10.23	7.44	7.59
Mean squared errors	**0.13**	**0.06**	**0.07**	**0.13**	0.28	0.38	0.3	0.32

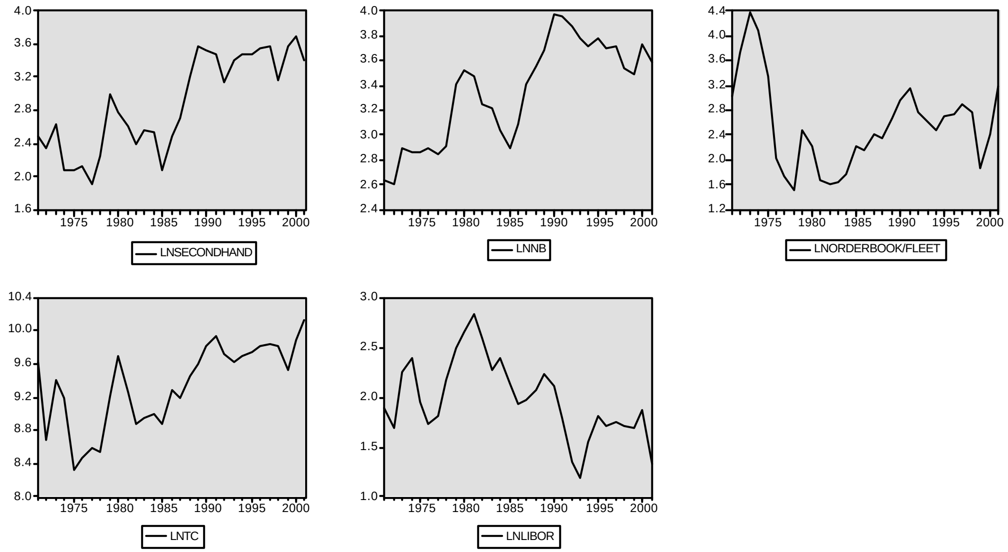
Graph 6.1: Variables included in the second-hand price model



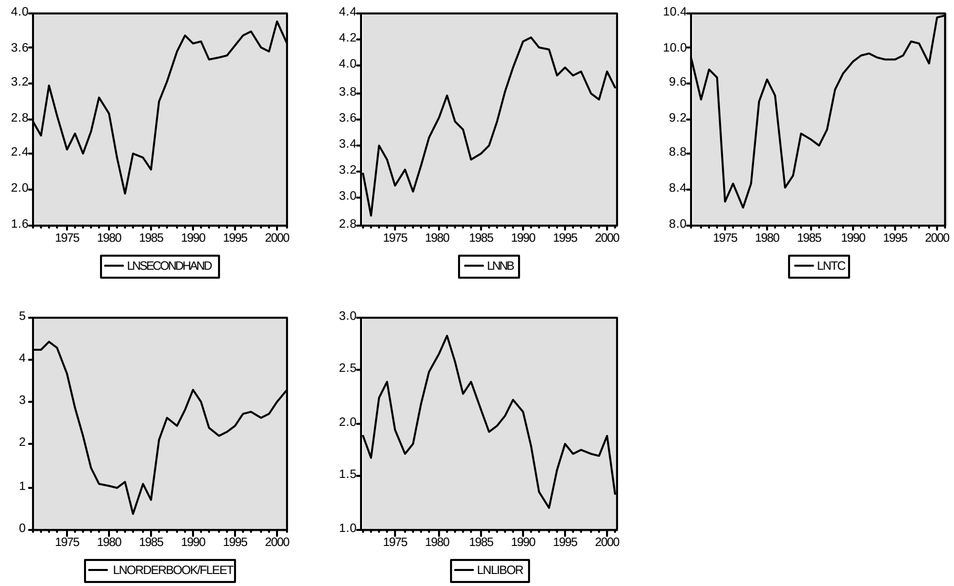
Panamax Tankers



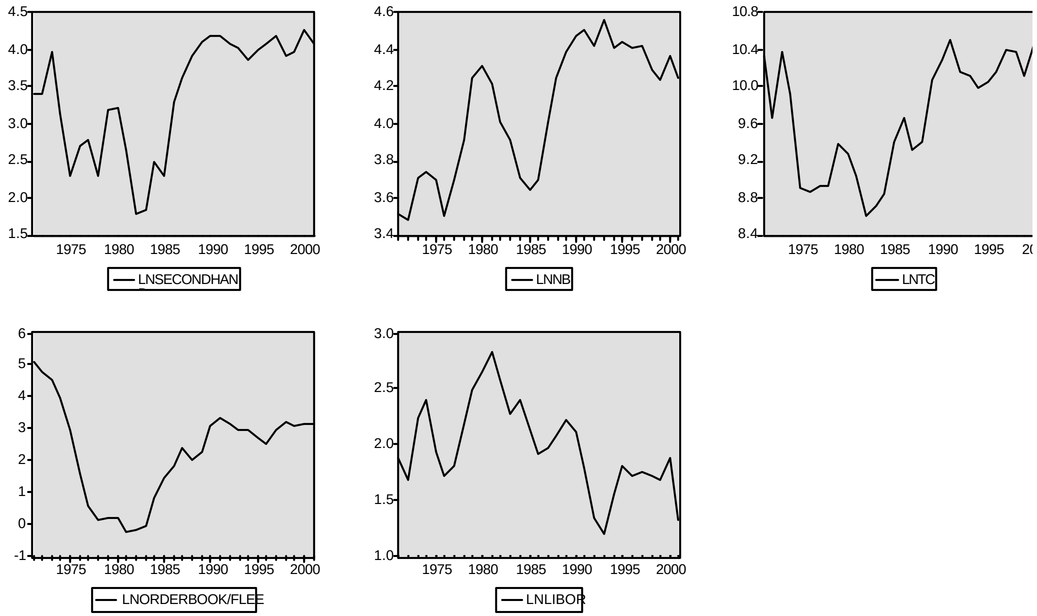
Aframax



Suezmax



VLCC



Chapter 7: Econometric Modelling of Ship Demolition Prices

7.1 Introduction

The rate of growth of the merchant fleet depends on the balance between deliveries of new ships and deletions from the fleet in the form of ships scrapped or lost at sea. Therefore, the scrap market can be described as the mechanism devoted to removing imbalances in the supply and demand for ships.

As freight rates fall during a recession, the profitability of ships and as a consequence their second-hand value also falls. Eventually, the price of the least efficient or older ships falls to scrap price. Ships are scrapped, removing them permanently from the market and reducing fleet surplus. This way, price mechanisms reduce supply of ships to the market. Conversely when ship shortages or increased demand push the freight rates higher, shipowners are keen to add to their fleet and due to ship shortage, shippers may decide to expand their own shipping operations or new players enter the market. With more buyers and sellers, ships appreciate in value, demolition levels reduce, second-hand prices rise until used ships are as expensive as newbuildings thus making the latter a financially sound option.

As we can see, the decision to scrap a ship is much easier if the owner feels gloomy about the future.

Stopford (1997, p. 153) lists the following commercial influences on a scrapping decision:

- Financial performance of the owner
- Vessel age and size
- Market expectations
- Increasing operating costs due to the use of obsolete technology
- Scrap prices
- Market conditions
- Vessel's book value compared to its scrap or resale price
- Company cashflow
- Management policies and attitudes

Old or obsolete ships are sold for scrap often with speculators acting as intermediaries between the shipowners and the demolition merchants.

Valuing a ship for demolition starts with the lwt tonnage of the ship. This is the physical weight of the vessel. Scrap prices are quoted in $/lwt ton and are as volatile as second-hand ship prices. The price also varies from ship to ship, depending on its suitability for scrapping. For example tankers tend to obtain higher prices than bulk carriers because their steel plates are not subject to as many cargoes of corrosive nature as bulk carriers are and they tend to be of better quality at the end of their life. Also, general cargo and container ships tend to obtain an even higher premium because they are easier to dismantle due to the number of decks thus improving the demolition yards' productivity. Furthermore, large ships tend to obtain higher prices than smaller ones, about 5% more, since their steel will be subject to fewer stresses and as a result of better quality.

Despite its volatility and importance, very few researchers have analysed the market for ship demolition and only two, Hawdon (1978) and Beenstock and Vergottis (1993), take a modelling approach. The main reason for this may be the complexity of the industry. Another reason may be the industry's secrecy that does not facilitate the compilation of long and reliable data. For example, most of the deals are done on private terms with the details seldom coming on surface. Also, price fluctuations are to a large extent dependent on government intervention, such as reduction in tax duties and slashing of income tax which is done on a rather selective and irregular basis. Furthermore, price fluctuations also depend on rather regular unforeseen events such as extreme weather conditions like typhoons that may hamper breaking yards' infrastructure or international legislation stemming from sea accidents or pollution. An example is European Union's decision following the Prestige accident to move towards a ban on the single hull tankers wishing to enter EU waters earlier than was originally agreed. Finally, activists campaigning for improved environmental and labour conditions in the shipbreaking industry may disrupt the smooth operation of the industry. Due to these reasons, the demolition market is less appealing than the other three shipping markets (freight, second-hand and newbuilding) are for researchers to analyse, with the resulting limited amount of studies.

Buxton (1991) is one of the studies analysing the market for ship demolition. According to Buxton either technical or economic obsolescence may be the cause for scrapping a ship, where the later is strongly influenced not only by anticipated freight rates but from the rate at which more efficiently ships are introduced as well. For Buxton the ship's scrap value is a function of both the realisable value of the materials within the ship and demolition cost. Both are strongly influenced by the cost structures prevailing in the likely country of demolition. Also, the rate of technological progress is a main determinant. More efficient tonnage initially achieves a better rate of return at prevailing freight rates but once such ships are present in any quantity, they drive freight rates down to lower real levels, thus accelerating the scrapping of older tonnage of marginal profitability. Buxton (1991) explores the future industry trends by observing the shift of the demolition market from Europe to Asia and more specifically the Indian sub-continent.

Modelling of the scrap market is only limited to two studies, Hawdon (1978) and Beenstock and Vergottis (1993). Both of them however, do not model scrap prices but scrap volumes. Hawdon (1978) estimates scrapping as a function of current and last period's freight rates, fleet size and tanker demand. On the other hand, the main determinant in Beenstock and Vergottis (1993) is the ratio of the second-hand price and the scrapping price. If this ratio is high, the shipowner might want to hold onto the ship or sell it in the second-hand market instead of scrapping it.

By developing a theoretical (Error Correction) model for the demolition market price that gives reliable results this chapter aims at filling a gap in maritime economics literature. The rest of the contributions are the same as in the other three markets analysed in Chapters 4-6.

The chapter is structured as follows. The following section provides focuses on the development of this chapter's modelling strategy. Methodological analysis is followed by model estimation and results discussion. Finally, the chapter compares the forecasting abilities of the developed model with that of an Autoregressive (AR) one for all ship types under investigation.

7.2 Methodology: Model Specification, Data collection and analysis

7.2.1 Variable Identification

An analysis of the demolition market can be represented in terms of a supply and demand framework.

Demand for ship demolition can be expressed as a function of the price of scrap steel and the ship's scrap price.

$$Q_{SD}^{D} = f(Shipscrap, Steelscrap)$$

By the same token supply of vessels for demolition is a function of the vessel's timecharter rate, the volume of ship scrapping and the vessel's scrap price:

$$Q_{SD}^{S} = f(TC, Shipscrap, Scrapvol)$$

Since $Q^{D}_{SD}=Q^{S}_{SD}$, the function can be inverted to obtain scrap ship prices expressed as a function of:

$$Shipscrap = f(\overset{+}{TC}, \overset{+}{Steelscrap}, \overset{-}{Scrapvol})$$

Where:

Shipscrap = Vessel's scrap price expressed in $/ldt
TC = The vessel's average timecharter rate per day for the year
Steelscrap= Price of scrap steel
Scrapvol= Volume of ships scrapped
On top of each variable, the expected sign is given.

Market Freight rate

The decision to scrap is primarily based on the owner's expectations of the ship's profitability, expressed by the time charter rate that affect his/her financial position. Tsolakis, Cridland and Haralambides (2003) analyse the reasons for timecharter being a better market indicator than freight Worldscale rates. If during a recession, a shipowner senses there is a potential for an upcoming freight market boom he will be reluctant to sell unprofitable ships for scrap. This is because the possible earnings during a freight market boom are so great that they may justify incurring a small operating loss for a period of years up to that date. Old ships will be forced out by the cost of repairs. However, where vessels are still serviceable, extensive scrapping to remove a surplus capacity is only likely to occur when the shipowner believes that there is no prospect of profitable trading for older ships in the foreseeable future or when companies need cash so urgently that they are forced into 'distress' sales to shipbreakers. It follows that scrapping will occur only when cash reserves and optimism run down. Therefore, the higher the ship's profits and shipowner's market expectations, the less reluctant they will be to scrap their ships and the higher the price shipbreakers will have to pay for ships to scrap. As a result, a positive sign is expected for this variable.

Scrap Price

In Asia where the major shipbreaking countries are situated, much of the scrap is used in local markets where it provides a convenient supply of raw materials for mini-mills, or cold rolled for construction. Thus demand for ship demolition depends on the state of the local steel market, though availability of scrapping facilities is sometimes a consideration. Therefore, the higher the demand for scrap steel, the higher its price and as a result the higher the price shipbreakers will be willing to pay to shipowners to tempt them to scrap their ships. As a result, a positive sign is also expected for this variable.

Scrap Volume

An increase in the supply of ships heading to the scrap yards, due to adverse market conditions and expectations, technical obsolescence or unforeseen events such as new legislation, especially when this supply volume exceeds demand for scrap steel will put pressure on the ship's scrap price. This is because shipbreakers will be forced to accept a lower price for their scrap steel, since demand will exceed supply and as a result they will only be able to offer a lower price to shipowners, who will be eager or forced to accept. Consequently, a negative sign is expected for this variable.

7.2.2 Testing for a Unit Root

The Augmented Dickey Fuller Test was applied in order to test for a unit root in shipping related variables.

Insert Table 7.1 somewhere here

The results in table 7.1 indicate that log-levels of most variables are non-stationary, while their log-first differences are stationary. This suggests that these variables are in fact integrated of first order, I(1). The exceptions are the timecharter variable for all bulk carriers as well as Handy bulk carrier newbuilding and orderbook as a percentage of the fleet variables, which are stationary I(0).

From the analysis of the shipping related variables above it is shown that they are a mixture of I(0) and I(1). This means that if a regression includes such a mixture, no inferences can be made from the results.

In order however not to lose the whole framework of regression based statistical inference, we need to deal with the unit root so that standard assymptotics do apply again. One way to do this is to use an error correction model or an equilibrium correction model like the following:

$$\Delta \ln ShipScrap_t = \boldsymbol{a}_1 + \boldsymbol{a}_2 \Delta \ln SteelScrap_t + \boldsymbol{a}_3 \Delta \ln TC_t + \boldsymbol{a}_4 \Delta \ln ScrapVol_t + \boldsymbol{a}_5 DUMMY$$
$$+ \boldsymbol{a}_6 (\ln ShipScrap_{t-1} - \ln TC_{t-1} - \ln XSteelScrap_{t-1} - \ln ScrapVol_{t-1})$$

In order to specify such a model cointegration tests have to be performed so that cointegrating relations are found. It has to be noted here that an assumption is made that only one cointegrating relationship exists between the variables with the demolition price being the dependent one. This thesis will not analyse whether more than one cointegrating relationship exist between the variables, and especially between variables that do not include the dependent one since it is beyond its scope.

7.2.3 Testing for Cointegration

To test for cointegration the Johansen (1991) approach was taken. Since, based on graph 7.1 most of the variables display trending patterns, the following version of the Johansen approach, corresponding with Option 4 in the relevant routine in EViews, was estimated:

$$\Delta_1 Y_t = \mu_0 + \alpha(\beta' \ln Y_{t-1} - \mu_1 - \delta_1 t) + \varepsilon_t$$
where
$$Y_t = \begin{pmatrix} \ln ShipScrap_t \\ \ln TC_t \\ \ln SteelScrap_t \\ \ln ScrapVol_t \end{pmatrix}$$

Where α and β' are *(m X r)* full rank matrices, the first one *(α)* of the adjustment factors while the second one (β') of the cointegrating vectors *lnShipScrap, lnTC, lnScrapVol, lnScrapSteel*. What is reported in table 7.2 for every ship type rejects the hypothesis that there is no cointegration among our variables at 5% level. Where applicable, different combinations of cointegrated variables based on theory and the robustness of the model (based on diagnostic tests), were used as error terms in our model according to the characteristics of each ship type. The various combinations of the cointegrating variables are also reported in table 7.2

Insert Graph 7.1 somewhere here

Insert Table 7.2 somewhere here

7.3 Output of estimations and test results

In all models R^2 is high and ranges from 0.753 (Panamax Tankers) to 0.86 (Handy size bulk carriers) with the rest ranging between 0.76 and 0.85. The fit of all equations is good as indicated by the SE of regressions ranging from 0.12 to 0.18.

7.3.1 Bulk Carrier Results

In Handy size, bulk carriers about 4.85% of disequilibrium is corrected every year by changes in demolition price itself. The figure is about the same for Panamax bulk carriers (5.3%) and a little lower for cape size bulk carriers (3.75%). In all three sizes, the time charter rate is the only statistically significant variable. In addition to this, since we are able to explain 80 to 85% of the variability of the ships' demolition price, we can conclude that bulk carrier demolition prices are primarily driven by current market conditions and shipowners' expectations as these are expressed by the time charter rate. For example, an increase in time charter rates by 10% will make scrap prices for handy bulk carriers increase by approximately 5%.

7.3.2 Tanker Results

The fact that demolition prices are primarily driven by the state of the market and shipowners' expectations is also supported by tanker results. The time charter rate is highly significant in all ship types and for large tankers like Aframaxes and Suezmaxes both in the short and the long run. In addition to that, a significant percentage of the disequilibrium for all ship types (from 3.2% for Panamax tankers to 9.7% for Suezmax tankers with the rest around 5%) is corrected each year by changes in the demolition price itself. Finally, for some tanker types other variables are also statistically significant. For VLCCs for example the price of scrap steel is found to be statistically significant in the short run, where a 10% increase results in an increase of about 8% for the demolition price of a VLCC. An increase in the demand of scrap steel will make steel mills or scrap steel traders to ask for larger quantities of scrap steel. To satisfy this demand, shipbreakers and cash buyers will be eager to pay a premium for very large ships with a lot of lightship like VLCCs or ULCCs.

Also, the volume of ships sold for scrap was found to be statistically significant for Panamax and Suezmax tankers, for the latter both in the long and the short run. Again this is in line with theory. For medium and large tankers, apart from the freight market conditions and owners expectations, new legislation stemming from a major accident or pollution may force shipowners to sell ships for demolition earlier than originally anticipated due to lack of compliance with the new rules. Recent examples include a single hull ban resulting from the Oil Pollution Act (OPA 90) in the US after the Exxon Valdez accident or a possible EUROPA stemming from accidents like Erika or Prestige. Thus, such an increase in scrap volume will affect tanker demolition prices negatively.

Overall, it can be said that demolition prices in both tankers and bulk carriers are primarily dictated by current market conditions and shipowners' expectations. However, it can be seen that different variables have varying effects on different ship types. For example, for some tanker sizes, in addition to time charter rates, variables such as the price of scrap steel or the volume of ships sold for scrap have a significant effect.

7.4 Diagnostic Tests

The diagnostic tests results are summarised in table 7.4 and indicate that neither autocorrelation nor Heteroscedasticity exists. Therefore our OLS estimation is consistent or maximum likelihood.

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Insert Tables 7.3 and 7.4 somewhere here.

7.5 Forecasts

Based on the model estimated above, forecasts were made for all ship types for the period 2000-2001. In addition to that an Autoregressive Moving Average (ARMA) model was calculated for all ship types and forecasts were made for the same period. The Bayesian and Akaike Information criteria were used in all cases in order to determine the lag of the model, which for this case is 1. Therefore, our Auto Regressive Moving Average model has the following form:

$$\ln ShipScrap_{t+1} = \mu + \rho \ln ShipScrap_t + \vartheta \eta_t + \eta_{t+1}$$

Where μ is the mean $\eta(t)$ denotes the shock at time t, ρ is the autoregressive coefficient and θ is the moving average coefficient..

Table 7.5 compares the forecasting capabilities of these two different econometric methods. The size of the errors of the model for the actual levels of both ECM and ARMA are demonstrated with absolute errors, percentage errors and the root mean squared error. These are used to compare the performance of the forecasts of the models.

From this table, it can be seen that ARMA forecasts outperform those of ECM in four out of eight cases namely for the all tankers except Handy. The Error Correction Model outperforms ARMA estimates for Handy tankers and all bulk carriers. These results are similar to those of the previous three chapters.

Insert Table 7.5 somewhere here

7.6 Conclusion

This chapter developed a theoretical model from which, thanks to the employment of modern econometric techniques and various diagnostic tests, statistical inferences can be made, thus filling in a gap in the literature of vessel demolition prices.

The variables determining ship demolition prices have different effects on different ship types, thus adding validity to the argument that analysis at a disaggregated level is needed in order to understand each market segment better. The results obtained are in line with the economic theory stating that demolition prices are primarily driven by market conditions and expectations. Furthermore for VLCCs, the price of scrap steel was also found to be significant. This is due to increasing demand for scrap steel that makes demolition traders eager to offer higher prices for larger tankers to satisfy demand. Also, the volume of scrapped ships had a negative effect on the demolition price of medium and large tankers. This is due to new legislation usually stemming from an accident or environmental campaigns that may force shipowners to scrap their ships earlier than they had originally anticipated.

Finally, the chapter compared different econometric methods, the theoretical error correction and the atheoretical Auto Regressive Moving Average (ARMA) models. Theoretical Error Correction Models, are still to be preferred if one wants to achieve the classical objectives of EBCR simultaneously (to describe and forecast cycles and to evaluate policies and test economic theories).

However, if not all goals have to be met with a single vehicle, other methods may serve the purpose equally well or even better as is the case with the Auto Regressive Moving Average method whose forecasts outperform those of ECM on many occasions.

Table 7.1: ADF Test Results for Stationarity

	Bulkers						Tankers									
	Handy		Panamax		Capes		Handy		Panamax		Aframax		Suezmax		VLCC	
	Level	1st Dif	Level	1st Dif	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.	Level	1st Dif.
LnScrap	-3.92*	-7.41*	-3.92	-7.41*	-3.92	-5.07*	-2.71	-5.26*	-2.71	-5.26*	-3.88	-7.44*	-3.88	-7.44*	-3.88	-7.44*
LnTC	-3.82*	-5.46*	-4.24*	-5.55*	-4.12*	-5.84*	-3.37	-4.41*	-3.49	-4.93*	-3.03	-5.10*	-3.13	-4.51*	-2.32	-4.88*
LnScrapvol	-3.42	-5.64*	-2.90	-4.37*	-3.14	-5.23*	-2.45	-7.65*	-2.26	-4.73*	-3.05	-4.40*	-2.78	-5.32*	-2.17	-5.47*
	Levels		1st Dif.													
LnScrapprice	-2.69		-5.21													

ADF test models contain an intercept and a trend. The null hypothesis is that the series is non-stationary. This hypothesis is rejected if the statistics are larger in absolute values than the critical values. Number of lagged first difference terms added to the regression: One(1).

*, Denotes variable stationarity based on MacKinnon's critical value of -3.5731 at 5% level

Table 7.2 Johansen Cointegration Tests Newbuilding Prices (std. Errors in parentheses)

	Bulkers			Tankers						
	Handy	Panamax	Capes	Handy		Panamax	Aframax	Suezmax		VLCC
LnShipScrap	1	1	1	1	1	1	1	1	1	1
LnSteelScrap	-226.23 (46.23)	1.87 (0.49)	0.86 (0.35)	4.79 (0.59)	-	-1.53 (2.6)	2.42 (0.35)	-0.8 (0.33)	-	-16.21 (4.89)
LnTC	-	-	-	-2.54 (0.37)	-5.55 (0.41)	-6.22 (0.83)	-4.43 (0.35)	0.47 (0.11)	0.16 (0.22)	-15.56 (3.14)
LnScrapvol	-43.86 (9.06)	0.26 (0.1)	0.22 (0.08)	0.2 (0.1)	-0.38 (0.01)	0.61 (0.21)	-0.02 (0.13)	0.64 (0.09)	1.26 (0.15)	-4.77 (0.54)
Trend	6.92 (1.53)	-0.7 (0.02)	-0.05 (0.01)	-0.7 (0.01)	0.1 (0.01)	0.32 (0.07)	0.13 (0.02)	-0.045 (0.01)	-0.07 (0.01)	1.73 (0.27)
Eigenvalue	0.65	0.63	0.61	0.81	0.91	0.73	0.92	0.84	0.82	0.88
λ trace	51.34	44.72	42.72	87.9	88.96	68.5	122.6	105.89	75.6	117.2
λ max for 1 coint. Eq.@5%	42.44	42.44	42.44	62.99	42.44	62.99	62.99	62.99	42.44	62.99
Log Likelihood	-1.49	-5.83	-1.43	31.33	20.36	3.7	28.87	22.44	-6.15	-0.26

Table 7.3: Regression Results OLS Scrap Ship Prices

	Bulkers			Tankers				
	Handy	**Panamax**	**Capes**	**Handy**	**Panamax**	**Aframax**	**Suezmax**	**VLCC**
C(1)	1.90* (0.4)	1.46* (0.46)	2.18* (0.5)	0.37 (1.7)	3.14* (1.06)	1.41 (1.76)	5.50* (1.4)	2.35* (0.73)
D(LNTC)	0.51* (0.13)	0.35* (0.09)	0.25* (0.1)	0.61* (0.25)	0.52* (0.1)	0.66* (0.17)	0.37* (0.12)	0.18* (0.11)
D(LNSTEELSCRAP)	0.08 (0.18)	0.27 (0.20)	0.07 (0.24)	0.40 (0.23)	-0.08 (0.27)	-0.40 (0.32)	0.30 (0.23)	0.78* (0.23)
D(LNSCRAPVOL)	0.05 (0.03)	0.02 (0.03)	0.04 (0.04)	0.01 (0.05)	-0.09* (0.04)	-0.08 (0.06)	-0.12* (0.06)	-0.04 (0.04)
LNSHIPSCRAP(-1)	-0.49* (0.1)	-0.53* (0.12)	-0.38* (0.12)	-0.50* (0.18)	-0.33* (0.16)	-0.58* (0.19)	-0.97* (0.18)	-0.41* (0.14)
LNSTEELSCRAP(-1)	0.23 (0.28)	0.49 (0.27)	-0.17 (0.57)	-	-1.73 (1.54)	-0.87 (0.62)	-	-0.59 (0.76)
LNSCRAPVOL(-1)	0.08 (0.07)	-0.04 (0.06)	0.00 (0.1)	-0.12 (0.22)	-0.11 (0.14)	-0.12 (0.03)	-0.22* (0.07)	-0.04 (0.04)
LNTC(-1)	-	-	-	0.51 (0.29)	0.50 (0.38)	0.70* (0.31)	0.26* (0.08)	0.25 (0.21)
DUMMY	0.13 (0.12)	-0.20* (0.1)	-0.06 (0.12)	-0.52* (0.15)	-0.17 (0.16)	-0.19* (0.16)	1.08* (0.08)	-1.11* (0.24)
R-squared	0.86	0.85	0.78	0.77	0.8	0.8	0.75	0.78
Adj. R-squared	0.81	0.81	0.71	0.66	0.71	0.72	0.67	0.69
S.E. of regres.	0.12	0.12	0.15	0.18	0.17	0.17	0.18	0.15
Sum sqd resid	0.3	0.31	0.46	0.62	0.55	0.55	0.67	0.42
Durbin Watson	1.66	1.96	1.79	1.98	1.72	1.88	1.53	2.11

* = Denotes significance at 5% level , Std. Errors in parentheses, Series in logarithms

Table 7.4: Diagnostic Tests (p-values in parentheses)

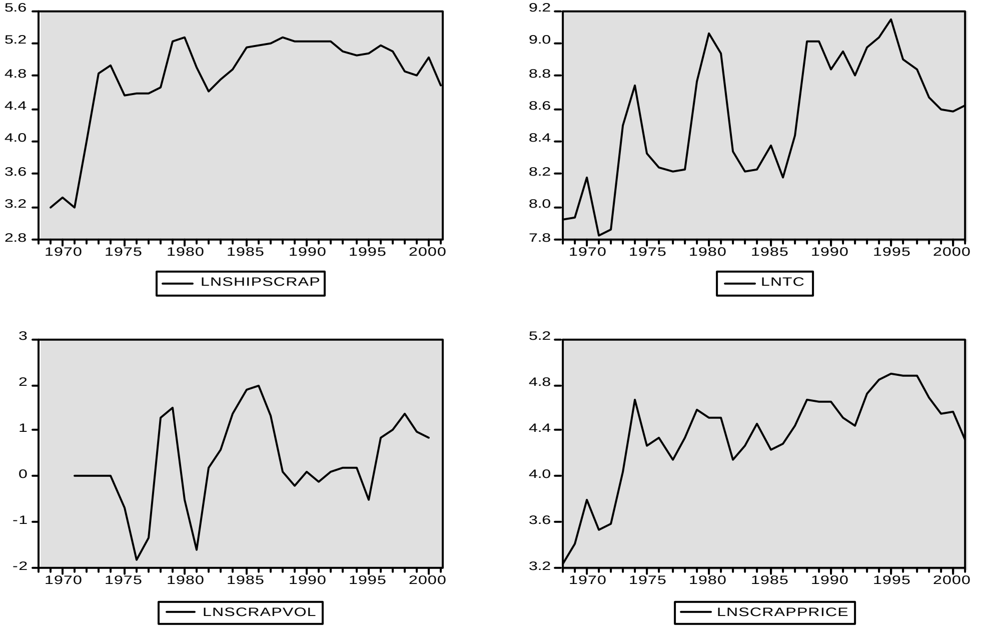
	Correlogram Q Statistic (1 lag)	Correlogram Squared Residuals (1 lag)	Serial Correlation LM Test (2 lags)		ARCH LM Test (1 lag)		White Heteroscedasticity Test (no cross terms)	
Ship Type			F Statistic	Obs*R-Squared	F Statistic	Obs*R-Squared	F Statistic	Obs*R-Squared
Handy Size Bulk Carrier	0.67 (0.41)	0.62 (0.43)	1.77 (1.2)	4.55 (0.1)	0.52 (0.478)	0.55 (0.46)	1.37 (0.29)	17.7 (0.28)
Panamax Bulk Carrier	0.00 (0.96)	0.34 (0.56)	0.1 (0.91)	0.29 (0.87)	0.28 (0.6)	0.30 (0.58)	0.81 (0.66)	14.02 (0.52)
Cape Size Bulk Carrier	0.25 (0.62)	0.81 (0.37)	0.23 (0.8)	0.69 (0.71)	0.68 (0.42)	0.72 (0.4)	1.24 (0.36)	17.01 (0.32)
Handy Tanker	0.03 (0.86)	0.00 (0.96)	0.02 (0.98)	0.06 (0.97)	0.00 (0.97)	0.00 (0.97)	0.42 (0.94)	9.86 (0.83)
Panamax Tanker	0.52 (0.47)	0.1 (0.75)	0.52 (0.61)	1.6 (0.45)	0.08 (0.77)	0.09 (0.76)	0.45 (0.93)	10.13 (0.81)
Aframax tanker	0.06 (0.8)	1.75 (0.19)	1.05 (0.37)	3.07 (0.22)	1.50 (0.23)	1.53 (0.22)	1.36 (0.3)	17.6 (0.28)
Suezmax Tanker	1.45 (0.23)	0.53 (0.47)	1.85 (0.19)	4.77 (0.09)	0.44 (0.51)	0.47 (0.49)	0.82 (0.65)	14.13 (0.52)
VLCC	0.16 (0.69)	2.78 (0.1)	1.76 (0.2)	4.87 (0.09)	2.53 (0.13)	2.48 (0.12)	2.07 (0.11)	19.95 (0.17)

Table 7.5: ECM-AR(MA) Forecast Comparison 2000-2001	Handy B/C ARMA (1,2)	Panamax B/C ARMA (1,2)	Cape B/C ARMA (1,2)	Handy Tanker ARMA (1,1)	Panamax Tanker ARMA (1,3)	Aframax Tanker ARMA (1,2)	Suezmax Tanker ARMA (1,2)	VLCC Tanker ARMA (1,2)
SEM								
Absolute errors	**0.09**	**0.08**	**0.11**	**0.09**	0.12	0.14	0.14	0.16
Percentage errors	**1.74**	**1.53**	**2.22**	**0.17**	2.3	2.82	2.64	3
Mean squared errors	**0.09**	**0.08**	**0.11**	**0.09**	0.12	0.14	0.14	0.16
AR								

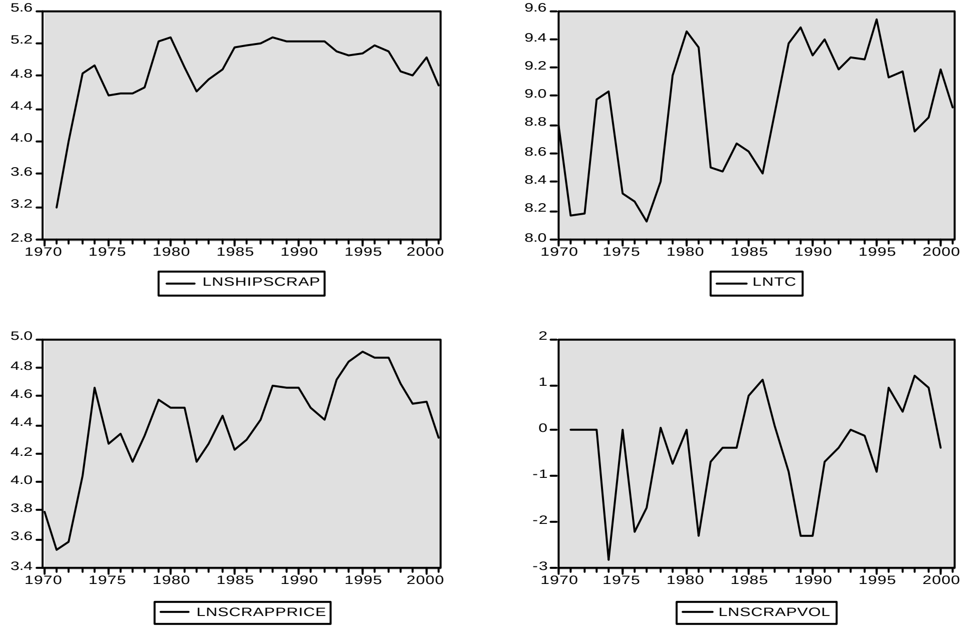
Absolute errors	0.15	0.15	0.15	0.15	**0.13**	**0.10**	**0.10**	**0.15**
Percentage errors	3.08	3.08	3.06	3.03	**2.14**	**2.13**	**2.13**	**2.99**
Mean squared errors	0.16	0.16	0.17	0.17	**0.14**	**0.14**	**0.14**	**0.19**

Graph 7.1: Variables included in the ship scrap market model

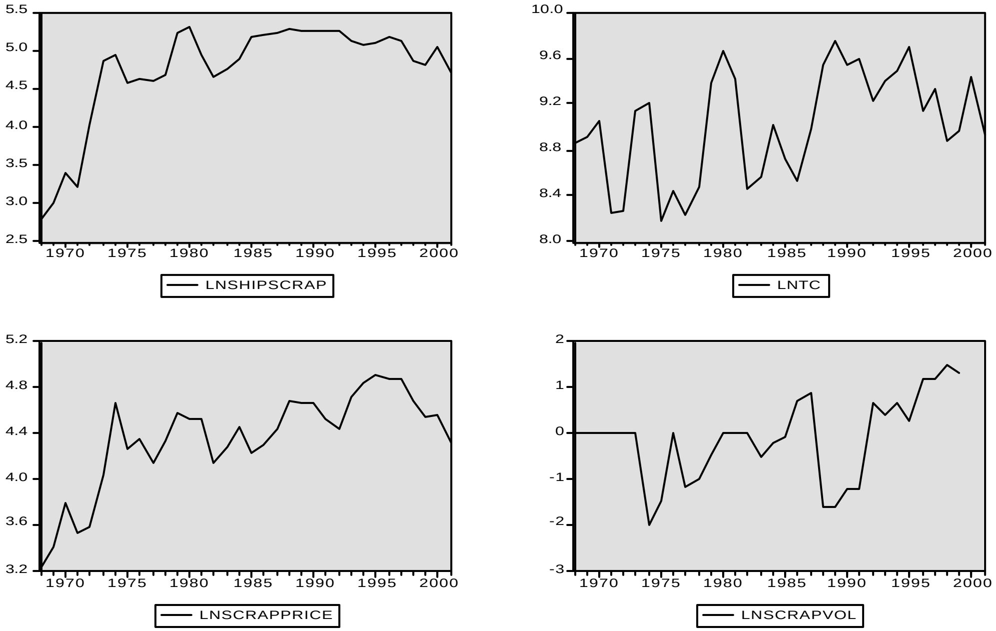
Handy Bulkers



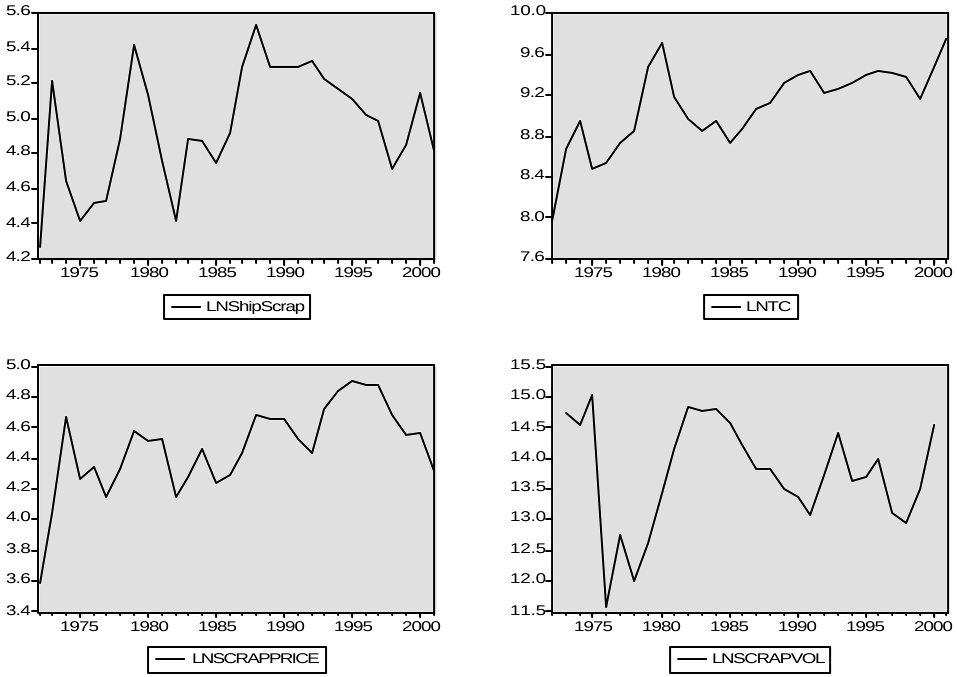
Panamax Bulkers



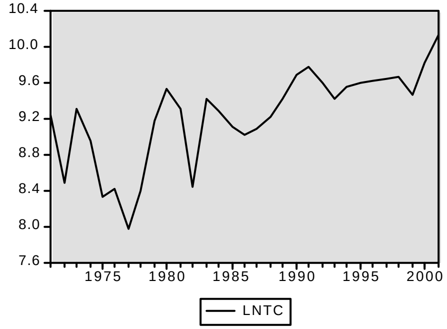
Cape Size Bulk Carriers

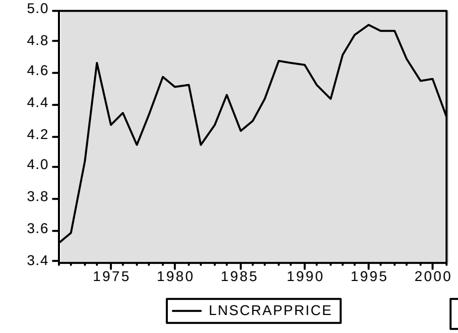


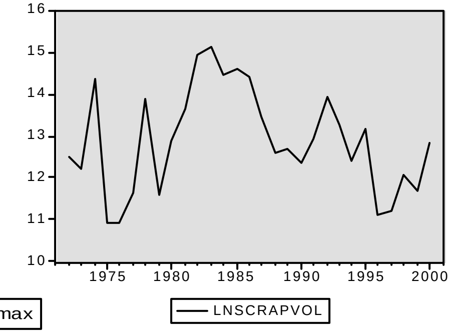
Handy Tankers



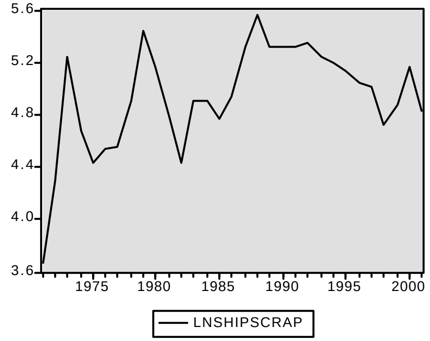
Panamax Tankers

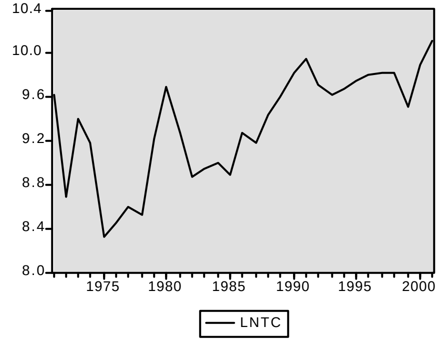


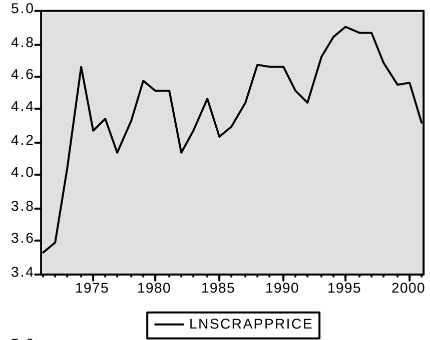


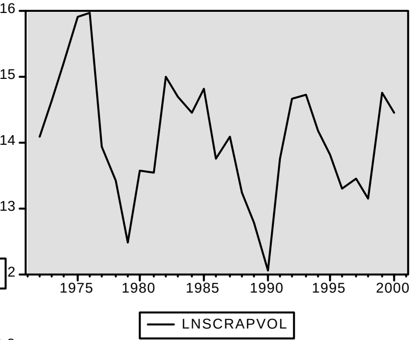


Aframax

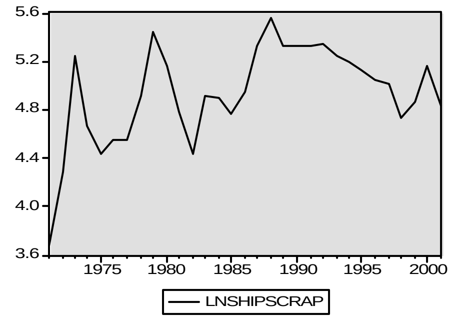


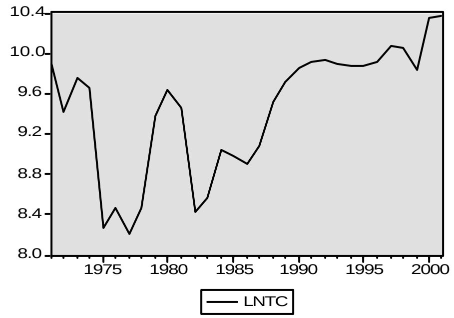


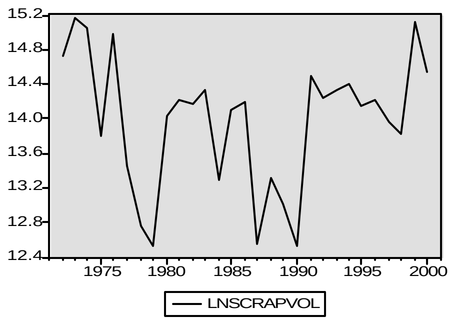


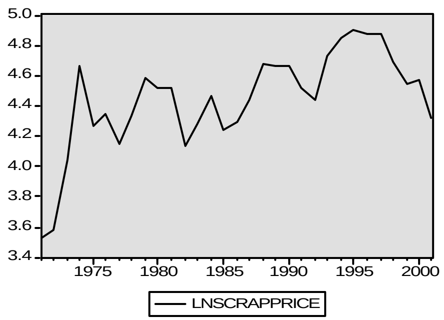


Suezmax

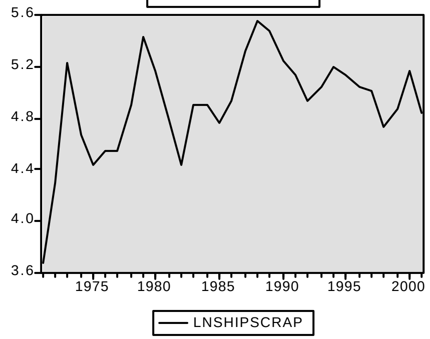


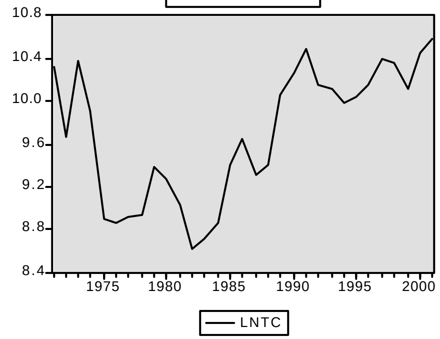


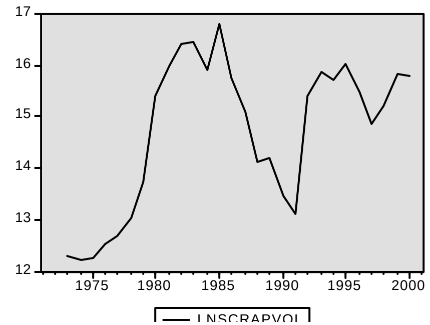


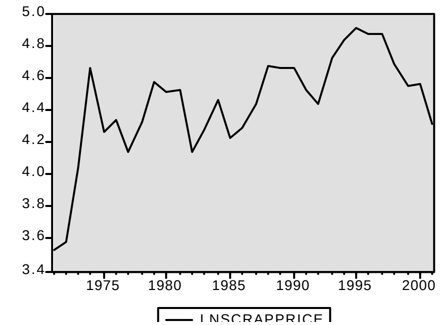


VLCC









Chapter 8: Integration and Efficiency of Bulk Shipping Markets

8.1 Introduction

Timing is one of the most important elements in the investment decision process particularly in an industry like shipping where the market returns and the values of the assets generating them fluctuate violently over regular intervals.
Exiting the market at the peak of the cycle and entering at the bottom would seem to be a simple enough creed to follow but although it has many believers few of them adhere to it.

However, most of those in shipping hardly want to get out of it, though particularly in the bulk market (both dry and wet), this might be a sensible thing to do from time to time. Furthermore, in a relationship business such as shipping, continuity counts. Moreover, identifying the peak and the trough of the shipping market is a very difficult task depending on many imponderable parameters.

Although there are regular cycles in the market their peaks and troughs shift back and forward in time. Someone can always find in shipping the odd example of huge gains or losses on the purchase and subsequent sale of a ship or group of ships. Nevertheless, as already mentioned, most ship investors do not enjoy taking risks. Therefore they require a higher expected return from risky investments. However that raises two questions, one with respect to how we measure risk and the second with respect to the relationship between risk and expected return. These are questions tackled later in the thesis.

According to Brealey and Myers (2003), risk is best judged in a portfolio context. Most investors do not put all their eggs into one basket but they tend to diversify. Quite often shipowners invest in different ship markets and vessel sizes in the expectation of achieving a reduction in risk via the resulting diversification in their income. Thus the effective risk of a shipping market cannot be judged by an examination of one market or ship size alone. Part of the uncertainty about the market's or segment's return is diversified away when this market or segment is grouped with others in a portfolio.

In the shipping industry, we can find examples of companies that tend to operate a diversified fleet as well as of companies that tend to focus on one or two shipping segments. Therefore, on the one hand we have the example of Alpha Shipping, a company that issued bonds in 1998, that according to Tradewinds (October 22 1999) chose to build up and operate a mixed fleet of bulkers, tankers and reefers. This was because of its director's belief that shipping cycles rarely coincide in all sectors (Tradewinds October 22 1999).

This strategy found supporters even in well-known rating organisations. For example, at the time of the issue, Standard and Poor's (S&P) argued that despite Alpha Shipping’s worse-than-average industry characteristics and the company's weak financial profile, its relatively large and diversified fleet bolstered the outlook (Tradewinds, January 30 1998).

Therefore, because of the fleet's diversification, S&P assessed Alpha as offering greater freight-rate stability than companies that are focused on a particular market sector.

On the other hand, we have companies like Stelmar that tend to focus on a fleet of sister vessels of one or two ship types at most. According to the company's website:

Stelmar is developing its fleet with an emphasis on the Panamax and Handymax classes in order to take advantage of the long-term positive fundamentals in both sectors. The Handymax class makes strategic sense for Stelmar for two reasons. The rates for Handymax vessels are less volatile than other classes of ships since there is no direct correlation between OPEC decisions and Handymax rates. Stelmar is also able to capitalize on increasing oil demand with these vessels, given the limited refinery capacity in developed countries.

The Panamax expansion program has enabled Stelmar to establish a strong position in a favorable niche market. In this class, almost 50% of the world's fleet is over 20 years old and is expected to be phased out over the next few years. Stelmar has one of the youngest Panamax fleets in the industry, with an average age of two years and is now better positioned to capitalize on the opportunities resulting from the aging profile of the world's Panamax class. With its continued Panamax fleet expansion, the Company is also poised to take greater advantage of the increasing oil trade from South America to the United States.

Furthermore, many of Stelmar's vessels are sister ships. This increases Stelmar's operating efficiencies, provides better scheduling flexibility so that customer needs can best be met and gives the Company greater economies of scale (www.stelmar.com).

From the fate of these two companies, the collapse of Alpha Shipping and the great success of Stelmar, it is observed that shipping companies focusing on a particular ship type achieve equally good or even better risk levels than those investing in various ship types and sizes. Therefore the question that arises is whether such diversification strategies really reduce the investor's risk.

If the income, expressed in time charter equivalent rates, of the various ship types or sizes is very strongly correlated in the long run, diversification will be less effective than if the ship markets or segments operated independently of one another. An important indication of the degree to which long run diversification is available to shipping investors is given by determining whether the markets are cointegrated.

This chapter aims at investigating long run relationships in the bulk shipping industry and finding whether and in which cases, diversification through investing in different shipping markets, or market segments, reduces risk.

To achieve this aim, the following objectives have to be met:

- To analyse the traditional approach (portfolio variance and standard deviation measurement) to measuring diversification effects through Portfolio risk.
- To investigate the shortcomings of this approach.
- To identify ways the proposed approach to measuring diversification effects (cointegration analysis) improves on these shortcomings.
- To analyse the implications for portfolio diversification if any two shipping markets are cointegrated.
- To discuss and analyse the effects and implications our results have for shipping investors wishing to reduce their risk through diversification.

The remainder of this chapter is constructed as follows: in the following section we analyse and apply to shipping the traditional approach to measuring diversification effects, through the calculation of the portfolio variance and standard deviation. This is followed by an analysis of the shortcomings of this approach and the introduction of the concept of cointegration. The following section outlines the implications for portfolio diversification and market efficiency if any two markets are cointegrated. After that we decide on the modelling approach we take to test for cointegration through a comparison of the methods available. Finally, the empirical results of the cointegrating regressions of 247 combinations of the eight different ship types are presented and analysed followed by the conclusions.

8.2 Measuring Diversification effects through Portfolio risk in shipping

The shipping market is risky because there is a spread of possible outcomes. The usual measure of this spread is the standard deviation (ó) or the variance (ó^{2}). The risk of any ship segment can be broken down into two parts. There is the unique risk that is peculiar to that market, and there is the systematic or market risk that is associated with market variations. Investors can eliminate unique risk by holding a well-diversified portfolio. For example, a shipowner or ship investor may decide to invest in more than one of the eight different ship types (handy size, panamax and cape size bulk carriers or handy size, panamax, aframax, suezmax and Very Large Crude Carrier (VLCC) tankers), in order to reduce his/her risk. This way a sharp drop in the income of a particular ship size can be compensated by a less severe drop or even an increase in the income in another one.

According to Brealey and Myers (2003), diversification is a strategy designed to reduce risk by spreading the portfolio across many investments. Nevertheless, diversification cannot eliminate market risk. All the risk of a fully diversified portfolio is market risk.

Market risk is the average covariance, which constitutes the bedrock of risk after diversification has done its work. Market risk is measured by beta. The beta of a security measures its sensitivity to market movements. Beta is defined as the ratio of the covariance between the stock's and the market's return over the variance of the market return

8.3 Descriptive Statistics

Table 8.1 reports descriptive statistics of timecharter rates in levels for bulk carriers and tankers. The results indicate that the mean returns for larger vessels are higher than smaller ones. Unconditional volatilities (variances and standard deviations) indicate a pattern similar to the mean levels across all ship sizes. That is, time charter rates for larger vessels fluctuate more than smaller ones. The results are consistent with those in Kavussanos and Alizadeh (2002b).

Insert Table 8.1 somewhere here

8.4 Calculating Portfolio Risk

The risk of a well-diversified portfolio depends on the market risk of the securities included in the portfolio.

When there are many securities, the number of covariances is much larger than the number of variances. Thus the variability of a well-diversified portfolio reflects mainly the covariances.

8.4.1 Covariance

Covariance is a statistical measure of the relationship between two random variables. A positive value denotes that the securities returns tend to move in the same direction. A relatively small or zero value covariance indicates that there is little or no relationship between the returns for the two securities.

The covariance can be expressed as the product of the correlation coefficient of two variables and their standard deviations.

8.4.2 Correlation

Correlation coefficients are numerical indices providing information regarding the relationship between two variables. Correlation coefficients range from -1 through 0 to +1. Coefficients close -1 and +1 indicate strong linear relationships, whereas coefficients close to zero indicate weak ones.

The greatest payoff to diversification comes when the two assets are perfectly negatively correlated. In this case, there is always a portfolio strategy represented by a particular set of portfolio weights that will completely eliminate risk. Unfortunately, this almost never occurs in practice.

Table 8.2 presents a correlation matrix of the time charter equivalent rate (TCE) of the different ship types. In this case we can see that most ship types are highly correlated to each other. This means that risk reduction opportunities through diversification are rather limited. This is especially true in the case of bulk carriers where the correlation between Panamax and Handy Bulk carriers and Panamax and Cape size bulk carriers is almost perfect (0.94 and 0.95 respectively). In tankers, correlation coefficients are still high but not close to those of bulk carriers thus increasing the probability of higher diversification. What is interesting is that correlation coefficients between very large tankers (VLCCs and Suezmaxes) and bulk carriers is the lowest and therefore the probability for someone investing in a portfolio comprising a combination of these two markets of achieving risk reduction through diversification is higher. This is quite reasonable if someone takes into account that apart from carrying different types of cargo, wet versus dry bulk, very large tanker returns tend to be influenced by political events since they operate mostly in and out of the Arabian Gulf, whereas bulk carrier returns are mostly affected by business cycle fluctuations.

Insert Table 8.2 somewhere here

8.5 Calculating the Portfolio's Standard Deviation

The total risk of any portfolio can be viewed as having two components similar to the two components of the total risk of an individual security (market risk and unique risk).

The standard deviation of a portfolio is calculated the following way:

The number of terms to be added together equals the number of securities squared. This can be expressed mathematically the following way:

$$(1) \quad \sigma_p = \left[\sum_{i=1}^{N} \sum_{j=1}^{N} X_i X_j \sigma_{ij} \right]^{1/2}$$

Where X_i and X_j are the percentage of the portfolio invested in assets *i* and *j* respectively while σ_{ij} is their covariance.

As we can see, double sum involves both variance and covariance terms. A security's contribution to portfolio risk is not its variance but its covariance (Sharpe, Alexander and Bailey 2001).

For example, let us consider a shipowner who owns VLCCs and in order to reduce his/her risk, decides to invest an amount equal to his/her investment in VLCCs, into handy size bulk carriers. The standard deviation of his/her portfolio will be equal to

$$(2) \quad \text{Portfolio} \quad \text{Standard Deviation} = [x_1^2\sigma_1^2 + x_2^2\sigma_2^2 + 2(x_1 x_2 \rho_{12}\sigma_1\sigma_2)]^{1/2}$$

Where X_1 σ^2_1 and X_2 σ^2_2 are the amounts invested (50% each) and the variance of VLCCs and Handy size bulk carriers respectively and ρ_{12} is their correlation coefficient. Note that in this case covariance is expressed as the product of the correlation of the two variables and their variances. By using in the equation the data we have from tables 8.1 and 8.2 we find that the standard deviation of this portfolio is about 0.46 a risk reduction of 3% compared to the risk of investing solely in VLCCs. Of course, the shipowner may opt to invest different proportions of his/her capital not only in two ship types but also in a variety of them to reduce his/her risk even further.

From the example above, we can see that infinite possibilities of combinations and therefore diversification exist between varying levels of investment in different ship types and sizes that may lead to risk reduction.

In other words, as a portfolio becomes diversified its unique risk and in turn its total risk will be smaller.

If the amounts invested in all the securities are equal, then the proportion *Xi* will equal *1/N* and the level of unique risk will be equal to:

$$(3) \quad \sigma^2_{\varepsilon p} = \sum_{i=1}^{N} \left[\frac{1}{N}\right]^2 \sigma^2_{\varepsilon i} = \frac{1}{N}\left[\frac{\sigma^2_{\varepsilon 1} + \sigma^2_{\varepsilon 2} + \ldots + \sigma^2_{\varepsilon N}}{N}\right]$$

The value inside the square brackets is simply the average unique risk of the component securities. As the portfolio becomes more diversified, the number of securities in it becomes larger. In turn, the portfolio will have less unique risk. That is diversification can substantially reduce unique risk.

In theory a portfolio that has equal proportions of all different ship types in it will have a relatively small amount of unique risk. Its total risk will be only slightly greater than the amount of market risk that is present. Thus such portfolios are well diversified. This theory is tested for validity later in the thesis through the investigation of long run relationships between variables. The existence of such long run relationships can nullify any potential diversification benefits.

8.6 Drawbacks of using the correlation coefficient to determine our investment strategies

The correlation coefficient, the usual parameter used to measure the degree of integration between any two markets by financial analysts may be misleading since markets often diverge considerably in the short-run, like periods of up to a year, but may actually be well integrated over longer periods. For example a low correlation coefficient may suggest that ships A and B offer diversification opportunities relative to other ship markets, and as a result shipowners and other investors with long investment horizons may diversify between these two markets believing that they will be spreading their risk more effectively. However, if the markets are in fact integrated to an extent that is not obvious by looking at the simple correlation coefficients then investors may not achieve the degree of diversification initially expected (Clare, Maras and Thomas 1995, p.314). Financial economists (Levy and Lerman, 1988 or Thomas, 1989) often search for portfolio diversification possibilities by plotting mean variance efficient frontiers. Such frontiers are constructed using conditional expectations of returns and covariances. However, this methodology may also subsume short-run market fluctuations into the covariance structure needed to plot the frontier, once again possibly underestimating the degree to which markets are truly integrated.

8.7 Alternative Methodology- the Cointegration approach

An alternative methodology exists however, for determining the degree to which two markets are integrated that allows for these short-term fluctuations or dynamics in time series of asset returns (Dickey and Fuller 1979, Engle and Granger 1987; Johansen and Juselius, 1990a, 1990b; Johansen 1991). This method is cointegration analysis.

By using cointegration we can decompose the comovement of time series variables into their short or dynamic and long-run components. Such a technique should help in making sensible long-term investment decisions. As mentioned earlier, the correlation coefficient cannot distinguish between short and long-run covariation and consequently analysts are forced to consider different sample periods making inferences based on differing correlation coefficients for those periods. Cointegration analysis on the other hand allows us to combine all the historical information at once enabling us to separate short from long-run covariation.

In shipping for example, there are many investors famous for their asset playing strategies that enter and exit the market in the short run. In other words, they tend to invest in a ship during market trough and sell it at a profit one or two years later after the market picks up. Hence these people are not so much interested in long run investment possibilities. However, given the long-term nature of many ship investor liabilities, any additional information about long-run ship diversification possibilities will be very useful. An important indication of the degree to which long-run diversification is available to shipping is given by determining whether the markets are cointegrated. If for example, timecharter rates for different ship types are very strongly correlated in the long run, diversification will be less effective than if their levels are determined independently of one another. Lack of cointegration between the income of the different ship types will imply that ship investors can gain substantial diversification benefits.

The cointegration approach to the problem is proposed here not as a substitute for the construction of mean-variance efficient frontiers or correlation coefficients, but as a complement to such more usual measures.

Using monthly time charter data for all major ship types both in dry (Clarksons data) and wet (Braemar Seascope data) bulk markets, we apply cointegration analysis to determine whether the revenues of these ship types are integrated in the long run. The methodology allows us to filter out any short-run vessel specific or dynamic effects in the relationship between any two asset markets.

8.8 Cointegration, Portfolio Diversification and Market Efficiency

Cointegration literature focuses upon non-stationary time series, variables whose means and variances are not constant over time. Vessel time charter rates are good examples of nonstationary series. The series for both tankers and bulk carriers in natural logarithms are plotted in figures 8.1 and 8.2. From these it is clear that all series are nonstationary although their order of integration is less clearcut. The exact order of integration can be determined by performing a sequence of unit root tests, in this case the Augmented Dickey Fuller unit root tests.

Insert Figures 8.1 and 8.2 somewhere here

8.9 Testing for unit roots

The Augmented Dickey-Fuller test results summarised in table 8.3 indicate that all variables are of integrated order 1 (I(1)), since they have to be differenced once in order to become stationary.

Insert Table 8.3 somewhere here

8.10 Cointegration Tests and Results

The tables below summarise the results of the cointegration tests for all possible combinations of two, three, four, five, six, seven and all (eight) different ship types.

The null hypothesis is that no cointegrating relation exists between the variables under investigation.

In order to determine the number of combinations of possible complete selections of two, three, four, five, six, seven and all (eight) different ship types (in other words the number of k element subsets of a set with n elements) we estimate

$$(7) \quad \binom{n}{k} = \frac{n!}{k!(n-k)!}$$

Based on this model, 247 different combinations were derived in total. The different combinations for investing in different ship types are as follows:

- 2 different ship types 28 different combinations
- 3 different ship types 56 different combinations
- 4 different ship types 70 different combinations
- 5 different ship types 56 different combinations
- 6 different ship types 28 different combinations
- 7 different ship types 8 different combinations
- All different ship types, 1 combination

All combinations were tested for cointegration by employing the Johansen approach. The number of lags (4) was determined by the Bayesian Information Criterion. The model is corresponding with Option 4 in the relevant routine in EViews and looks as follows for the eight ship type combination:

$$\Delta_1 Y_t = m_0 + a(b' \ln Y_{t-1} - m_1 - d_1 t) + e_t + b_1 \Delta_1 \mathrm{Y}_{t-1} + b_2 \Delta_1 \mathrm{Y}_{t-2} + b_3 \Delta_1 \mathrm{Y}_{t-3} + b_4 \Delta_1 \mathrm{Y}_{t-4}$$

where

$$Y_t = \begin{pmatrix} handybulkers \\ panamax\ bulkers \\ capes \\ handy\ tankers \\ panamax\ tankers \\ aframax \\ suezmax \\ vlcc \end{pmatrix}$$

The cointegrating vectors comprising Y_t vary for each of the 247 models depending on the number of ship types and their possible combinations.

Table 8.4 summarises the results of the cointegration tests for all possible combinations of two, three, four, five, six, seven and all (eight) different ship types and in how many cases diversification benefits exist in the long run. More extensive results can be found in the Appendix in tables A1 to A6, at the end of this chapter. These results can be used as a guide to ship investors to identify whether any long run risk reduction benefits can be obtained by investing into different ship types and sizes, before deciding to diversify.

Insert Table 8.4 somewhere here

Where no long-run relationship exists between the returns on these shipping segments and diversification benefits can be obtained in the long run. For all other cases, results indicate that at least one cointegrating equation exists among the variables thus eliminating any potential for risk diversification in the long-run.

The results from tables A2, A4 indicate that when someone invests only in all tankers sizes or only in all bulk carrier sizes, he/she cannot obtain any risk reduction benefits through diversification. The Johansen test results show that the null hypothesis that no cointegrating equation exists in these cases is rejected and that at least one such equation exists. This finding is in line with the findings of various authors who have applied cointegration analysis in shipping (Glen 1996 and Berg-Andreassen 1997 in tankers, Hale and Vanags 1996, Veenstra and Franses 1997 and Wright 1999 in bulk carriers). Moreover, this study complements previous research on the area by finding that investment in all different ship sizes, both in dry and wet bulk, does not lead to risk reduction since at least one cointegrating equation exists among them. This result is reported in table A6.

From table A1 we can see that diversification benefits can be obtained for all combination of two ship sizes, provided that not both of them are bulk carriers. Overall it can be said that investments including more than one type/size of bulk carrier do not yield any risk reduction benefits.

We can also see from tables A2 and A3 that diversification benefits may also exist in combinations of three and four vessel types. However, it has to be noted that out of the four different ship types, one has to be a bulk carrier in order to obtain diversification benefits, the exception being the combination of VLCC, Aframax, Panamax and Handy tankers. The same result that diversification benefits can be obtained through the combination of one type of bulk carrier and tankers is also obtained in the case of investment in three and two different ship sizes respectively as well. However, the results there are less obvious, since diversification benefits can be obtained from different combinations of different types of tankers as well.

Results in tables A4 to A6 indicate that any diversification benefits are non-existent in investments involving at least five different sizes of vessels. In all cases we can see that the null hypothesis that no cointegrating equation exists between the variables is rejected. Furthermore, from tables A1 to A3 we can see that the possible combinations where risk reduction can be achieved through diversification is reduced as the number of ship types/sizes the shipowner invests in increases. These results are in line with research on international equity market diversification where it has been suggested that long-run covariances between markets are higher than in the short run and hence benefits of international diversification are lower (Grubel and Fadner 1971, Panton, Lessig and Joy, 1976; and Taylor and Tonks, 1989).

Moreover, these results seem to be in contrast to the portfolio risk measurement theory which claims that risk reduction benefits increase with the inclusion of the investor's portfolio of more different assets, in other words with higher diversification. Therefore, while it may be true that greater diversification leads to higher risk reduction in the short run, in the long run, as our cointegration estimates show, such benefits are lost. This can be an explanation as to how a company that only focuses on one or maximum two ship types can perform better than another one that focuses on more, as is the case with Stelmar and Alpha Shipping.

A drawback of the cointegration approach however, is that despite providing evidence that diversification benefits decrease with time horizon, it does not provide evidence by how much. One way of trying to quantify how much diversification benefit is lost as time horizon increases, is to look at how the correlation coefficients of our time series change as our time horizon changes.

By comparing the correlation among the ship types obtained in table 8.2 with those of tables A7 and A8 (quarter and annual horizon respectively), we can see that in most cases the correlation coefficients increase as time horizon increases. This may offer a sort of quantifiable explanation for the loss of diversification benefits in the long run because the higher the correlation coefficients, the lower the risk reduction benefits we obtain through diversification. This can be seen from table 8.5 where we see that the number of combinations where no cointegrating relations and thus diversification benefits exist reduces with increasing time horizon.

Insert Table 8.5 somewhere here

Therefore, due to this shortcoming of the cointegration approach and some mix results, our results should not be interpreted as a challenge to the validity of risk reduction through diversification but rather as a supplement to it. After all, Brealey and Meyers (2003) mention that any risk reduction benefits through diversification are short-lived and may disappear in the long run. Finally, it has to be noted that such long run relationships support the existence of inefficiencies in the shipping freight market. This finding is in line with the findings of Kavussanos and Alizadeh (2002b), who have identified inefficiencies in the bulk shipping markets.

8.11 Conclusion

This chapter has investigated the potential of risk reduction benefits for a bulk shipping investor through diversification. It first analysed the traditional risk reduction approach of calculating the variance and the standard deviation of a portfolio. The results showed that risk reduction benefits could be achieved through diversification. Then the thesis built upon the shortcomings of correlation, the key parameter used to measure the degree of integration between any two markets by financial analysts. Namely this has to do with the fact that while markets may tend to diverge considerably in the short-run, like periods of up to a year, they may actually be integrated over longer periods. Based on that finding the cointegration approach was proposed to ascertain the degree to which nonstationary time series, in this case bulk carrier and tanker time charter rates move together in the long run.

The chapter employed the Johansen method for testing for long run relations in the income of different ship types and sizes. Out of 247 different combinations of investment in the dry and wet bulk markets, the thesis identified cases where long run risk reduction benefits can be obtained by investing into different ship types and sizes. This way it developed a good guide to the ship investor seeking risk reduction benefits through diversification.

The thesis found that investing in more than one type of bulk carrier nullifies any risk reduction benefits. Furthermore, risk reduction benefits decrease as diversification increases with no risk reduction benefits obtained when investment involves more than five different ship types/sizes. This may explain the success of some companies that tend to focus one or two ship types compared to the failure of others that tend to operate a more diversified fleet. However, the cointegration methodology cannot quantify this risk reduction. One way this thesis tried to achieve that was by measuring the correlation coefficients for different time horizon. The thesis found that in most cases, correlation coefficients increased with an increase in time horizon, thus indicating a loss of diversification benefit in the long run.

These results initially seem to be in contrast to the portfolio risk measurement theory which claims that risk reduction benefits increase with higher diversification. However, the reason behind this difference lies with time horizon. It may be true that greater diversification leads to higher risk reduction in the short run but in the long run, as our cointegration estimates show, such benefits are lost. Therefore, the results actually supplement the theory of risk reduction through diversification by showing that the benefits of diversification in most cases may exist in the short run but disappear in the long run.

Finally, finding such long run relationships support the existence of inefficiencies in the shipping freight market a finding in line with previous research.

Chapter 8 Appendix: individual cointegration test results and correlation matrices for different investment horizons

Non-existence of a cointegration relationship is indicated in bold.

Table A1:Cointegration Results- Combination of Two Different Ship Types[1]		
Cointegrating Equations =0	**Eigenvalue**	**Trace Statistic***
Ac	**0.045907**	**18.45648**
Ahb	**0.055008**	**19.62732**
Aht	**0.046773**	**21.37591**
Apb	**0.061872**	**22.22719**
Apt	**0.046665**	**22.16840**
Chb	0.076645	27.59016
Cpb	0.088055	31.78281
Cht	**0.043069**	**18.61324**
Hthb	**0.057863**	**21.60447**
Pbhb	0.074298	26.77530
HtPb	**0.053676**	**21.35294**
Ptc	**0.045133**	**19.15380**
Pthb	**0.062687**	**22.73149**
Ptht	**0.046215**	**21.82343**
Ptpb	**0.062557**	**23.42335**
Sa	**0.042198**	**17.65238**
Sc	**0.054664**	**24.42194**
Shb	**0.050547**	**19.50433**
Sht	**0.049933**	**24.08916**
Spb	**0.054923**	**22.26961**
Spt	**0.047354**	**20.26476**
Va	**0.055218**	**23.16868**
Vc	**0.057845**	**23.20538**
Vhb	**0.049678**	**19.47746**
Vht	**0.045089**	**21.71453**
Vpb	**0.057107**	**22.32158**
Vpt	**0.053562**	**23.54575**
Vs	**0.043066**	**19.51548**
***Critical Value at 5%: 25.32**		

Table A2:Cointegration Results- Combination of Three Different Ship Types		
Cointegrating Equations =0	**Eigenvalue**	**Trace Statistic***
All Bulk Carriers	0.104492	57.16132
Achb	0.084573	42.87744
Acpb	0.111231	50.80594
Ahtc	**0.059783**	**35.41319**
Ahthb	**0.064322**	**36.34402**
Ahtpb	**0.075699**	**39.86045**
Apbhb	0.081710	42.94129
Aptc	**0.061179**	**36.06373**
Apthb	**0.069023**	**37.83192**
Aptht	0.083243	46.26165

[1] V= VLCC, S= Suezmax Tanker, A= Aframax Tanker, Pt= Panamax Tanker, Ht= Handy Size Tanker, C= Cape Size Bulk Carrier, Pb= Panamax Bulk Carrier, Hb= Handy Size Bulk Carrier

Aptpb	**0.078596**	**41.04042**
Htchb	0.094948	45.61167
Htcpb	0.112369	50.70797
Htpbhb	0.084030	45.23916
Ptchb	0.094043	45.88072
Ptcpb	0.124323	54.38878
Pthtc	**0.061238**	**36.05758**
Pththb	**0.066226**	**36.74522**
Pthtpb	**0.077577**	**40.46585**
Ptpbhb	0.075309	44.71820
Sac	**0.058526**	**36.59417**
Sahb	**0.058485**	**33.75945**
Saht	**0.052884**	**34.90896**
Sapb	**0.068363**	**38.93862**
Sapt	**0.052543**	**35.76348**
Schb	0.098571	49.82716
Scpb	0.119366	57.64083
Shtpb	**0.068175**	**42.13705**
Shtc	0.072750	43.08078
Shthb	**0.063180**	**39.06932**
Spbhb	0.082332	43.94548
Sptc	**0.067574**	**40.34335**
Spthb	**0.062452**	**37.88381**
Sptht	**0.053008**	**34.77479**
Sptpb	**0.069257**	**41.93696**
Vac	0.076240	44.45937
Vahb	**0.064425**	**40.00422**
Vaht	**0.057144**	**35.68943**
Vapb	0.083350	44.34014
Vapt	**0.057739**	**35.90337**
Vchb	0.096792	48.79404
Vcpb	0.113443	56.19249
Vpbhb	0.099932	46.12895
Vhtc	**0.076283**	**41.06482**
Vhthb	**0.068472**	**37.28664**
Vhtpb	**0.077881**	**39.55149**
Vptc	0.083933	44.19506
Vpthb	**0.077894**	**41.51843**
Vptht	**0.055945**	**36.02160**
Vptpb	0.091055	44.13780
Vshb	**0.060267**	**31.21117**
Vsht	0.071648	45.75947
Vspb	**0.067518**	**34.85740**
Vspt	0.075459	50.62588
Vsa	0.081138	47.65046
Vsc	**0.066569**	**35.98016**
***Critical Value at 5%: 42.44**		

Table A3: Cointegration Results- Combination of Four Different Ship Types

Cointegrating Equations =0	Eigenvalue	Trace Statistic*
Vsapt	*0.088450*	*66.81559*
Vsaht	*0.089021*	*66.61408*
Vaptht	**0.084778**	**60.67835**
Vahthb	**0.075061**	**54.20322**
Vsac	*0.087132*	*68.46475*

Vaptc	**0.084456**	**58.53496**
Vachb	0.102965	75.08248
Vsapb	0.091894	71.20451
Vaptpb	**0.095577**	**59.28320**
Vahtpb	**0.092978**	**58.87506**
Vacpb	0.123922	83.00439
Vapbhb	*0.113855*	*69.99236*
Vsahb	0.095469	68.31076
Vapthb	**0.078841**	**54.82292**
Vsptht	*0.086788*	*66.08529*
Vpthtc	**0.083163**	**58.15486**
Vpthtpb	**0.093830**	**58.90135**
Vpththb	**0.076382**	**54.46942**
Vshthb	*0.085100*	*63.50200*
Vhtchb	0.125694	75.34893
Vhtpbhb	*0.128214*	*72.37662*
Vscpb	0.122601	70.85414
Vptcpb	0.134032	84.16792
Vhtcpb	0.122234	77.13617
Vcpbhb	0.123462	82.87344
Vschb	**0.100037**	**62.45368**
Vptchb	0.116394	78.09085
Vspbhb	**0.101713**	**59.42297**
Vptpbhb	*0.118160*	*72.17398*
Vsptc	0.098845	73.64806
Vsptpb	0.108978	75.02913
Vspthb	0.092569	72.89746
Vshtc	*0.089476*	*68.14594*
Vahtc	**0.083095**	**58.62020**
Vshtpb	*0.091132*	*66.27925*
Saptht	*0.094261*	*63.14098*
Sahtc	**0.076443**	**57.66482**
Sahtpb	**0.077331**	**60.29815**
Sahthb	**0.067228**	**53.74507**
Saptc	**0.076462**	**58.35697**
Sacpb	0.136035	76.92737
Sachb	*0.101775*	*64.96606*
Saptpb	**0.080690**	**61.25664**
Sapbhb	**0.094296**	**62.24979**
Sapthb	**0.071833**	**55.09307**
Spthtc	**0.077434**	**57.67973**
Spthtpb	**0.079523**	**60.27124**
Spththb	**0.069169**	**53.84483**
Sptchb	0.122397	75.13247
Shtchb	0.152638	85.42508
Shtpbhb	*0.116343*	*73.72192*
Shtcpb	0.158422	89.18321
Scpbhb	0.122431	81.59222
Sptpbhb	*0.090158*	*67.00919*
Sptcpb	0.155316	86.25400
Apthtc	*0.099999*	*66.95833*
Apthtpb	0.098639	72.97770
Apththb	0.092537	65.91239
Ahtcpb	0.121345	70.63021
Ahtchb	*0.123127*	*70.49086*
Ahtpbhb	*0.151584*	*80.04602*
Acpbhb	0.125051	76.47618
Aptchb	*0.120863*	*70.37093*

Aptcpb	0.122695	71.03934
Aptpbhb	*0.147033*	*79.76805*
Pthtchb	*0.128027*	*72.71631*
Pthtpbhb	*0.156708*	*82.22599*
Ptcpbhb	0.130433	79.45220
Pthtcpb	0.123533	71.76311
Htcpbhb	0.117275	77.98112
***Critical Value at 5%: 62.99**		

Table A4: Cointegration Results- Combination of Five Different Ship Types		
Cointegrating Equations =0	**Eigenvalue**	**Trace Statistic***
All Tankers	0.100792	92.04193
Five no Achb	0.106398	93.39345
Five no Acpb	0.107552	91.57018
Five no Ahtc	0.151925	108.4805
Five no Ahthb	0.158859	122.9799
Five no Ahtpb	0.159263	116.7826
Five no Apbhb	0.099889	90.07795
Five no Aptc	0.151196	104.0982
Five no Apthb	0.158317	114.9571
Five no Aptht	0.130881	98.19256
Five no Aptpb	0.174214	114.5180
Five no Htchb	0.106630	93.65683
Five no Htcpb	0.105101	91.65878
Five no Htpbhb	0.100065	90.37831
Five no Ptchb	0.107929	93.57957
Five no Ptcpb	0.106509	91.19419
Five no Pthtc	0.137163	101.0004
Five no Pththb	0.139607	113.8865
Five no Pthtpb	0.134548	104.7253
Five no Ptpbhb	0.100610	90.60722
Five no Sac	0.181831	107.8204
Five no Sahb	0.131812	98.59853
Five no Saht	0.144464	114.6807
Five no Sapb	0.144487	102.0943
Five no Sapt	0.138656	112.1512
Five no Schb	0.110356	92.81061
Five no Scpb	0.132914	100.8091
Five no Shtpb	0.177100	106.8157
Five no Shtc	0.177100	106.8157
Five no Shthb	0.130368	98.70251
Five no Spbhb	0.107415	89.62430
Five no Sptc	0.180010	107.0372
Five no Spthb	0.130087	98.76804
Five no Sptht	0.140049	111.9942
Five no Sptpb	0.142018	101.4665
Five no Vac	0.171198	106.2815
Five no Vahb	0.162831	106.0950
Five no Vaht	0.159118	112.3910
Five no Vapb	0.179576	108.3398
Five no Vapt	0.168869	120.7667
Five no Vchb	0.123548	88.48782
Five no Vcpb	0.126938	92.32803
Five no Vpbhb	0.112291	90.13170
Five no Vhtc	0.167467	106.1764

Five no Vhthb	0.161606	106.1864
Five no Vhtpb	0.178039	108.2825
Five no Vptc	0.169653	105.8298
Five no Vpthb	0.160772	105.5949
Five no Vptht	0.147359	103.5780
Five no Vptpb	0.160772	105.5949
Five no Vshb	0.143226	107.5676
Five no Vsht	0.158803	113.2916
Five no Vspb	0.153773	109.1994
Five no Vspt	0.160957	114.0567
Five no Vsa	0.164132	116.3612
Five no Vsc	0.164487	115.0038
***Critical Value at 5%: 87.31**		

Table A5: Cointegration Results- Combination of Six Different Ship Types

Cointegrating Equations =0	Eigenvalue	Trace Statistic*
All no a, c	0.189829	146.0140
All no a, hb	0.163526	142.0863
All no a, ht	0.163509	157.4768
All no a, pb	0.188550	148.0690
All no a, pt	0.172298	153.0610
All no c, hb	0.115287	127.0267
All no c, pb	0.112875	122.5433
All no ht, c	0.188637	145.9216
All no ht, hb	0.161658	141.6634
All no ht, pb	0.189143	147.9489
All no pb, hb	0.114287	121.8131
All no pt, c	0.189801	145.8765
All no pt, hb	0.161734	142.0443
All no pt, ht	0.158135	147.3600
All no pt, pb	0.187529	147.4616
All no s, a	0.186853	149.3258
All no s, c	0.183381	141.4476
All no s, hb	0.145926	133.4398
All no s, ht	0.183066	148.3848
All no s, pb	0.163371	138.5424
All no s, pt	0.185430	149.0621
All no v, a	0.184029	153.4595
All no v, c	0.170946	138.6150
All no v, hb	0.166093	139.8933
All no v, ht	0.180545	152.5188
All no v, pb	0.185638	142.4486
All no v, pt	0.182253	152.6142
All no v, s	0.167049	152.0278
***Critical Value at 5%: 114.9**		

Table A6: Cointegration Results- Combination of All and Seven Different Ship Types

Cointegrating Equations =0	Eigenvalue	Trace Statistic*
All vessel types	0.195568	226.4375
All no v	0.185774	185.9427
All no s	0.186662	183.4232
All no a	0.195438	195.9314
All no pt	0.195159	195.7132
All no ht	0.194524	195.1345

All no c	0.188636	177.6475
All no pb	0.194018	181.4229
All no hb	0.166150	174.5396
***Critical Value at 5%: seven Types: 146.76, All ship types: 182.82**		

Table A7: Correlation Matrix for Different Ship Types Time Charter Rates (Quarterly Time Horizon)								
	LNVLCC	**LNSUEZ**	**LNAFRA**	**LNPANAMAXT**	**LNHANDYT**	**LNCAPE**	**LNPANAMAXB**	**LNHANDYB**
LNVLCC	1	0.906844	0.871968	0.82913	0.711755	0.450321	0.488811	0.596945
LNSUEZ	0.906844	1	0.908544	0.878779	0.7743	0.455254	0.500186	0.63131
LNAFRA	0.871968	0.908544	1	0.970041	0.864142	0.556921	0.610366	0.699721
LNPANAMAXT	0.82913	0.878779	0.970041	1	0.960149	0.575837	0.640253	0.738536
LNHANDYT	0.711755	0.7743	0.864142	0.960149	1	0.554926	0.629899	0.731464
LNCAPE	**0.450321**	**0.455254**	**0.556921**	**0.575837**	**0.554926**	1	0.956963	0.856787
LNPANAMAXB	**0.488811**	**0.500186**	**0.610366**	**0.640253**	**0.629899**	0.956963	1	0.937775
LNHANDYB	0.596945	0.63131	0.699721	0.738536	0.731464	**0.856787**	0.937775	1

Table A8: Correlation Matrix for Different Ship Types Time Charter Rates (Annual Time Horizon)								
	LNVLCC	**LNSUEZ**	**LNAFRA**	**LNPANAMAXT**	**LNHANDYT**	**LNCAPE**	**LNPANAMAXB**	**LNHANDYB**
LNVLCC	1	0.911745	0.894345	0.841747	0.723112	0.40173	0.47491	0.609053
LNSUEZ	0.911745	1	0.922837	0.888286	0.787883	0.391419	0.470366	0.635264
LNAFRA	0.894345	0.922837	1	0.975284	0.884382	0.513644	0.608505	0.732604
LNPANAMAXT	0.841747	0.888286	0.975284	1	0.965451	0.527893	0.631551	0.765218
LNHANDYT	0.723112	0.787883	0.884382	0.965451	1	0.513429	0.622238	0.758619
LNCAPE	0.40173	0.391419	0.513644	0.527893	0.513429	1	0.965839	0.84177
LNPANAMAXB	0.47491	0.470366	0.608505	0.631551	0.622238	0.965839	1	0.932826
LNHANDYB	0.609053	0.635264	0.732604	0.765218	0.758619	0.84177	0.932826	1

Table 8.1: Descriptive Statistics for Vessel Time Charter Rates (series in logarithms) Sample: 01:1979-01:2002								
	LNVLCC	**LNSUEZ**	**LNAFRA**	**LNPANAMAXT**	**LNHANDYT**	**LNCAPE**	**LNPANAMAXB**	**LNHANDYB**
Mean	9.497627	9.464477	9.371799	9.189636	9.206576	9.183453	9.048721	8.735402
Std. Dev.	0.490902	0.476048	0.450228	0.381973	0.319443	0.429875	0.362865	0.309059
Variance	0.240985	0.226622	0.202705	0.145903	0.102044	0.184793	0.131671	0.095517
Skewness	-0.438839	0.023047	-0.914062	-0.923832	-0.728688	-0.413610	-0.419862	-0.662580
Kurtosis	2.447258	2.272318	3.300513	3.292954	3.245124	2.014473	1.996687	2.238791
Jarque-Bera	12.41701	6.136075	39.61497	40.39222	25.20735	19.10789	19.75673	26.95544
Probability	0.002012	0.046512	0.000000	0.000000	0.000003	0.000071	0.000051	0.000001
Observations	277	277	277	277	277	277	277	277

Table 8.2: Correlation Matrix for Different Ship Types Time Charter Rates								
	LNVLCC	**LNSUEZ**	**LNAFRA**	**LNPANAMAXT**	**LNHANDYT**	**LNCAPE**	**LNPANAMAXB**	**LNHANDYB**
LNVLCC	1.000000	0.902316	0.862594	0.823537	0.707863	0.450603	0.488685	0.591826
LNSUEZ	0.902316	1.000000	0.903130	0.875947	0.771547	0.461644	0.503784	0.629122
LNAFRA	0.862594	0.903130	1.000000	0.968746	0.858954	0.563556	0.611843	0.694109
LNPANAMAXT	0.823537	0.875947	0.968746	1.000000	0.958674	0.582049	0.642341	0.734546
LNHANDYT	0.707863	0.771547	0.858954	0.958674	1.000000	0.558047	0.630219	0.727033
LNCAPE	0.450603	0.461644	0.563556	0.582049	0.558047	1.000000	0.949750	0.854773
LNPANAMAXB	0.488685	0.503784	0.611843	0.642341	0.630219	0.949750	1.000000	0.936190
LNHANDYB	0.591826	0.629122	0.694109	0.734546	0.727033	0.854773	0.936190	1.000000

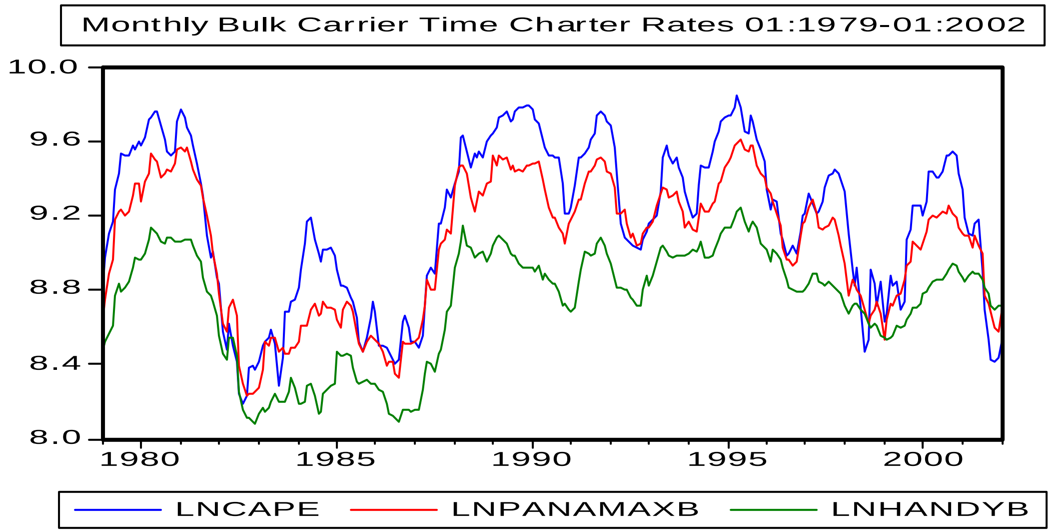

Monthly Bulk Carrier Time Charter Rates 01:1979-01:2002
10.0
9.6
9.2
8.8
8.4
8.0
1980
1985
1990
1995
2000
LNCAPE
LNPANAMAXB
LNHANDYB

Figure 8.1

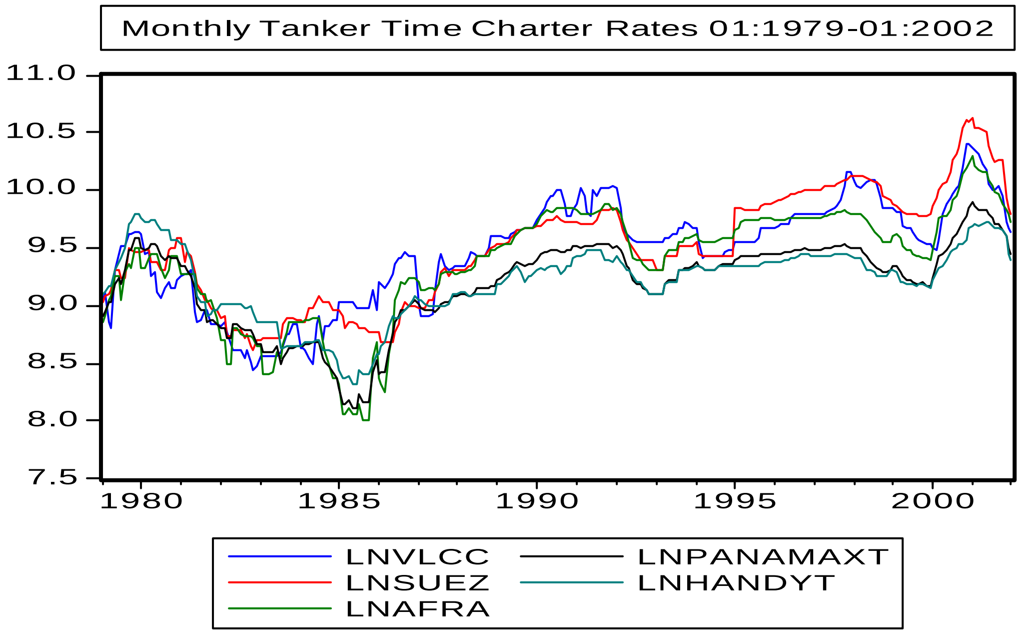


Figure 8.2

Table 8.3: ADF Test Results for Stationarity (Series in Logarithms, 4 lags, series include a trend and a constant)						
Ship Type	**Levels**	**Stationarity**	**1st Difference**	**Stationarity**	**MacKinnon Critical Values**	
					1%	5%
					-3.9953	-3.4277
Bulk Carriers						
Handysize	-2.246258	No	-5.309194	Yes		
Panamax	-2.513415	No	-6.169636	Yes		
Capesize	-2.512756	No	-5.676855	Yes		
Tankers						
Handysize	-2.953178	No	-5.024282	Yes		
Panamax	-2.838627	No	-4.493382	Yes		
Aframax	-2.401120	No	-6.151297	Yes		
Suezmax	-3.148792	No	-4.895036	Yes		
VLCC	-3.152489	No	-7.755459	Yes		

Table 8.4: summary of cointegration tests		
Nr of ship types and sizes	**Potential nr of diversification combinations**	**Nr of found diversification combinations**
2	28	25
3	56	31
4	70	22
5	56	0
6	28	0
7	8	0
8	1	0

Table 8.5: Number of diversification combinations for different time horizons				
Nr of ship types and sizes	**Potential nr of diversification combinations**	**Nr of found diversification combinations Monthly Horizon**	**Nr of found diversification combinations Quarterly Horizon**	**Nr of found diversification combinations Annual Horizon**
2	28	25	9	15
3	56	31	7	15
4	70	22	5	3
5	56	0	0	0
6	28	0	0	0
7	8	0	0	0
8	1	0	0	0

Chapter 9: Assessing and Controlling Freight Risks in Bulk Shipping within a VaR-CVaR framework

9.1 Introduction

The shipping industry is widely accepted as risky by nature. This can be seen by both freight and asset market volatility. Such riskiness is caused by factors like uncertainties in the demand for the service, cost, prices or technological developments.

In addition to traditional risk management methods such as period chartering, freight derivatives grew in response to a need to hedge shipping risks, along with its inevitable counterpart, a search for speculative profits. As risk management tools, derivatives provide a market for the reallocation of risks. With the derivatives market becoming more mainstream risk management tools now apply to a wider variety of financial instruments. As a result, risk management is now applied at the level of the whole corporation.

On the downside, the technology behind the creation of ever-more complex derivatives instruments seems at times to have advanced faster than our ability to control or understand it. As a result, decisions can be made based on nothing more than figures provided by a 'black box' without any further intuition. This way, the probability for losses may actually increase rather than decrease. Also, a major problem affecting all trading activity is that agents often have incentives to engage in risk-taking activity that may not be in the best interest of the firm they work for. Thus profit-based compensation creates incentives to take on extra risk, while the opposite leads to complacency. For this reason there is now such a great focus on controls and risk management systems.

Furthermore, derivatives have been viewed as dangerous financial instruments that caused huge losses and should be curtailed. Recent examples in shipping include BHP and Bocimar that have lost around 40 million USD each on the futures markets (Tradewinds 2003). However, losses in shipping are dwarfed by derivatives losses in other industries. Examples include Barrings' $1.4 billion loss, Orange County's $1.7 billion and Long Term Capital Management's loss of $3.7 billion. Such disasters have made one of the most famous investors in the world, Warren Buffet to describe derivatives as financial weapons of mass destruction.

However, provided they are judiciously used, derivatives are inherently stabilizing because they allow better allocation of risk. Furthermore, according to regulators, the devotion of substantial resources to the development of more sophisticated risk management tools have had favourable spill-over effects on institutions' abilities to manage their total portfolios not just their derivatives activities (Jorion 1997, page xiii). From such risk management tools, Value at Risk (VaR), a concept made famous by JP Morgan in mid 90's is increasingly gaining popularity among financial institutions and is becoming the standard tool for measuring and managing risk across such organisations.

Nevertheless, despite the fact that such systems have been employed for years in financial institutions their use has been negligible in transportation and particularly in shipping, despite its highly volatile nature.

This chapter is concerned with the measurement of one particular form of financial shipping risk namely market risk or the risk of loss arising from unexpected changes in market prices such as ship prices, or market rates such as freight rates. This way, the thesis contributes to transport economics and policy literature by employing different methods (the delta normal as well as historical and Monte Carlo simulation) for calculating Value at Risk (VaR) of a large shipping portfolio. Therefore, this chapter develops an analytical tool for shipowners and managers to measure the possible losses of their portfolios within a pre-specified time horizon and confidence interval. Furthermore, this tool allows managers to identify the extent to which each asset contributes to these possible losses, as well as get an idea of the maximum possible losses should the worst case scenario occur. By obtaining these figures and comparing them to total earnings or income, shipowners-managers can determine to what extent these potential losses are acceptable and decide whether or not to hedge their positions, either by using freight derivatives or entering their ships into period charter contracts.

The chapter is structured as follows:
The following section analyses the hedging strategies open to shipowners. The next one introduces Value at Risk, explains its use, and compares and contrasts the different methods for computing it. After that the Delta-Normal, the historical simulation and Monte Carlo methods are used to calculate both total and Incremental Value at Risk for different ships. In addition, the portfolio's conditional VaR or Expected Tail Loss (ETL) is estimated in order to obtain the maximum potential loss in case things really go wrong. A discussion follows on whether, based on the estimates, it makes sense to hedge potential losses by using derivatives or period charters, followed by the conclusions.

9.2 Risk Management in Shipping

One factor behind the development of risk management in shipping and other industries is the high level of instability in the economic environment within which firms operate. A volatile environment exposes firms to greater financial risk and therefore provides them with an incentive to find new and better ways of managing this risk. As a result, the primal role of forward and future markets is that of hedging. Derivatives markets exist in the shipping industry to provide instruments for market agents to reduce or control the undesired risk of adverse price movements of freight, bunkers, interest and foreign exchange rates and transferring this risk to others who are willing to bear it. In addition to derivatives, shipowners also have the time charter or period market to hedge their spot position in the physical market. This tool is particular to the shipping industry and its mechanics, as we can see in the following paragraph, resemble those of a swap agreement.

9.2.1 The Period Charter as a Hedging Tool

Period or Time charter rates can represent two things:

The first one is to reflect the equivalent of currency unit (normally dollars) paid per tonne of cargo loaded in the equivalent currency unit per day. This term is known as time charter equivalent. Time charter equivalent is derived if we subtract the voyage costs from net freight (that is freight rate per tonne of cargo loaded minus commissions) and we divide it by the voyage days:

$$TCE = \frac{(FR * T_c) - (VC + COM + Ft)}{d_v}$$

where:
TCE= The Time Charter Equivalent Rate
FR= Freight rate per tonne of cargo
T_c = Tonnes of cargo loaded
VC= Voyage Costs
COM= Commission
Ft = Freight Tax (if applicable)
d_v= Voyage days

By agreeing to enter into a trip timecharter, the shipowner passes the risk of an increase in voyage costs to the charterer. For example, if the vessel is delayed in a port due to congestion, this delay will be paid by the charterer without affecting the shipowner's profit.

Also, timecharter rates reflect expectations of shipowners and charterers with regard to future developments in the voyage or spot charter market. This is the case where the vessel is chartered out for long periods of time, anything from 3 months and above. This resembles the mechanics of a swap agreement since under a period charter the shipowner receives a fixed rate from the charterer who in return assumes a floating one.

9.2.2 Shipping Futures and Forwards

There are two derivative products known in shipping: The Baltic International Freight Futures (BIFFEX) contracts were launched in 1985 and survived until April 2002.

In 1992 a new kind of derivative product became available that could be used instead of BIFFEX, the Forward Freight Agreements (FFAs). These contracts are sold over the counter by a number of authorised brokers to manage uncertainty in rates.

A BIFFEX contract involves the buying or selling of the value of the Baltic Index (the underlying commodity) at the price determined by the market, with the agreement of reversing this action on a specified date in future, when the contract matures.

The same principles apply with the FFAs but this time instead of buying or selling the index value, the agents enter into route specific contracts between a seller and a buyer to settle a freight rate. The freight rate agreement is for a specified quantity of cargo or type of vessel for usually one or a combination of the major trade routes.

According to Table 9.1 and Figure 9.1, participants in the shipping markets had been switching gradually from using BIFFEX to FFA contracts for risk management purposes until the former was scrapped in April 2002. Reasons for not using BIFFEX included ignorance, wrong perception of BIFFEX as a speculative arrangement as well as questions regarding the effectiveness of BIFFEX as a hedging instrument (Haralambides 1993b). Also, according to Kavussanos and Visvikis (2003), BIFFEX contracts did not perform well as hedging instruments as the underlying asset of the BIFFEX contract was an index and consequently involved cross hedging. BIFFEX neither shifted nor reduced freight risk; it merely established a second market position that had its own risk. A hedge is considered effective if the two price risks are offsetting (Haralambides 1991, 1993a, 1993b). Most agents however in the shipping industry operate in specific routes and therefore demand route-specific derivatives contracts. Furthermore, research has shown that the reduction in risk of the spot position in freight markets is not as large as in other markets. The hedging effectiveness of the BIFFEX contract varies from from 4 to 23.25%. For FFAs the risk reduction is greater (from 18.03 to 32.16%) but is still far from satisfactory (Kavussanos and Visvikis 2003).

Insert Figure 9.1 and Table 9.1 somewhere here

In derivative markets, the spot position is neutralised by holding an opposite position in derivatives. Such risk management policies allow market agents to stabilise their revenue or the cost side of their balance sheet. Although big sums of money are involved in shipping, the risk management techniques are not as developed or popular as in other sectors of the economy. One of the main reasons for this is that the market is fragmented without any big owners controlling the market. Because transaction costs only decrease with volume, shipowners and charterers must have large positions both in ships and/or cargoes and cash to follow a hedging strategy using derivatives that makes economic sense. As a result the extra transaction costs for derivatives trading, even if they are not very high compared to shipbrokers' freight commission, make derivatives unattractive to most shipowners from an economic point of view. Therefore, small and medium size shipowners and charterers that form the majority of the market agents avoid using derivatives. Another reason, which was already discussed above, is derivatives' hedging effectiveness. According to Haralambides (1993b), futures trading is rarely perfectly effective and hedging would very seldom eliminate freight rate risk by one hundred percent. Certain risk called basis risk will always remain and this is particularly true with cross hedges as BIFFEX. If the basis risk is less that the freight rate risk alone, then the hedges is said to be at least partially effective. Therefore, the assumption that is violated is that the decline in freight rates is proportionately exactly equal to the decline in the price of futures contracts.

The most important reason however has to do with the fact that shipowners have a very simple, effective and cheap tool to hedge their freight risks, unique to the shipping industry, the time charter. Based on their gut feeling or their market expectations, shipowners can decide to 'hedge' their position by entering part or all of their fleet into period charter rates. A successful example of such a strategy is Stelmar. By following a period charter strategy with reputable charterers for the majority of its fleet, Stelmar has managed to ride the shipping cycles profitably and at low risk and cost.

According to Kavussanos and Visvikis (2003), the hedger shall initially consider two issues that will determine the type of contract that is most appropriate to use and how the hedge will be constructed; the type of derivatives and maturity date. Nevertheless, the first question the shipmanagers need to answer before they enter this procedure is whether the risks they run are acceptable to them. The answer to this question shall then determine whether it makes sense to hedge or not. This is where risk management tools and the Value at Risk methodology in particular serves its main purpose, which is to determine a level of risk within a confidence interval for a specific horizon so that the management can assess whether or not to hedge. They can then hedge their positions either by entering into period charters or using freight derivatives. For the latter, the extra transaction and brokerage costs have to be taken into account as well.

9.3 Value at Risk (VaR)

Modern Portfolio Theory tells us that the risk in a portfolio can be proxied by the portfolio standard deviation, a measure of dispersion in a distribution. That is, standard deviation is all you need to know in order to firstly encapsulate all the information about risk that is relevant, and secondly to construct risk-based rules for optimal risk "management" decisions. However, according to Schachter (1997) standard deviation has some characteristics that make it unappealing to managers. First, managers think of risk in terms of dollars of loss, whereas standard deviation defines risk in terms of deviations, either above or below, expected return and is therefore not intuitive. Second, in trading portfolios, deviations of a given amount below expected return do not occur with the same likelihood as deviations resulting from positions in options and option-like instruments, whereas the use of standard deviation for risk management assumes symmetry.

As a result, an alternative measure of risk, namely the Value at Risk (VaR) was developed in mid 1990s.[1] VaR provides users with a summary measure of market risk. This number summarizes the company's exposure to market risk as well as the probability of an adverse move. Equally important, it measures risk using the same units as the company's bottom line, dollars. Shareholders and managers can then decide whether they feel comfortable with this level of risk. If the answer is no, the process that led to the computation of VaR can be use to decide where to trim the risk (McDonald 2003).

Overall, VaR provides an integrated framework to evaluate effectiveness of hedging policies. However, VaR measures are useful only insofar as users grasp their limitations. It is only an educated estimate of market risk and shall be viewed as a necessary but not sufficient procedure for controlling it. It must be supplemented by limits and controls in addition to an independent risk management function.

9.4 Calculating VaR

VaR is a function of two parameters: the time horizon and the confidence level.

In general when N days is the time horizon and X% is the confidence level, VaR is the loss corresponding to the (100-X) percentile point of the distribution of the change in the value of the portfolio over the next N days.

9.4.1 Determining the portfolio VaR horizon and confidence interval

From the users' point of view, the horizon can be determined by the portfolio nature. Since shipping companies adjust their risk exposures only slowly just like the investment funds, using monthly horizon seems to make more sense for determining Value at Risk.

The choice of confidence level is important for model validation and should be chosen in preference to a higher level, which would give a loss measure that would rarely be exceeded. Take for instance a 95% level. We know that just by chance we

[1] Earlier than VaR, Haralambides (1991, 1993a), introduced a measure for risk on the basis of random sampling and Monte Carlo simulation, defined as the 'probability of losing one's money).

expect a loss worse than the VaR figure in 1 month out of 20 (Jorion 1997, p. 87). If we had chosen a 99% level, we would have to wait on average 100 days to confirm that the model conforms to reality. In our case, since we have chosen a monthly horizon and by the time that VaR in a shipping company can be mostly used as a yardstick to compare risk around different sectors, the 95% level seems the most appropriate.

9.4.2 Different Approaches to measuring VaR

Approaches to VaR can be basically classified into two groups. The first group is based on a local valuation; such an example is the delta-normal method. The second group uses full valuation. Full valuation is implemented in the historical simulation method, the stress testing method and the structured Monte Carlo method. A third method is the historical simulation.

Table 9.2 describes the pros and cons of each method.

Insert Table 9.2 somewhere here

The choice of method depends largely on portfolio composition. For portfolios with no options, the delta normal method may well be the best choice. VaR is relatively easy to compute and not too prone to model risk due to faulty assumptions or computations. The resulting VaR is easy to explain to management and the public. For portfolios with option positions however, this method is not appropriate. Instead, users should turn to historical or Monte Carlo simulations.

Historical simulation is also relatively easy to implement and uses actual, full valuation of all securities. However, it cannot account for time variation in risk and like delta-normal model can be caught short by extreme events.

In theory, the Monte Carlo approach can alleviate all of these technical difficulties. It can incorporate non-linear positions, non-normal distributions, implied parameters and even user-defined scenarios. However, computer and data requirements are a quantum step above the other two approaches, model risk looms large and value at risk loses its intuitive appeal.

All these methods present some advantages. They are also related. For example, Monte Carlo analysis of simple positions with normal returns should yield the same result as the delta-normal method.

From the analysis above we have seen that optionality is a major determinant of which method to choose to calculate Value at Risk. In shipping options exist in the form of sale or purchase options, options to extent or reduce a period charter or the option to order additional ships from a shipyard at a predetermined price. These options however do not require an up-front payment, as is the case with financial options. As a result, implementing advanced methods such as Monte Carlo or the Historical Simulation to calculate VaR for the shipping industry, which is characterised by small companies without sophisticated risk management departments, may unnecessarily increase complexity and make it difficult to understand by the management. Therefore, it seems that thanks to its simplicity and its easiness to compute along with the simple structure of shipping options that do not require up-front payments as other financial options do, the delta normal method is the one to be preferred for adoption and application in the majority of shipping companies. For the purpose of this chapter however, in addition to the Delta-Normal method, Historical and Monte Carlo simulation will also be utilised to calculate VaR.

9.5 Applying Value at Risk to Shipping

Let us consider a relatively large shipping company operating a modern fleet of five Suezmax tankers, five Aframax tankers and six Panamax bulk carriers. Based on SSY data, the time charter equivalent rates are \$20545, \$15852 and \$12300 per day per ship for the Suezmax, the Aframax and the Panamax bulkers respectively. Therefore, the company will have a monthly income of approximately \$7.674 million out of which approximately \$3.082 will come from the Suezmaxes, \$2.378 million from the Aframaxes with the remaining \$2.214 million from the Panamax Bulk Carrier fleet. Based on monthly historical data spanning from 1979 to 2002 from Braemar Seascope, the variance is estimated to be 0.62, 0.67 and 0.73 for Panamax Bulk carriers, Aframax and Suezmax tankers respectively.

Focusing solely on freight rates the question is; what is the VaR of the company's cash flows over a monthly horizon? The corporation's exposure derives from the time charter equivalent of the freight rates the ships in its fleet receive on a daily basis.

9.6 Adjusting for Non-Normality-The Cornish-Fisher Expansion

Despite our assumption of the returns being normally distributed, the descriptive statistics of monthly Timecharter equivalent returns indicate small departure from normality. The Cornish-Fisher expansion is used to determine the percentiles of distribution that are near normal. The actual expansion provides an adjustment factor that can be used to adjust estimated percentiles or variates for non-normality, and the adjustment is reliable provided departures from normality are 'small' (Dowd 2002, p. 197). Therefore, the Cornish-Fisher expansion can be used to estimate VaR when the returns' distribution has some but not too much non-normality.

If α_{cl} is a standard normal variate for a confidence level cl (i.e. $\alpha_{0.95}$= -1.645), the Cornish-Fisher expansion is:

$$\alpha_{cl} + (1/6)(\alpha_{cl}^2 - 1)\rho_3 + (1/24)(\alpha_{cl}^3 - 3\alpha_{cl})\rho_4 - (1/36)(2\alpha_{cl}^3 - 5\alpha_{cl})\rho_3^2$$

Where ρ_3 is the distribution's skewness coefficient and ρ_4 is its kurtosis (Lee and Lin 1992, p.234, Zangari 1996, p.9).

The new confidence level we obtain is equivalent to adjusting the normal variate α_{cl} for non-normal skewness and/or kurtosis. The adjusted confidence intervals can be found in table 9.3. This chapter includes VaR estimates for both the normal and the adjusted variate.

Insert Table 9.3 somewhere here

9.7 Calculating VaR with the Delta Normal Method

Tables 9.4 and 9.5 show the computation for the VaR of the total cash flows by using the Delta Normal Method. The first matrix V reports the product of the variance σ of each ship type and α, which is the inverse of the standard normal cumulative distribution for a specified z value. For the 95% confidence level α is equal to approximately 1.645. Matrix R denotes the correlation between the time charter equivalents of each ship type, x is the matrix denoting the monthly income for every ship type. The last column of the top panel reports the product of the income and matrix V. From matrices V and R we can see that the volatility increases with ship size while the rates are highly correlated.

Based on the above information the monthly VaR of the portfolio can be estimated by taking the square root of the product x'V'RVx, where prime, ', denotes a transposed matrix, or else:

$$VaR = \sqrt{x'V'RVx}$$

According to our estimates, the Value at Risk for this company is 77416.71 (66397.56 for adjusted α) US dollars over a monthly horizon at the 95% level. Therefore, under normal market conditions, the company could lose as much as \$77416.71 in a month or 77416.71*√12=\$268179.4 (\$230007.9 adjusted for non-normality) in a year due to unfavourable movements in freight rates.

Insert Tables 9.4 and 9.5 somewhere here

9.7.1 Incremental VaR

An important aspect of calculating VaR is to understand which asset or combination thereof contributes most to risk. Armed with this information, users can alter positions to modify their VaR accordingly. This information can be obtained by estimating the Incremental VaR of each ship type. The computations for incremental VaR are displayed in the last two columns of tables 4 and 5. First we need to compute the β of each cashflow, which is obtained by dividing each element in the first column by the total VaR:

$$\beta = \frac{V'RVx}{\sqrt{x'V'RVx}} = \frac{V'RVx}{\text{VaR}}$$

The marginal contribution of each asset to portfolio risk is β times x times VaR. This represents the proportion of total VaR due to the position x_i in ship type i. By construction it adds up to the total VaR.

The incremental VaR for the Suezmax tankers position is \$34269.02 (34719.99 for adjusted α) against \$24918.12 (16156.45) and \$17869.58(15521.13) for the Aframax tankers and the Panamax Bulk Carriers respectively. It is higher for Suezmax tankers because the position is greater and because this ship's income is more volatile than the others are.

9.8 Monte Carlo Simulation

In order to estimate Value at Risk with Monte Carlo simulation in our case of three risk factors, our discretised geometric Brownian motion process is:

$$\Delta S_1 / S_1 = \mu_1 \Delta t + \sigma_1 \phi_1 \sqrt{\Delta t}$$
$$\Delta S_2 / S_2 = \mu_2 \Delta t + \sigma_2 \phi_2 \sqrt{\Delta t}$$
$$\Delta S_3 / S_3 = \mu_3 \Delta t + \sigma_3 \phi_3 \sqrt{\Delta t}$$

The random variables φ1, φ2 and φ3 were generated by Choleski decomposition. Elements of this decomposition matrix were calculated according to formula for Choleski terms given in Kreyszig (1988). After 1000 simulations a VaR figure almost identical to the Delta Normal method was obtained ($77661.99($66375.94 for adjusted variate)). These almost identical results were expected since the portfolio does not contain any options.

9.9 Historical Simulation

For the purpose of estimating VaR with historical simulation, the historical asset returns from January 1979 to January 2002 were obtained for a hypothetical portfolio comprised of 44% investment in Suezmaxes, 34% in Aframaxes and 22% in Panamax bulk carriers. Then these observations were ordered, the VaR confidence level (normal and Cornish-Fisher adjusted) was obtained, and the VaR was estimated as the negative of the ordered asset return values.

As results in table 9.6 indicate, Value at Risk was estimated for the whole period as well as for 20, 10 and five years of data. With this method VaR estimates at 95% confidence interval vary from $72692.38 ($70268.22 with adjusted confidence interval) to $81573.26 per month (78852,94) depending on the data period.

Insert Table 9.6 somewhere here

9.10 Conditional VaR

From the previous section we saw that VaR is relatively simple to compute and has a clear interpretation. However Artzner et al. (1999) point out that there are conceptual problems with VaR. For example, a reasonable risk measure should have certain properties, among them subadditivity. This means that the risk measure for the two activities combined should be less than for the two activities separately.

Artzner, Delbaen, Eber and Heath (1999) show that VaR is not sub-additive, hence non convex and not coherent. Additionally, the lack of sub-additivity has far reaching implications and may occur under rather general conditions. It implies that diversification may increase rather than decrease global risk. Furthermore, lack of convexity implies that VaR based control strategies, or portfolio optimisation under VaR constraints, may result in non-convex optimisation problems. Finally, the VaR measure has also been criticised due to its lack of informativeness far in the tail.

For these reasons, alternative risk measures have been proposed. Out of these methods, the Conditional Value at Risk (CVaR) or expected shortfall or expected tail loss is attracting increasing interest. CVaR is defined as the expected loss beyond VaR: it depends on those rare losses that once in a while occur beyond the VaR at 95% or 99% (McDonald 2003).

9.10.1 Calculating CVaR

According to Dowd (2002), estimating CVaR can be problematic. Formulas for CVaR are relatively few and far between, and this raises an obvious problem: how to estimate parametric CVaR when there is no CVaR formula to use.

CVaR is the probability-weighted average of tail losses, or losses bigger than VaR. Thus, we can estimate the CVaR as an average of 'tail VaRs': we slice the tail into a large number *n* of slices, each of which has the same probability-mass, estimate the VaR associated with each slice, and take the CVaR as the average of these VaRs.

In our example, let us work with the very small value of *n* 10.This value gives us 9 (i. e., *n* 1) tail- VaRs, or VaRs at confidence levels in excess of 95%. These VaRs are shown in Table 9.7, and vary from $78221.43 (for VaR at a confidence level of 95.5%) to $118842.6 (for VaR at a confidence level of 99.5%). Our estimated CVAR is the average of these VaRs, which is $93427.23. Of course the higher n is the more accurate our estimations are. With 100 tail VaRs for example CVaR becomes $92097.22. However, even in this case we see that the tail loss is small compared to total income. Therefore, chapter hedging is still an unattractive alternative.

Insert Table 9.7 somewhere here

Conditional Value- at- Risk is able to quantify dangers beyond Value- at- Risk, and moreover it is coherent in the sense of Artzner, Delbaen, Eber and Heath (1999) (translation invariant, sub- additive, positively homogeneous, monotonic with respect to Stochastic Dominance). Other advantages over VaR include (Uryasev 2000):

- Measures downside risk
- It is applicable to non- symmetric loss distributions
- CVaR accounts for risks beyond VaR (more conservative than VaR)
- CVaR is convex with respect to portfolio positions

9.11 Policy Implications

Value and/or Conditional Value at Risk calculations are essential decision making tools that determine whether or not to hedge a position. In shipping, hedging can be achieved with derivatives or by entering some of the ships into period charters. Thus VaR is an essential first step towards an informed risk management system.

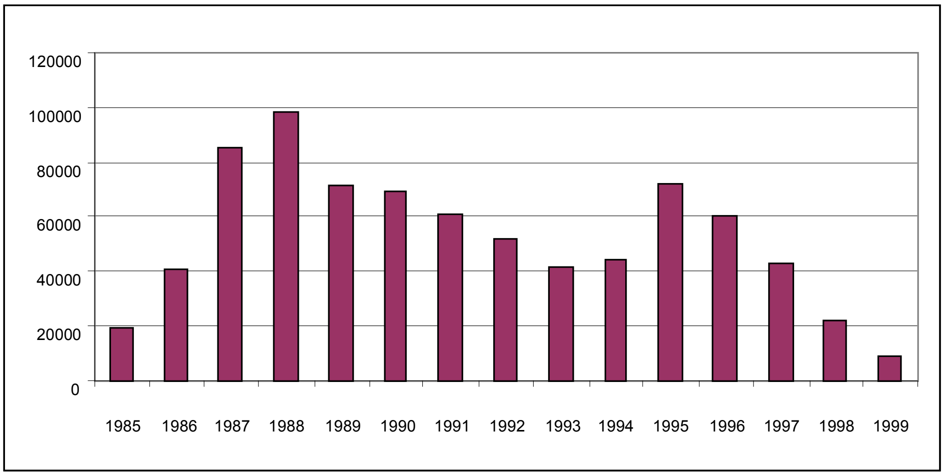
Overall in relation to the company's total annual revenue of approximately $92 million, the risk of losses due to freight rate fluctuations is small even for this large shipping portfolio. This may be a first reason to avoid hedging and explains a lot about the industry's reluctance to adopt freight derivatives as hedging tools. However, even if the shipping company still wants to hedge against the downturn it can easily avoid the extra brokerage and transaction costs associated with taking a position in the charter market and opt for long period time charters at no additional cost. Bearing in mind that the bulk shipping market is highly fragmented and that the smaller the company the higher the transaction costs clearly favour time charter as a risk management tool. This unique tool helps shipowners to minimise their risks much easier and at lower costs than entrepreneurs in other industries who have derivatives markets as their only solution. Therefore, despite all the promotion of shipping futures and forwards over the last twenty years, freight derivatives have not been embraced by the shipping industry until recently. Furthermore, the relatively low amounts of value at risk compared to total revenues even for a relatively large company in our example, may add up to the industry's reluctance to use freight derivatives on a large scale. However, it is wrong to conclude from this chapter that shipping is a relatively low risk industry or that freight derivatives should be avoided by shipping professionals as hedging tools. In previous chapters we saw the volatility and consequently the risks characterising the shipping markets. At the same time we see that more and more shipping professionals today embrace FFAs as a hedging mechanism with trading volumes skyrocketing. What is important to note from this chapter is that in order to be able to determine the amount of risk and subsequently the way we hedge against it effectively, we have to quantify the risk first. This way, we will be able to see whether this value at risk is acceptable to us and if not then proceed with hedging either the traditional way with long-term charters or through FFAs. And the best way to do this is by adopting risk management systems such as VaR or CVaR in shipping's day-to-day operations.

The next logical step in risk management and the company's decision-making process after that will be the measurement of economic risks due to financial variables, not just cashflow risks. For example, the previous analysis assumes that quantities do not change with prices. In practice, changing prices in freight rates may affect demand and thus total revenues. Whether these financial risks should be hedged is a more complex matter.

9.12 Conclusion

By applying the delta normal, historical and Monte Carlo simulation methods for calculating Value at Risk on the portfolio of a large shipping company, this chapter developed an analytical tool for shipowners and managers to measure the possible losses within a pre-specified time horizon and confidence interval of their portfolios. This tool allows the managers to identify the extent to which each asset contributes to these possible losses, as well as get an idea of the maximum possible losses should the worst case scenario occurs. By obtaining these figures and comparing them to total earnings or income, shipowners-managers can determine to what extent these potential losses are acceptable and decide whether or not to hedge their positions, either by using freight derivatives or entering their ships into period charter contracts. Overall, VaR provides a framework to compare profitability of various operations on a risk-adjusted basis. Based on this framework, shipping firms can then make informed decisions about maintaining or expanding lines of business, or whether to hedge financial risks at the firm level. For the example used it was found that both VaR and CVaR figures are not high enough for the managers to seek hedging their positions. The chapter also argued that even if the managers decide to hedge it may make more sense to enter some of the ships into period charters rather than using freight derivatives due to the high transaction and brokerage costs associated with the latter. However, the purpose of the example was neither to show that shipping is low risk or disregard the use of freight derivatives as hedging tools but rather to promote VaR and CVaR as essential tools for risk measurement and hedging strategy determination in day-to-day shipping operations. Nevertheless, VaR-CVaR calculations should only be considered as a first order approximation and users should not be lulled into a state of complacency but rather recognise its limitations.

Figure 9.1 Yearly Volumes of the BIFFEX Contract (May 1985 – June 1999)



Source: Kavussanos and Visvikis (2002)

Table 9.1 Indications of activity growth in the FFA Market

Year	Average Number of Deals per month	Number of Counterparties	Freight Covered by Trading FFAs ($m.)
1992	2	10	0.5
1993	4	18	48
1994	10	25	70
1995	20	35	203
1996	27	52	331
1997	55	86	852
1998	90	118	1114

Source: Kavussanos, Visvikis and Batchelor (2003)

Table 9. 2: **Comparison of Approaches to Measuring VaR (Jorion 1997)**	**Delta Normal**	**Historical Simulation**	**Monte Carlo**
Position Valuation Nonlinear assets	 Linear No	 Full Yes	 Full Yes
Distribution Historical Time varying Implied	 Normal Yes Possible	 Actual No No	 Full Yes Yes
Market Non-normal distribution Measure ext. events Use correlations	 No Somewhat Yes	 Yes Somewhat Yes	 Yes Possible Yes
Implementation Avoid model risk Ease of computation Communicability Major pitfalls	 Somewhat Yes Easy Nonlinearities, extreme events	 Yes Somewhat Easy Time variation, extreme events	 No No Difficult Model risk

Table 9.3: Descriptive Statistics of log returns of Timecharter Equivalent Rates and adjusted Cornish-Fisher variates

	LNSUEZ	LNAFRA	LNPANAMAXB
Mean	9.497627	9.371799	9.048721
Std. Dev.	0.533241	0.442718	0.422686
Skewness	0.023047	-0.91406	-0.41986
Kurtosis	2.272318	3.300513	1.996687
Jarque-Bera	6.136075	39.61497	19.75673
Probability	0.046512	0	0.000051
Observations	277	277	277
Conf Level@95%	1.644853		
Cornish-Fisher adjustment	-0.00834	-0.57022	-0.20637
Adjusted Conf. Level	1.636518	1.074632	1.438487

Table 9.4: Computing the VaR of the cashflow of a shipping company (monthly VaR at 95% level)

	V=ασ			R='Rcorr'			X	xV='xV'
Suezmax	0.012011	0	0	1	0.903	0.503	3081775	37016.03
Aframax	0	0.010944	0	0.903	1	0.62	2377800	26023.52
Panamax B	0	0	0.010694	0.503	0.62	1	2214000	23676.29

	Monthly	Annual
VAR	77416.71	268179.4

Incremental VAR		B
Suezmax	34629.02	0.011237
Aframax	24918.12	0.010479
Panamax B	17869.58	0.008071
Total VaR	77416.71	

Table 9.5: Computing the VaR of the cashflow of a shipping company -Cornish-Fisher adjusted variate

	V=ασ			R='Rcorr'			X	xV='xV'
Suezmax	0.01195	0	0	1	0.903	0.503	3081775	36828.45
Aframax	0	0.00715	0	0.903	1	0.62	2377800	17001.95
Panamax B	0	0	0.009352	0.503	0.62	1	2214000	20705.83

	Monthly	Annual
VAR	66397.56	230007.9

Incremental VAR		β
Suezmax	34719.99	0.011266
Aframax	16156.45	0.006795
Panamax	15521.13	0.00701
Total VaR	66397.56	

Adjusted α	
Suezmax	1.636518
Aframax	1.074632
Panamax B/C	1.438487

Table 9.6: Historical Simulation VaR		
		VaR
Entire Period	95%	81573.26
	Adjusted (1.59)	78852.94
20 years	95%	76133.71
	Adjusted (1.59)	73594.78
10 years	95%	72692.38
	Adjusted (1.59)	70268.22
5 years	95%	76252.16
	Adjusted (1.59)	73709.29

Table 9.7: Conditional Value at Risk Calculation	
Confidence Level	**VaR**
0.955	78221.43
0.96	80772.29
0.965	83597.16
0.97	86774.93
0.975	90427.7
0.98	94754.81
0.985	100122.6
0.99	107331.6
0.995	118842.6
CvaR	**93427.23**

Chapter 10: Real option applications to investment decisions in the shipping industry

10.1 Introduction

Shipping is a complex industry involving the management of units of varying carrying capacity and technological complexity. It is a risky business due to its high fixed and variable costs, and because both ship values and income are highly variable in time.

As we have seen in the previous chapters, the remuneration value is affected by both economic (motion of market influence factors) and technical uncertainties (new technologies, obsolescence, new contract types and performance of new ships) (d'Almeida, Lopez and Diaz (2003) p.2). In addition to market fluctuations, a vessel's value is depreciated by wear and tear and increasing maintenance requirements while the technological development makes it less competitive. Therefore, total returns can be reduced either by a fall in the ship's daily-rate or by its productive useful life decrease or a combination of both.

Since a vessel's income is highly volatile, shipowning is economically extremely exciting in periods of high demand and low supply since it is highly profitable and rather dull when demand slows down, supply increases and freight rates fall. Moreover, the lead-time between a ship order and delivery is approximately two years, which means that upon delivery the market fundamentals may substantially differ from the ones when the ship was ordered thus creating opportunities for asset play or conditions for financial disaster.

Thus, shipping companies support periods of negative cash flow in expectation of the situation reversal, as they know that the exit – and an eventual comeback – has a cost; and prevents (or makes difficult) realization of future profits in case of market recovery. However, it is usual that the nearer the end of a ship's useful life, the smaller the tendency to support such losses.

All these imply that ship managers are not passive: they must revise investment and operating decisions in response to market conditions, in order to maximize their company's wealth. They act to take advantage of "good times" (market's upside) and mitigate losses in "bad times" (market's downside). Therefore, due to economic uncertainty, active management adds value to investment opportunity, which is not captured by the traditional use of discounted cash flow (DCF) methods (Trigeorgis & Mason (1987, p.15)

Such flexibility in timing of decisions about the firm's capabilities and opportunities give managers 'real options'. A real option is the right - but not the obligation - to acquire the gross present value of expected cash flows by making an irreversible investment on or before the date the opportunity ceases to be available (McDonald 2003). Thus, the beneficial asymmetry between the right and the obligation to invest under these conditions is what generates the option's value.

Shipping projects have the characteristics where Real Options are usually embedded: irreversible investments, asymmetric pay off structures, uncertainty and flexibility to act with respect to the uncertainty present.

10.2 Real Options and Shipping-Thesis Contribution

Shipping researchers were possibly the first to investigate and apply real options for project evaluation. Svendsen (1958) and Zannetos (1966) analyse extensively the decision to mothball (lay-up) a ship or scrap it (abandonment option) based on the ship's remuneration, the supply-demand fundamentals and the overall economic condition. Subsequent research in the shipping industry has focused exclusively on the option to abandon. Dixit and Pindyck (1994) use a tanker vessel example to explain the manager's decision to mothball the ship in anticipation of improved market conditions or to scrap it if there is no hope for recovery. Goncalves de Oliveira (1993) applies the Brennan and Schwarz (1985) model on valuing natural mineral resources in bulk shipping while Siodal (2001, 2003) bases his research on Dixit and Pindyck's methodology. However, despite having the option to abandon exhausted, no researcher has applied real options in valuing other ship management decisions.

This chapter aims at filling this gap in literature by evaluating the shipmanagers decision-making process within a real options framework. The strategies under investigation are:

- The option to expand
- The option to contract
- The option to wait or defer an investment
- The option to choose on the best of two assets and
- The option to vary the mix of output or the firm's production methods.

Furthermore, the thesis contributes to the general literature on real option theory by employing a series of exotic options for valuing projects with valuation methods adjusted to the needs of valuing real projects rather than exchange traded options.

10.3 The option to expand

Let us consider the case where a liner shipping company is considering placing orders for Post-Panamax containerships. Shipyards are quite busy at the moment and deliveries can only take place in 2007. Each of these ships will be capable of carrying up to 8,500 Twenty-foot Equivalent Unit (TEU) containers per trip to facilitate the liner company with the massive volume of containers it carries on an annual basis. Therefore, the decision may have huge impact on the company's worldwide business. If the company's Far East to Europe and Far East to North America trade continues to expand and the ships are efficient and reliable, the company will need more vessels.

A problem for the shipping company is the lead time between a ship order and its delivery which can take up to three or four years depending on the availability of building berths. Such long lead times mean that liner companies ordering ships today, normally boosted by high growth levels and high profitability may end up not needing them when they take delivery. Therefore, the shipping company cannot be sure that these new ships will actually be needed.

Let us suppose that a liner company forecasts a need for eight new Post-Panamax containerships four years ahead. Thus it has at least three choices:

- Commit now. It can commit now to buy the ships, in exchange for the shipyard's offer of locked-in price and delivery date.
- Wait and decide later. The shipyard will be happy to sell another ship at any time in the future if the company wants to buy one. However, the company may have to pay a higher price and wait longer for delivery, especially if the shipping industry is flying high and many ships are on order.
- Acquire option. It can seek a purchase option from the shipyard, allowing it to decide later whether to buy. These options do not commit the company to expand

but give it the flexibility to do so. Assuming the company can wait until 2005 to decide whether to acquire the additional ships, the company may then decide to exercise its options. Here the future decision is easy. Buy the ships only if demand is high and the company can operate them profitably. If demand is low, the company walks away and leaves the shipyard with the problem of filling in the shipyard berths that were reserved for building the company's options to some other shipowner.

Such options to expand do not show up in the assets that the company lists in the balance sheet, but investors are aware of their existence. If a shipping company has valuable real options that can allow it to invest in new profitable projects, its market value will be higher than the value of its physical assets now in place.

Figure 10.1 displays the term of a typical purchase option for a container ship. The option must be exercised in year 2, when final assembly of the ship will begin. The option fixes the purchase price and the delivery date in year 4. The bottom half of the figure shows the consequences of wait and decide later. We assume that the decision will come in year 2. If the decision is to buy, the Liner Company pays the price in year 2 and joins the queue for delivery in year 5 or later.

Insert figure 10.1 somewhere here

The payoffs from wait and decide later can never be better than the payoffs from a ship purchase option, since the shipping company can discard the option and negotiate afresh with the shipyard if it wishes. In most cases the liner company will be better off in future with the option rather than without it. The company is at least guaranteed a place in the production line and it may have locked in a favourable purchase price. The latter can be of particular importance for a shipowner who wants to do asset play. During periods of low freight rates, shipowners are reluctant to order new ships and shipyards are keen to offer attractive, even below cost, prices in order to fill in their empty berths. Therefore, a shipowner may lock in a firm order at a favourable price today and if he predicts the market correctly. Thus, if the freight market recovers when he takes delivery of the ship, he can sell it at a profit. By acquiring an option for a second or more ships at the same favourable price exercisable one year before the delivery, the shipowner can see the market direction with greater certainty. If the market is expected to go up, he can exercise his options for additional ships at favourable prices and sell them at a higher profit upon delivery.

10.3.1 Valuing the Option to expand

In order to value such an option we have to treat it as a compound one. A compound option is an option to buy an option. Compound options are a little more complicated than ordinary options because there are two strike prices and two expiration dates, one each for the underlying option and for the compound option. Our pricing formulas for estimating this compound option are based on McDonald (2003). In our example, the market price for an 8500 TEU ship is $70 million. The company has already got a firm order for four ships worth $280 million and has purchased the option to buy another four for 284 million USD. In shipping, it is customary for options not to require an up-front payment and the cost of the option is reflected in the asset price. Therefore, it is assumed here that the exercise price to buy the asset remains the same and the exercise price to buy the option is $4 million. We have estimated the volatility of the newbuilding price for such ships to be 20% and the risk free rate at 3%. The option to exercise the option or not expires in 2 years while the maturity for the underlying option is 4 years from now. Since the ships are under construction and not operating and are built for a service that does not exist yet, we assume that there is no dividend yield.

Table 10.1 reports the results of our estimates. We can see that the option to buy the right to build the four additional ships is worth $55,937,240. Furthermore, it makes no sense to sell this right to another shipowner since the loss of the put option to the holder will amount to $154,436. Therefore it does not make sense for another party to acquire the option to buy these additional ships upon these circumstances. From this data the liner company can estimate the critical ship price that determines whether it makes sense to sell or exercise the option to build these ships for its own account. In this case by the time the value of the ships is higher than $191 million it makes sense to exercise the option to build the ships for its own account. If the price of the ships however exceeds $381.6 million it makes sense to sell the option to build the ships to someone else. The pricing of the option can also include the put on put or the call on put option, which however is not applicable in this case. Therefore, we can see that by applying real option theory not only can a shipowner optimise and evaluate his investment decisions more accurately, he can spot and quantify the opportunities for future asset play as well. This is something he would have been unable to do by employing solely the Discounted Cash Flow Method.

Insert Table 10.1 somewhere here

10.4 The option to wait when uncertainty about the project value can be resolved

Timing is of essence in an industry as volatile as shipping since higher profits can be made from asset play. In addition to this decision the shipowner also needs to consider whether or not to invest in a new or a second-hand ship.
Let us consider a bulk shipping company that is evaluating investment opportunities for three different projects.

Project A has to do with the purchase of a thirteen-year-old single hull handy tanker. Due to high demand for oil mainly from China, the company feels that the income will be high and relatively steady over the project period. The investment price may be lower than a double hull double bottom vessel of the same vintage and characteristics but the asset value may be prone to external shocks such as a marine accident leading to an oil spill and consequently to further restrictions on single hull tanker trading.

Project B involves the purchase of two 20- year old handy size bulk carriers. The vessels are old and bought at a premium due to the strong market but the freight rates are expected to be so high over the next couple of years due to supply shortages and strong demand for dry bulk commodities that the company feels they are worth the investment.

Project C involves placing an order for a 16,000 dwt IMO II chemical tanker in a not very well known South Korean yard. It is the company's first step in this sector. However, due to the fact that the great majority of the fleet is single hull and will have to be scrapped the company feels that in a few years time there will be a strong demand for such modern vessels. Since it has no previous experience or approval by oil major the company will have to accept a low freight rate for the first years of operation that will yield a negative NPV.

Table 10.2 provides input values for the valuation of each of the three investment projects. For more details on these input values see the appendix.

Insert Table 10.2 somewhere here

The investment decision to buy a ship is irreversible, as the ship cannot be used for a different purpose. However the decision to defer the investment is indeed reversible. Thus we can derive an investment decision based on whether the benefits from investing exceed the costs of building the ship. This opportunity to invest can therefore be valued as a Call Option on the underlying value of the expected future cash flows of the project.

As a result, the value of this investment opportunity exceeds the value of the NPV for direct investment by the flexibility of deferring the investment.

Although the exercise price is fixed and known in advance (at the moment of the purchase of the option) in a typical (“vanilla”) call option, this is rarely the case in a real options context. While a company may be able to make a fairly accurate estimate of the cost of current investment, there is much less precision about investment costs in the future.

As a consequence, the real option to invest in the future corresponds to an exchange option and not to a simple call option, because of its uncertain exercise price. The investment corresponds to the exchange of a risky asset, investment cost, for another one, the gross project value. So, generally, when we value an investment opportunity, we are exposed to two sources of uncertainty, i.e. to two stochastic variables.

Therefore, the Black-Scholes (1973) model should not be used to value projects with these characteristics.

We can obtain a solution for our investment-timing problem in the context of the volatile shipping industry, by following Rubinstein (1991a), who argues that the use of a binomial approach clarifies the intuitive economic intuition behind the derivation of an exchange option formulated by Margrabe (1978). Thus, we are able to solve the investment timing issue inherent in the shipping market by using the binomial formula for an american exchange option.

Model Implementation and Results

Using the methodology in the previous section and the inputs in table 10.2, we obtain the results reported in table 10.3.

Insert Table 10.3 somewhere here

Starting with project A the results indicate that despite the positive NPV, the project should not be undertaken immediately due to the high positive value of the deferment option.

As far as project B is concerned, the deferment option has no value since the project is far in the money. Consequently, it is more valuable to exercise the option to invest now than to keep that option alive.

Finally, project C has a negative NPV, which initially indicates that the project shall be abandoned. Nevertheless, this project has a high deferment option value that gives the company the flexibility to wait and see along with the right to invest in the project in future should the uncertainties be resolved in the project's favour.

The values obtained from the two methodologies and the resulting investment-timing decisions are summarised in Table 10.4. We can see that the NPV method undervalues projects A (oil tanker) and C (chemical tanker) significantly and its implementation leads to the wrong decision. Only in project B (two old bulk carriers) both methodologies yield the same result and propose the same investment-timing signal. Therefore, table 10.4 illustrates that the traditional NPV methodology is not adequate to value investment opportunities in an uncertain environment, especially when investing in a project can be deferred to a later date.

Insert Table 10.4 somewhere here

10.5 Choosing the best strategy

Let us consider now the case of a shipowner who owns two modern Aframax tankers, each worth $25 million, which are on a two-year charter to an Oil Major. Within the next two years the shipowner has to decide what to do with the company. There are several options available to him:

The first one is at the end of year two to buy from the Oil Major, a third ship of similar specifications for $24 million. This will increase the size of his operation by a third.

The second option is to sell one of his tankers to the Oil Major again for $24 million, thereby reducing the size of his operation by half.

Finally, the Oil Major has made him an offer to buy his company at the end of year two for $ 40 million. The shipowner needs to notify the Oil Major of his decision six months before the expiration of the contract, that is one and a half years from now.

As we can see, the shipowner has to evaluate three options that are open to him, expansion, contraction and abandonment, and take the most economic sound choice. To evaluate these options we use a chooser option.

A chooser is an option where the investor has the opportunity to choose whether the option is a put or a call at a certain point in time during the life of the option. It is also known as hermaphrodite or AC-DC option (www.investopedia.com/terms/c/chooseroption.asp, 2003).

Table 10.5 provides an estimation of a chooser option for the above case. In order to calculate the option we calculate the volatility from monthly returns over a period of 24 years (1979-2003) to be 44%, while the risk free rate and the dividend yield is 2 and 10 per cent respectively. The calculations indicate a chooser option value of 20.85. This means that both the contraction and the expansion strategies are worth less than the abandonment option that is worth $40 million. In other words the most profitable strategy for the shipowner is to sell the ships to the Oil Major for $40 million at the end of the two year contract.

However let us assume that the shipowner can also sell one of his tankers to a third party for a higher price ($30 million) than the one he can obtain from the Oil Major in two and a half years. In this case where the maturity and the strike price of the put and call options vary we can use a complex chooser option. In this case, the value of the complex chooser option is 22.45, which means that the contraction option is more profitable than the abandonment one since it is worth (0.5*22.45)+30=$41.225 million. Therefore, in this case the most profitable strategy will be to sell one ship to a third party after two and a half years.

The formulae for both the simple and the complex chooser option can be found in Rubinstein (1991b).

Insert Table 10.5 somewhere here

In comparison, if we use the Black-Scholes model on the problem, we obtain differing and misleading results as seen in table 10.5.

Clearly, valuing a combination of real options by performing them individually and then summing them yields different and incorrect results. We need to account for the interaction of option types within the same project. According to Mun (2002, p. 184), the reason for the sum of individual options being different from the interaction of the same options is due to the mutually exclusive and independent nature of these options. That is the firm can never, for example, both expand and abandon at the same time. This mutually exclusive behaviour is captured using the chooser option. If performed separately, the expansion option analysis may indicate that it is optimal to expand, while the contraction option analysis that is optimal to contract, thereby creating a higher total value. However, this interaction is precluded from happening when a chooser option is used because multiple option execution cannot occupy the same state.

10.6 Options on the Best of Two Assets and to vary the mix of output or the firm's production methods

Companies often have an option to vary either the inputs in the production process or the outputs. In such cases the firm has the option to acquire one asset in exchange for another. Shipowners are always on the lookout for opportunities to invest into other ship types or in different ship sizes either for diversification or speculation or both. Consider for example a shipping company owning a five-year old handymax size bulk carrier that is exploring the possibility of investing instead in an Aframax tankers of the same vintage. You can think of the company as having an option to 'buy' a tanker vessel in exchange for a bulk carrier one. If freight rates and ship values were certain, this would be a simple call option on a tanker vessel with a fixed exercise price (the value of the ship). If the freight rates and ship values in the tanker market are sufficiently high it pays to exercise the option and switch to oil trades.

In practice, both dry bulk and tanker freight rates and ship values are likely to vary. This means that the exercise price of the company's call option changes as freight rates and vessel prices change. Uncertainty about this exercise price could reduce or enhance the value of the option, depending on the correlation between the prices of the two assets. If dry bulk and oil tanker freight rates moved together dollar for dollar, the option to switch trades would be valueless. The benefit of a rise in the value of the underlying asset (the handymax size bulk carrier) would be exactly offset by a rise in the option's exercise price (the Aframax tanker value). The best of all worlds would occur if the prices of the two rates were negatively correlated. In this case whenever tanker rates increased, bulk carrier rates would go down. In these (unlikely) circumstances the option to switch between two trades would be particularly valuable.

We can value such real options by using an exchange option. We saw a more extended variation of such an option in the timing option analysis. An exchange option, also called an outperformance option, pays off only if the underlying asset outperforms another asset, called the benchmark. According to McDonald (2003), exercising any option entails exchanging one asset for another and that a standard call option is an exchange option in which the asset has to outperform cash in order for the option to pay off. In general, the exchange option provides the owner the right to exchange one asset for another, where both may be risky.

By setting the dividend yields and volatility appropriately, with an exchange call we have the option to give up K (the Aframax tanker) for acquiring S (Handymax size bulk carrier). For a put option we give up the underlying asset S for K.

American Exchange options can be valued using a two-state variable binomial tree. This is because with the binomial model it is possible to check at every point in an option's life (i.e. at every step of the binomial tree) for the possibility of early exercise (eg where, due to a dividend, or a put being deeply in the money the option price at that point is less than its intrinsic value).

The binomial model basically solves the same equation, using a computational procedure that the Black-Scholes model solves using an analytic approach and in doing so provides opportunities along the way to check for early exercise for American options.

Based on Rubinstein (1991a), we estimate both European and American call and put Exchange options, employing both the Black Scholes and the Binomial Method. According to the SSY Monthly Shipping Review July 2003 issue a five-year-old handymax bulk carrier of 45000 dwt is worth $15 million. By the same token a five- year-old Aframax is worth $33 million. Monthly data from 1979 to 2002 indicates volatility of 52% per annum for the handymax price and of 57% for the Aframax. The correlation between the two assets is 0.867. Based on industry data we assume a 15% dividend yield for the bulk carrier and zero yield for the tanker since the company does not own it. We assume that the company has to decide whether to leave dry bulk carriers for tankers within a year, either at the end of the period, European Exchange Option valued with Black-Scholes, or within the one year, American Exchange Option valued with a binomial model. The results are reported in Table 10.6. As we can see both the European and the American call options are valueless due to the high correlation of the price of the two assets. On the other hand however, we see that both the American and the European put options, the option to give up the bulk carrier business in exchange for the tanker have a value of approximately $20.1 million. If you add up this figure to the $15 million the company can obtain by selling the bulk carrier gives a total value that exceeds the tanker's price by $2.1 million. Therefore, the price premium on this option suggests that the firm will be better off selling the bulk carrier during the year and investing in an Aframax tanker.

We can see in this case how real option theory can help the managers evaluate their decision to diversify or enter new markets in a way that traditional Discount Cash Flow techniques cannot.

10.7 Conclusion

Since carriage of goods by sea is a derived demand, it is heavily dependent on the state of the world economy. In addition to that it is also prone to supply demand fluctuations within the industry as well as world politics. All these make the shipping industry highly volatile. As a result, ship managers have to be active in their decision making process in order to be able to adapt to the challenges that arise constantly.

Traditional Capital Budgeting Techniques are not suitable for valuing investments into an uncertain market. The reason is that they are not treating the risks involved as a source of value creation that might arise from managerial flexibility inherent in the project to act to changes in the environment. This chapter introduced Real Option Analysis and exotic options in particular as an alternative technique to cope with the value of flexibility incorporated in the process to capture the true value of a series of shipping projects. This way ship owners and managers can facilitate and optimise their financial decision making process.

The chapter considered the following strategic options:

- The option to expand
- The timing and defer options
- The option to choose the best of two assets and
- The option to vary the mix of output or the firm's production methods.

By employing a compound option to value the option to expand by ordering an additional number of ships at a predetermined price, the chapter showed that such options may increase the shareholders' value substantially. It also provided a framework to critically assess opportunities for asset play, a strategy that has traditionally rewarded ship-owners that have employed it successfully with high profits.

It was also shown that there is a value of waiting to invest in an uncertain market environment. The option to wait was valued as an American exchange option with an uncertain underlying project value as well as uncertainty about the future strike price. It was found that traditional DCF methods undervalue such projects significantly. As a result the sole reliance on such methods may lead to incorrect investment and investment timing decisions. By evaluating investment opportunities using the American Exchange Option methodology, substantial differences were found compared to the traditional NPV method in both the value of the investment opportunities and the timing of when the project is undertaken.

Furthermore, simple and complex chooser options were employed to evaluate the various options open to a shipowner in order to optimise his strategic decision making process.

Finally, European and American Exchange options were used to value the decision to invest in a new ship type or optimise the performance of an asset.

Overall, this chapter found that Real Options are useful tools for evaluating projects in an industry as volatile as shipping, where the agents need to value complex projects and make timely strategic decisions on a regular basis.

The liner shipping company's vessel purchase option				
	Year 0	Year 2	Year 4	Year 5 or later
Buy Option	Liner Company and Shipyard set price and delivery date	Exercise? Yes or No	Ship delivered if option exercised	
Wait	Wait	Buy now? If yes negotiate price and wait for delivery		Ship delivered if purchased in year 3

Figure 10.1: Shipping purchase options

Table 10.1: Pricing the Option to Expand for a Liner Shipping Company by employing a Compound Option	
Ship Price (4*$70million)(S)	280
Exercise Price to buy asset(K)	280
Exercise Price to buy option(x)	4
Volatility(σ)	20.000%
Risk-free interest rate(r)	3.000%
Expiration for Option on Option (years)(t1)	2
Expiration for Underlying Option (years)(t2)	4
Dividend Yield(δ)	0.000%
Call on Call	55.93724
Put on Call	0.154436
Critical Ship price (S) for compound call (4 Ships)	191.0413
Critical Ship Price (S) for compound put (4 Ships)	381.5925

Table 10.2: Input Values for the valuation of each project (in $ mil.)			
	Project A	**Project B**	**Project C**
V	**18500000**	**21750000**	**18500000**
F	**15500000**	**20000000**	**20500000**
NPV	**3000000**	**1750000**	**(2000000)**
Time to Expiration (T-t)	**4**	**4**	**4**
σ_v	**39.00%**	**36.50%**	**42.00%**
σ_f	**52.00%**	**30.00%**	**43.00%**

δ_v	10.00%	10.00%	10.00%
δ_f	0.00%	0.00%	0.00%
ρ	0.82	0.90	0.85

Table 10.3: NPV and American Exchange Option Value (in $ mil.)			
	Project A	Project B	Project C
NPV	3000000	1750000	(2000000)
American Exchange Option (Analytical)	3520552	0	942627.41
American Exchange Option Value (Binomial)	3493825	1750000	885236.7)
Value of Deferment Option (Analytical)	520552	0	2942627.41
Value of Deferment Option (Binomial)	493825	0	2885236.7

Table 10.4: Summary of the Investment timing decisions of the projects				
	Value		Timing	
	Am. Exchange Option	NPV	Am. Exchange Option	NPV
Project A	3520552	3000000	Defer	Invest Now
Project B	0	1750000	Invest Now	Invest Now
Project C	942627.41	(2000000)	Defer	Abandon

Table 10.5: The option to chooose among the best strategy	
Input Data	
Current Price	50.00
Strike price (Call)	24.00
Time to maturity (Call)	2.00
Risk-free rate	2.00%
Dividend	10.00%
Volatility	44.00%
Time to Choice	1.50
Additional Parameters for Complex Choosers	
Time to Maturity (Put)	2.50
Strike Price (Put)	30.00
Output Data	
Chooser (Simple)	20.85
Chooser (Complex)	22.45
Chooser (Simple) - Call and put parameters are the same.	
Chooser (Complex) - Time to maturity and strike price vary.	

BS Value of Option to Abandon only	**20.97**
Value of Option to Expand only	**19.67**
Value of Option to Contract only	**19.47**

Table 10.6: Choosing the Best of Two Assets with an Exchange Option				
Inputs			**Black-Scholes**	
Underlying Asset (Handymax Bulk Carrier) (S)			**Call**	**Put**
Price	15	Price	0.000769	20.09015
Volatility	52.000%			
Dividend Yield	15.000%		**Binomial**	
Strike Asset (Aframax Tanker (K)			**Call**	**Put**
Price	33	Price	0	20.08938
Volatility	57.000%			
Dividend Yield	0.000%			
Other				
Correlation	0.867			
Time to Expiration (years)	1			
# Binomial Steps	10			

Chapter 10 Appendix: Model Implementation: Assumptions and Inputs

Gross Project Value (V)

Corresponds to the present value of the project's appropriately discounted expected cash flows, given the information available at the evaluation date. V is the value that the firm receives by paying the exercise price (by making the investment). While the value of V at the evaluation date is known, its future values are unknown. We assume that V is a stochastic variable that follows a geometric Brownian motion process.

Investment Cost (F)

The amount of capital that the company needs to invest "today" in the project. We do not know the value of D in the future, when the option to invest will be exercised. As for V, we assume that D follows the geometric Brownian motion process presented in (1b).

Time-to-Maturity (T-t)

Based on the average turn of a shipping cycle, we assume 2 years before each opportunity disappears. Therefore, we adopt a 2-year maturity for each project's deferment option. Since the options are American, the IO can be exercised anytime until (or at) the maturity date.

Dividend-Yield of V (δ_V)

Let μ be the (total) expected rate of return on V and α be the expected percentage rate of changes of V. We assume that $\delta=\mu-\alpha$ so that investment before the maturity date may be optimal, as in Dixit and Pindyck (1994).

As with call options, δ corresponds to the dividend yield of the stock. The total return earned by the owner of the stock is then: $\delta+\alpha=\mu$. In the absence of dividends on the underlying stock, the optimal decision is to hold the option until maturity. Since the total return on the stock is reflected in the prices of both the underlying stock and the option, there is no opportunity cost to maintaining the option "alive". In the case of a positive δ, there is an opportunity cost in holding the option instead of the stock. This opportunity cost corresponds to the dividends paid on the stock that are foregone by option holders.

The expected return from owning the completed project is also given by μ. In this case the expected rate of return is irrelevant given the current asset values, as in Black-Scholes (1973). This market-determined equilibrium rate includes an appropriate risk premium. If $\delta_V > 0$, then the (capital) gains on V will be lower than μ, so δ_V is the opportunity cost of deferring the project. If $\delta_V = 0$, no opportunity cost exists. Thus, it is never optimal to invest earlier than at maturity. For high values of δ_V (for high opportunity costs associated with holding the option), the value of the option goes to zero. This transforms the project into a "now or never" type, and makes the traditional NPV a valid assessment method. In practice, δ_V may represent several types of opportunity costs. One such opportunity cost is the cash flows foregone. Some authors (e.g. Trigeorgis, 1996) argue that δ_V may also incorporate another type of opportunity cost. Specifically, project deferment may contribute to the early entrance of a competitor in a competitive environment, which, in turn, may have a negative impact on the value of the project. Herein, we assume that the only cost resulting from the deferment decision is the lost cash flows. Thus, the parameter δ_V is the rate of cash flow yielded by the project.

As noted above, δ_V can be calculated as the difference between the total expected or required return on the project (i.e., the cost of capital or μ), and the expected growth rate of the project's value (α). We calculate α using $\alpha = (Vn/V0)^{(1_n)} - 1$ where *Vn* is the expected value of the project in year n, and *V0* is the project's current value if completed. Using the estimates of μ and α yields δ_V estimates of for projects A, B and C, respectively.

Dividend-Yield of D (δ_f)

According to the assumptions of the model, the "dividend yields" are assumed to be nonnegative constants. While this is true for δ_V , δ_f is negative when carrying costs are associated with the project's capital cost. In this model, we need to assume that such costs do not exist because δ_f cannot be negative. As pointed out by McDonald and Siegel (1986), the gain from deferral may increase with larger δ_f . In our application, we assume that $\delta_f = 0$ by assuming that there are no carrying costs associated with a project's capital costs nor benefits (from the capital cost's level) from deferring the project.

Volatility of V and D σ_v, σ_f

We assume that the volatility of the company's stock is an adequate proxy for the volatility of V (see, for example, Davis, 1998; Paxson, 1999; and Amram and Kulatilaka, 1999). It is also necessary to assume that the volatility of V is constant during the life of the option. The σ_v is calculated based on the natural logarithm of the monthly returns [Ln(n/(n-1)] of the time charter rate data obtained from January 1979 to January 2003 from Braemar Seascope. The annual σ_v corresponds to the monthly σ_v multiplied by the square root of the number of months in a year (12). As to the volatility of F, and knowing that the volatility of the price of second-hand and new vessels were obtained from Clarksons following the same methodology as with σ_v.

Correlation between the changes in V and F [$\rho(v,f)$]

We assume that the correlation between the changes in V and F can be approximated by the correlation between the monthly returns on the corresponding freight rates for every ship type and the monthly returns on the ship's values for the period described above.

A major characteristic of these investment opportunities is that they can be delayed or deferred for up to four years in order to resolve the uncertainties governing each project's value. However, if the company decides to postpone a project, it faces the uncertainties associated with future investment costs. Projects with these characteristics are similar to finite-lived American exchange options. Specifically, they have a finite maturity, they can be implement anytime before or at the maturity date, and both the present value of the projects' cash flows and the investment costs behave stochastically.

Chapter 11 Conclusion

This thesis has provided an econometric analysis of the bulk shipping markets and the implications for shipping investment and financial decision making.

Chapter 1 set the scene by providing a historic analysis of bulk shipping markets over the last 55 years. From this analysis, four shipping markets (freight, newbuilding, second-hand and demolition) were distinguished as well as a fifth one (ship finance) that acts as a facilitator to the other four. Also, with the help of correlation analysis the factors influencing these markets were identified. After that it described how the investment and financing opportunity set varies over time as the shipping markets move through the cycle from expansion, to credit crunch, to recession, to reliquification, and on to the following expansion. The chapter then considered five critical interdependent forces (economic structure, ship supply and demand capital flows expressed by investor preferences and investment performance) that comprise the shipping market and move in cyclic patterns. This way, it comprehended the role of the shipping cycle in devising investment strategies. Based on this analysis, Chapter 1 ended by defining the thesis aim and objectives.

Chapter 2 presented the methodology of this thesis. It critically analysed the methods used in the collection of data and the interpretation of it, as well as the problems experienced while collecting it.

Chapter 3 analysed the various econometric methods used in chapters 4 to 7 to model the determinants of the four shipping markets. It started by analysing the assumptions of the Classical Linear Regression Model and how these are violated, especially when the model is estimated from a combination of stationary and non-stationary variables. It then presented a number of tests for detecting such violations as well as defining the number of unit roots. After that it focused on developing a theoretical error correction model that caters for such problems. This model was then compared to atheoretical time-series models of the ARMA family, namely the autoregressive (AR), moving average (MA) and autoregressive moving average (ARMA) models. Comparison was made within an Econometric Business Cycle Research framework, as it was proposed by Tinbergen (1959). This was followed by a description of how forecasts are made with such models, while the chapter concluded by describing the modelling strategy followed in this thesis.

The four subsequent chapters presented the results of this strategy, stemming from the analysis of the four shipping markets (freight, newbuilding, second-hand and demolition). Based on theory, Error Correction Models describing and quantifying the relationships between the variables were developed for all four markets. This way it filled a gap in maritime economics literature by estimating models where none of the CLRM assumptions are violated. Consequently, statistical inferences from these models can be made safely. Furthermore, by desegregating into the different ship types according to size, this thesis found that different variables have different effects on each type, thus proving that each ship type has its own distinctive characteristics. Finally, chapters 4 to 7 compared different econometric methods, the theoretical Error Correction and the atheoretical family Auto Regressive Moving Average (ARMA) models. It was found that theoretical models, are still to be preferred if one wants to achieve the classical objectives of EBCR simultaneously (to describe and forecast cycles and to evaluate policies and test economic theories). However, if not all goals have to be met with a single vehicle, other methods might serve the purpose equally well or even better as is the case with the Auto Regressive method whose forecasts outperform those of the ECM method on many occasions.

More specifically, with respect to the period or time charter market, in Chapter 4 it was found that spot rates are the major determinant for period rates, thus the validity of the expectations hypothesis of the term structure relationship between spot and period rates. This hypothesis however is not always valid since on two occasions (Panamax bulk carriers and Aframax tankers), fleet changes, a variable incorporated in the model to depict market changes and risks was found to be statistically significant. This led to inconclusive evidence that requires further investigation. Finally, it was found that the forecasting ability of the models for the timecharter market was superior to that for the freight market. This was attributed to the dominance of the stochastic component over the deterministic one in the spot rate market that makes its accurate forecasting a very difficult task.

Chapter 5 developed a model for newbuilding vessel prices. The results obtained showed that newbuilding prices are primarily cost driven in contrast to second-hand prices that are market driven. Furthermore, it was found that orderbook as a percentage of the fleet used as an indicator of shipyard capacity plays an important role in the determination of tankers newbuilding prices rather than bulk carrier ones. The reason is that for shipyards bulk carriers are considered to be the vessels of last resort to build and as a result they increase their capacity with the prospects for more expensive ships in mind such as tankers, containers or LNGs. Moreover, the chapter found that newbuilding prices for some ship types might be driven to a certain extent by asset pricing and speculation.

Chapter 6 analysed second-hand prices. Newbuilding and Timecharter rates were found to have the greatest effect of all variables on the determination of second-hand values, in most cases both in the short and the long run. The coefficients however for the newbuilding variable were higher than the ones for the timecharter rate ones. A reason behind this may be asset play. The cost of capital was significant only for bulk carrier owners, and this only in the long run, rather than tanker owners. The only exception is the Suezmax segment due to its particular characteristics. What can be implied from this is that shipowners operating in the tanker sector possess more capital than their colleagues in the bulk carrier sector do.

Furthermore, orderbook as a percentage of the fleet was found to have a negative effect on the prices of second-hand vessels only in the long run and only in large (Suezmax, VLCCs) and Panamax tankers.

Chapter 7 analysed vessel demolition prices. The results obtained are in line with the economic theory stating that demolition prices are primarily driven by market conditions and expectations. Furthermore for VLCCs, the price of scrap steel was also found to be significant. This is due to increasing demand for scrap steel that makes demolition traders eager to offer higher prices for larger tankers to satisfy demand. Also, the volume of scrapped ships had a negative effect on the demolition price of medium and large tankers. The reason is new legislation usually stemming from an accident or environmental campaigns that may force shipowners to scrap their ships earlier than they had originally anticipated.

Chapters 8 to 10 dealt with the implications of the high volatility of the shipping markets for ship investment and financial decision making.

Chapter 8 investigated the potential of risk reduction benefits for a bulk shipping investor through diversification. It first analysed the traditional risk reduction approach of calculating the variance and the standard deviation of a portfolio. The results showed that risk reduction benefits could be achieved through diversification. Then it built upon the shortcomings of correlation, the key parameter used to measure the degree of integration between any two markets by financial analysts. These shortcomings have to do with the fact that while markets may tend to diverge considerably in the short-run, like periods of up to a year, they may actually be integrated over longer periods. Based on that finding the cointegration approach was proposed to ascertain the degree to which nonstationary time series, in this case bulk carrier and tanker time charter rates move together in the long run.

The chapter employed the Johansen method for testing for long run relations in the income of different ship types and sizes. Out of 247 different combinations of investment in the dry and wet bulk markets, it identified cases where long run risk reduction benefits can be obtained by investing into different ship types and sizes. This way it developed a good guide to the ship investor seeking risk reduction benefits through diversification.

The thesis found that investing in more than one type of bulk carrier nullifies any risk reduction benefits. Furthermore, risk reduction benefits decrease as diversification increases with no risk reduction benefits obtained when investment involves more than five different ship types/sizes. However, the cointegration methodology cannot quantify this risk reduction. One way this thesis tried to achieve that was by measuring the correlation coefficients for different time horizon. The thesis found that in most cases, correlation coefficients increased with an increase in time horizon, thus indicating a loss of diversification benefit in the long run.

These results initially seem to be in contrast to the portfolio risk measurement theory which claims that risk reduction benefits increase with higher diversification. However, the reason behind this difference lies with time horizon. It may be true that greater diversification leads to higher risk reduction in the short run but in the long run, as our cointegration estimates show, such benefits are lost. Therefore, the results actually supplement the theory of risk reduction through diversification by showing that the benefits of diversification in most cases may exist in the short run but disappear in the long run.

Finally, finding such long run relationships support the existence of inefficiencies in the shipping freight market a finding in line with previous research.

By applying the delta normal, historical and Monte Carlo simulation methods for calculating Value at Risk on the portfolio of a large shipping company, Chapter 9 developed an analytical tool for shipowners and managers to measure the possible losses within a pre-specified time horizon and confidence interval of their portfolios. This tool allows the managers to identify the extent to which each asset contributes to these possible losses, as well as get an idea of the maximum possible losses should the worst case scenario occurs. By obtaining these figures and comparing them to total earnings or income, shipowners-managers can determine to what extent these potential losses are acceptable and decide whether or not to hedge their positions, either by using freight derivatives or entering their ships into period charter contracts. Overall, VaR provides a framework to compare profitability of various operations on a risk-adjusted basis. Based on this framework, shipping firms can then make informed decisions about maintaining or expanding lines of business, or whether to hedge financial risks at the firm level. For the example used it was found that both VaR and CVaR figures are not high enough for the managers to seek hedging their positions. The chapter also argued that even if the managers decide to hedge it may make more sense to enter some of the ships into period charters rather than using freight derivatives due to the additional transaction and brokerage costs associated with the latter. Nevertheless, VaR-CVaR calculations should only be considered as a first order approximation and users should not be lulled into a state of complacency but rather recognise their limitations.

Finally, Chapter 10 applied real option theory to financial decision making in shipping. It argued that Traditional Capital Budgeting Techniques are not suitable for valuing investments into an uncertain and highly volatile market like bulk shipping. The reason is that they are not treating the risks involved as a source of value creation that might arise from managerial flexibility inherent in the project to act to changes in the environment. This chapter introduced Real Option Analysis and exotic options in particular as an alternative technique to cope with the value of flexibility incorporated in the process to capture the true value of a series of shipping projects. This way ship owners and managers can facilitate and optimise their financial decision making process.

The chapter considered the following strategic options:

- The option to expand
- The timing and defer options
- The option to choose the best of two assets and
- The option to vary the mix of output or the firm's production methods.

By employing a compound option to value the option to expand by ordering an additional number of ships at a predetermined price, the chapter showed that such options may increase the shareholders' value substantially. It also provided a framework to critically assess opportunities for asset play, a strategy that has traditionally rewarded ship-owners that have employed it successfully with high profits.

The option to wait was valued as an American exchange option with an uncertain underlying project value as well as uncertainty about the future strike price. It was found that traditional DCF methods undervalue such projects significantly. As a result the sole reliance on such methods may lead to incorrect investment and investment timing decisions. By evaluating investment opportunities using the American Exchange Option methodology, substantial differences were found compared to the traditional NPV method in both the value of the investment opportunities and the timing of when the project is undertaken.

Furthermore, simple and complex chooser options were employed to evaluate the various options open to a shipowner in order to optimise his strategic decision making process.

Finally, European and American Exchange options were used to value the decision to invest in a new ship type or optimise the performance of an asset. Overall, this chapter found that Real Options are useful tools for evaluating projects in an industry as volatile as shipping, where the agents need to value complex projects and make timely strategic decisions on a regular basis.

The thesis contribution to the maritime economics literature could be summed up in the following points:

- It has utilised modern econometric techniques thanks to which statistical inferences can be made from estimating the developed theoretical models of the four shipping markets. This way the reader can draw conclusions about the interaction and effects of different variables on the different markets with adequate confidence.
- By analysing the markets at a desegregated level it showed that different ships, differentiated by either or both size and type, are affected to varying degrees by different variables. Therefore, the thesis advocated the use of the modular and desegregated approach rather than the integrated and aggregated one for

modelling shipping markets to obtain a more thorough understanding of the industry.

- It comprehended the role of the shipping cycle in devising investment strategies. This was achieved by considering five critical interdependent forces (economic structure, ship supply and demand, capital flows expressed by investor preferences and investment performance) that comprise the shipping market and move in cyclic patterns rather than the traditional three (economic structure, ship supply and demand) considered by previous researchers on the topic. It was further enhanced by utilising sophisticated financial tools and techniques employed by more mature industries such as consulting, banking, biotechnology and pharmaceutical.

The data-set used in this thesis may provide some limitations to the study but as data both improves and increases with time and new econometric techniques are developed for more accurate forecasting, further research on the topic will help the author achieve his ultimate aim. To provide the reader and the industry as a whole with an ever better and more thorough understanding of the bulk shipping markets and with sophisticated financial tools to enhance and optimise ship investment strategies and financial decision making processes.

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Glossary[1]

AFRA- Average Freight Rate Assessments. A monthly estimate of tanker rates issued by London Tanker Brokers, AFRA, quoted on a WORLDSCALE basis, assists large oil companies' internal accounting, and provides a freight element for some netback deals.

AMERICAN OPTION- An option that may be exercised at any time during its life.

AMORTISATION- The repayment of a loan, including interest, by regular payments. Also, the amount by which the value of an asset is reduced by a charge against income investment.

ARREST- A seizure of property by legal authority. The arrest of vessels in port has been a measure to which creditors have had frequent recourse. Whenever liabilities are not paid by the borrower, the consequence is generally the arrest and auction of the vessel in compliance with the legal procedures of the country in which the vessel was seized.

ASSET PLAY- A term which describes investments in vessels when the market is relatively low with the intention of reselling such vessels at higher prices within a relatively short period of time, when markets have picked up, thus realising capital gains.

ASSET VALUE- The realisable value of the assets upon sale. Banks look to the resale value of ships as one protection in the event of a borrower defaulting on a ship mortgage loan and will attempt to limit the value of their loan to a percentage of the estimated value.

BASIS POINTS(bp)- The smallest unit applicable in a particular calculation. In terms of the spread over LIBOR, one basis point is equal to 0.01 per cent, so that 0.5 per cent would be 50 basis points.

BASLE RULES- Regulations compiled by the Bank for International Settlements (BIS) in Basle, covering capital adequacy requirements for banks involved in international lending.

BLACK SCHOLES FORMULA- the formula giving the price of a European call option as a function of the stock or asset price, strike price, time to expiration, interest rate, volatility and dividend yield.

BUNKERS- Fuel consumed by the engines of a ship; compartments or tanks in a ship for fuel storage.

CHARTERER- The person to whom is given the use of the whole of the carrying capacity of a ship for the transportation of cargo or passengers to a stated port for a specified time.

[1] Derived from various reports of Drewry and Clarkson, as well as Stokes (1997).

CHARTER RATES - The tariff applied for chartering tonnage in a particular trade.

CHARTER PARTY- A contractual agreement between a ship owner and a cargo owner, usually arranged by a broker, whereby a ship is chartered (hired) either for one voyage or a period of time.

CHOLESKY DECOMPOSITION- A formula used to construct a set of correlated random variables from a set of uncorrelated random ones.

COLLATERAL- Security against a loan. CROSS-COLLATERAL refers to additional security distinct from the primary asset.

COMBINATION CARRIERS- Vessels fitted to transport more than one types of cargo. The petroleum industry uses a fleet of OBOs, ships which transport both dry cargo and oil.

CONGESTIONS- Port/berth delays

CONTAINER SHIP - A ship constructed in such a way that she can easily stack containers near and on top of each other as well as on deck. A vessel designed to carry standard intermodal containers enabling efficient loading, unloading, and transport to and from the vessel. Oceangoing merchant ship designed to transport a unit load of standard-sized containers 8 feet square and 20 or 40 feet long. The hull is divided into cells that are easily accessible through large hatches, and more containers can be loaded on deck atop the closed hatches. Loading and unloading can proceed simultaneously using giant travelling cranes at special berths.

CONTRACT OF AFFREIGHTMENT (COA)- A service contract under which a ship owner agrees to transport a specified quantity of fuel products or specialty products, at a specified rate per ton, between designated loading and discharge ports. This type contract differs from a spot or consecutive voyage charter in that no particular vessel is specified.

DEADWEIGHT/DWT/DWCC- A common measure of ship carrying capacity. The number of tons (2240 lbs.) of cargo, stores and bunkers that a vessel can transport. It is the difference between the number of tons of water a vessel displaces "light" and the number of tons it displaces "when submerged to the 'deep load line'." A vessel's cargo capacity is less than its total deadweight tonnage. The difference in weight between a vessel when it is fully loaded and when it is empty (in general transportation terms, the net) measured by the water it displaces. This is the most common, and useful, measurement for shipping as it measures cargo capacity.

DEBT/EQUITY (GEARING) RATIO- The ratio of long-term debt. The current portion of debt to shareholders funds. Also known as GEARING RATIO.

DEFAULT- Failure to repay a loan or an overdraft as promised.

DEMURRAGE -A fee levied by the shipping company upon the port or supplier for not loading or unloading the vessel by a specified date agreed upon by contract. Usually, assessed upon a daily basis after the deadline.

DESPATCH- Time saved, reward for quick turnaround - in dry cargo only.

DOUBLE BOTTOM- General term for all watertight spaces contained between the outside bottom plating, the tank top and the margin plate. The double bottoms are sub-divided into a number of separate tanks which may contain boiler feed water, drinking water, fuel oil, ballast, etc.

DWT - Deadweight tons.

EUROPEAN OPTION- An option that can only be exercised at expiration.

FIRST MORTGAGE- A mortgage which is not subject to any prior mortgage. The primary form of security in ship finance.

FREIGHT RATE- The charge made for the transportation of freight.

FLOATING RATE- The basis on which interest is usually calculated in respect of shipping loans. The rate payable is set as a fixed margin above the relevant inter-bank offered rate, usually the LIBOR.

GDP -Gross Domestic Product: The total value of goods and services produced by a nation over a given period, usually 1 year.

GEARING- see DEBT/EQUITY ratio. Also referred to as LEVERAGE.

Gross and Net tonnage (GT and NT) - Gross tonnage is the basis on which manning rules and safety regulations are applied, and registration fees are reckoned. Port fees are also often reckoned on the basis of GT and NT. GT and NT are defined according to formulas which take account, among other things, of the volume of the vessel's enclosed spaces (GT) and the volume of its holds (NT).

GROSS REGISTERED TONS- A common measurement of the internal volume of a ship with certain spaces excluded. One ton equals 100 cubic feet; the total of all the enclosed spaces within a ship expressed in tons each of which is equivalent to 100 cubic feet.

HANDY SIZE- the description was originally applied to a tanker of about 30,000 dwt in the 1980s and with 20-50000 dwt bulk carriers. However, in the 1960s the term was synonymous with a 20,000 dwt tanker. The term came into general use in the 1960s when with the rapid increase in tanker and bulk carrier sizes, there were problems in providing full loads of cargoes, the increasing need for multi-port discharge of cargoes and limitations on the size of vessel that could be accepted in both loading and discharging ports.

HEDGE- The idea of a hedge is to reduce a physical contractual exposure such as an obligation to pay interest at a floating rate, by purchasing an appropriate paper contract or derivative such that a rise in one contract would be offset by a fall in the other, thus fixing the cost of the physical contract that is hedged. In one sense a hedge can be considered as a means of insurance for which the buyer is prepared to pay a PREMIUM.

IMF -International Monetary Fund.

IMO -International Maritime Organization: Formerly known as the Inter-Governmental Maritime Consultative Organization (IMCO), was established in 1958 through the United Nations to coordinate international maritime safety and related practices.

INTERTANKO- An association of independent tanker owners whose aims are to represent the views of its members internationally.

K/S FUNDS (KOMMANDITTSELSKAP)- A Norwegian or Danish limited partnership, which has been widely used in ship financing. At least one participant in the partnership must be fully liable, while at least one, usually many more, have limited liability. The attraction of such partnerships (also known as KGs in Germany and CVs in Holland) to investors paying an exceptionally high marginal rate of tax, are that the same tax benefits as would apply to direct ownership of an asset, while having only limited liability. However, in the last years, these partnerships have attracted people who are more interested in pure asset returns rather than tax benefits.

LAID-UP TONNAGE- Ships not in active service; a ship which is out of commission for fitting out, awaiting better markets, needing work for classification, etc.

LAY-UP -Temporary cessation of trading of a ship by a shipowner during a period when there is a surplus of ships in relation to the level of available cargoes. This surplus, known as overtonnaging, has the effect of depressing freight rates to the extent that some shipowners no long find it economical to trade their ship, preferring to lay them up until there is a reversal in the trend.

LIBOR- London Inter-bank Offered Rate. The interest rate at which banks lend and borrow dollars between each other. Acts as the main indicator of the floating bank rate in Europe.

LIGHT DISPLACEMENT TONNAGE (LDT/LWT)- The weight of a ship's hull, machinery, equipment and spares. This is often the basis on which ships are paid for when purchased for scrapping. The difference between the loaded displacement and light displacement is the ship's deadweight.

LIMITED PARTNERSHIP- A partnership consisting of one or more limited partners, whose liability is limited to the amounts they have invested, and one or more general partners, who are fully liable for the partnership’s debts.

LIQUIDITY- (i) Assets including cash, and securities which can quickly be sold. A company with high liquidity is more easily able to cope with adverse changes in cashflow. (ii) The maturity of a market, indicating the ease with which sellers can find buyers.

LNG -Liquefied Natural Gas, or a carrier of LNG.

LNG CARRIER - Liquefied natural gas carrier, perhaps the most sophisticated of all commercial ships. The cargo tanks are made of a special aluminium alloy and are heavily insulated to carry natural gas in its liquid state at a temperature of -2850F. The LNG ship costs about twice as much as an oil tanker of the same size.

LONG TON- 2,240 pounds.

LPG -Liquefied Petroleum Gas, or a carrier of LPG.

M/T -Metric tons (2,250 lbs.).

NET TONNAGE- Equals gross tonnage minus deductions for space occupied by crew accommodations, machinery, navigation equipment and bunkers. It represents space available for cargo (and passengers). Canal tolls are based on net (registered) tonnage.

NRT -Net registered tons. This tonnage is frequently shown on ship registration papers; it represents the volumetric area available for cargo at 100 cubic feet = 1 ton. It is often used by port and canal authorities as a basis for charges.

OBO- Ore/bulk/oil vessel

OBO SHIP- A multipurpose ship that can carry ore, heavy dry bulk goods and oil. Although more expensive to build, they ultimately are more economical because they can make return journeys with cargo rather than empty as single-purpose ships often must.

OPTIONS- A right but not the obligation to buy or sell a security or an asset at some future time at a predetermined price. The buyer of an option pays an amount of money upfront in exchange for being granted this right by the seller. This amount is called the premium.

PANAMAX- The largest size of vessel whose beam (32.2m) can fit in the Panama locks and thus cross the Panama canal.

PREMIUM- The transaction cost of a derivative contract.

PRODUCT CARRIER- A tanker which is generally below 70,000 deadweight tons and used to carry refined oil products from the refinery to the consumer. In many cases, four different grades of oil can be handled simultaneously.

SPOT (VOYAGE)- A charter for a particular vessel to move a single cargo between specified loading port(s) and discharge port(s) in the immediate future. Contract rate ("spot" rate) covers total operating expenses, i.e., bunkers, port charges, canal tolls, crew's wages and food, insurance and repairs. Cargo owner absorbs, in addition, any expenses specifically levied against the cargo.

SPREAD- The difference between the floating rate and the LIBOR rate. In other words the bank’s gross profit margin.

SUEZMAX TANKERS- The largest tankers capable of crossing the Suez Canal in a fully laden (loaded) condition. Very Large Crude Carriers (VLCCs) can also cross the Suez Canal, provided they are partly loaded or in ballast (empty) condition.

SWAP- a hedging mechanism whereby a spot transaction is wholly or partially matched by an opposite forward transaction.

T.E.U. -Twenty Foot Equivalent Unit (containers): A measurement of cargo-carrying capacity on a containership, referring to a common container size of 20 ft in length.

TIME CHARTER- A form of charter party wherein owner lets or leases his vessel and crew to the charterer for a stipulated period of time. The charterer pays for the bunkers and port charges in addition to the charter hire.

TON MILE- A measurement used in the economics of transportation to designate one ton being moved one mile. This is useful to the shipper because it includes the distance to move a commodity in the calculation.

VOYAGE CHARTER- A contract whereby the shipowner places the vessel at the disposal of the charterer for one or more voyages, the shipowner being responsible for the operation of the vessel.

WORLDSCALE- An index representing the cost of time chartering a tanker for a specific voyage at a given time. The index is given at Worldscale 100, which represents the price in dollars per ton for carrying the oil at that rate. The negotiated rate will be some percentage of the index value.

FOR EXAMPLE:

W1OO on the voyage Ras Tannura - Rotterdam (Cape-Cape) =
$31.16/ton of oil
W25 = 25% of W1OO
W25 = $7.79/ton of oil
N.B. rates may be above as well as below W1OO

Curriculum Vitae

Stavros Tsolakis was born on July 10 1978 in Katerini Pierias, Greece. He graduated with distinction from Anatolia College, the American College of Thessaloniki in 1996. He holds a BSc Honours degree in Shipping Operations from the Southampton Maritime Institute of Nottingham Trent University, UK, and MSc degrees in Business and Financial Economics from Rotterdam School of Management of Erasmus University Rotterdam, the Netherlands. From 1999-2004 he was an assistant professor of Maritime Economics as well as the Assistant Academic Director of the MSc in Maritime Economics and Logistics, one of the world's leading MSc programmes in the shipping industry today. He lectured in Shipping Economics and Policy and Shipping and Transport Finance with specialisation in econometric modelling of bulk shipping, shipping market analysis, shipping finance and policy. The course in Shipping and Transport Finance has been developed and delivered in partnership with DVB Bank, one of the world's leading financial institutions in ship finance today.

Stavros Tsolakis has also participated in the center's development of in-house training programmes for shipping companies like the one for Neptune Orient Lines/American President Lines in Singapore, where he also lectured in two modules. Similar activities included the development of new courses as well as lecturing in prestigious organisations such as the Panama Canal Authority. In March 2004 he was invited as a visiting Professor to Faculté des Sciences Economiques et de Gestion of the University of Nantes, France, to lecture on Bulk Shipping Market Structures, Ship Finance and Financial Risk Management in Shipping,

Research papers of his have been presented in International Conferences in Alexandria (Egypt), Rotterdam, Genoa (Italy), Ghent (Belgium), London, Panama, Busan (South Korea), Singapore and published in well-known journals such as the International Journal of Maritime Economics.

Stavros Tsolakis comes from a shipowning family with a long tradition dating back to the 1920s. Since 1998 he is the Vice-President of DST SHIPPING INC., a family business based in Thessaloniki, Greece, specialising in dry and chemical bulk transportation that has evolved into the largest shipowning group of Northern Greece.