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Econometric Modelling of Second-hand Ship Prices

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This paper provides an econometric analysis of second-hand ship prices. It starts with a presentation of previous attempts to model second-hand ship prices and their shortcomings. After that a theoretical Error Correction Model is developed making up for these shortcomings. Its results are analysed and compared to those of an atheoretical Autoregressive Model within the context of Econometric Business Cycle Research. This allows the model to describe and forecast cycles and to evaluate policies. It is demonstrated that second-hand prices of different ship sizes/segments react differently to changes in the market variables that determine them. This provides support for performing analysis at a disaggregated rather than an aggregated level. 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 due to its particular characteristics. Finally, it is found that the size of the 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.
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INTRODUCTION

The market for second-hand vessels

Shipping is one of the few industries having a separate and active market where the main capital assets of the industry, the ships 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 and contestability.

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 may arise through asset play, that is, 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 at low cost.

Second-hand ship markets have attracted the interest of many researchers who have developed and estimated theoretical models to explain fluctuations in second-hand ship values. Theoretical, structural, econometric models however often suffer from statistical shortcomings such as autocorrelation, multicollinearity and heteroscedasticity that make their estimates biased and, to an extent, unreliable. To overcome such shortcomings, atheoretical, time-series models have also been developed recently (see for example Veenstra, 1999, Kavussanos, 1996a, b, 1997). Therefore, the aim of the present paper is to bridge the gap in the two approaches, by providing a theoretical Error Correction model of second-hand ship prices that both caters for the above problems and allows statistical inferences to be made.

The paper 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 paper's modelling strategy. Methodological analysis is followed by model estimation and results discussion. Finally, the paper compares the forecasting abilities of the developed model with that of an Autoregressive (AR) one, for all ship types under investigation.

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 fairly debatable statement and as it will be shown later in the paper supply and demand analysis *is* appropriate for modelling ship prices.

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

$$\frac{F * PS_t}{W_t} = f_{PS}\left(\frac{E_t \Pi_{t+1}}{PS_t}, \frac{E_t PS_{t+1}}{PS_t}, i_t\right)$$

where PS is the second-hand price, W the world wealth, F the fleet size (bulk carrier or tanker depending on the circumstances), $E_t \Pi_{t+1}$ the expected ship earnings for the coming year, equal to timecharter minus operating costs, $E_t PS_{t+1}$ the expected second-hand price for next year and *i* the interest rate.

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

This capital asset equation is based on the assumption that the share of ships in 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 their price, since the relative return on ships falls as price rises, and because of wealth effects induced by relative (ship) price changes.

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

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, in the same paper 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 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 (Beenstock and Vergottis, 1989a, b, 1992, 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 supply factors (labour, raw materials, equipment, design, supervision, debt, exchange rates, etc) whereas second-hand prices are in turn more driven by demand.

In simple terms newbuilding prices represent a cost plus figure whereas second-hand prices are realisations of values not costs. However, 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, for example, 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 authors 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 such 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 cash flow 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 (2002) 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.

Despite the fact that all these studies have a sound theoretical basis, their estimates often suffer from either one or a mix of the following problems: autocorrelation, multicollinearity, heteroscedasticity and combination of stationary and non-stationarity variables in the same equation. The effect is that the results are biased and thus inferences are, to an extent, unreliable.

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.

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 ships, representing the speculative sales.

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, 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 Vanangs (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 paper is consistent with market efficiency in the long run.

Despite these recent applications of modern econometric techniques into modelling the behaviour of second-hand ship markets, none has so far applied such techniques to develop a model that is based on theory. By developing a theoretical (Error Correction) model for the second-hand vessel market that gives reliable results from which economic inferences can be made confidently, this paper aims at filling a gap in maritime economics literature. Another contribution is that by disaggregating into the different ship types according to size, the paper finds that different variables have different effects on each type thus proving that each ship type has its own distinctive characteristics. Furthermore, the paper is a first attempt to analyse, compare and contrast both the tanker and the dry bulk market simultaneously. Another contribution of the paper is that it compares the forecasting ability of the developed theoretical model with that of an atheoretical Autoregressive one. The final contribution of the paper to existing literature has to do with a 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 market players may utilise before designing and implementing their sale and purchase strategies.

METHODOLOGY: MODEL SPECIFICATION, DATA COLLECTION AND ANALYSIS

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.

$$Q_{SH}^{D} = f(fr,\ secondhand,\ nb,\ LIBOR)$$

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:

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

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

$$secondhand = f(\overset{+}{fr}, \overset{+}{nb}, \overset{+/-}{\frac{Orderbook}{Fleet}}, \overset{-}{LIBOR})$$

where *Secondhand* indicates Second-hand price of a vessel, *fr* the vessel's average timecharter rate per day for the year, *nb* the newbuilding price, Orderbook/Fleet the Orderbook as a percentage of the total fleet (including combined carriers) and LIBOR the interest rates (LIBOR).

On top of each variable, the expected sign 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 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 first 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 up second-hand ship prices despite low vessel earnings.

Apart from denoting expectations, the timecharter rate is also a much better market indicator than the freight rate, which is route specific, and more importantly in the tanker market, than the 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 a 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 exhibit the highs and 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 present only a snapshot in time, give no indication of forward expectations and are notoriously difficult to forecast. For all 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.

For Worldscale in particular, a common mistake among researchers (Hawdon, 1978; Beenstock and Vergottis, 1989a, b, 1993; Veenstra, 1999) is to use it as an income indicator over a period of time.

Worldscale is a cost-based schedule that 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 bunker prices, the port dues or the exchange rate of the currency of the States included in this route, WS100 for this year as Figure 1 shows, will be different in dollar terms than WS100 for the same route the previous year.

Furthermore, while in Worldscale terms 1 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 Figure 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. Consequently, discrepancies will occur between the WS and the actual rates obtained by the vessels over the years thus distorting the final results.

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

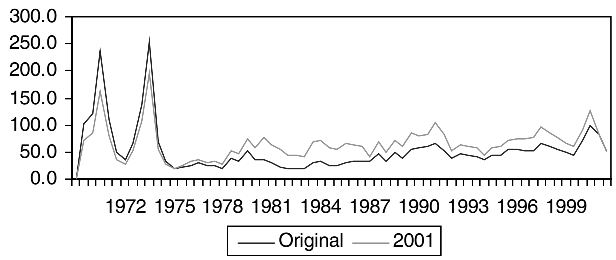

Figure 1: Comparison original WS with WS 2001.

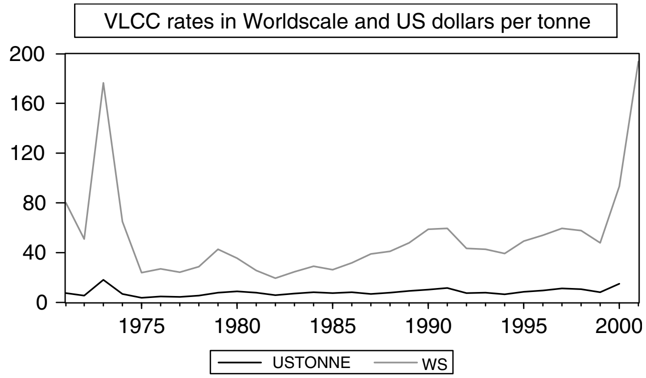

Figure 2: VLCC rates in Worldscale and US dollars per tonne.

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 able 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 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 by the authors 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).

Data collection and analysis

Financial data on the 3-month London Interbank Offered rate (3-month LIBOR), was obtained from Datastream International for the years 1960–2001. Shipping related data were 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 (Fearnleys Research, 1965–2001).

The first step was to distinguish between ship types. Therefore for the bulk carrier market three ship types were distinguished: Handy (15–49,999 dwt), Panamax (50–79,999 dwt) and Capesize (80,000 +) bulk carrier.

By the same token tankers were classified into Handy (15–49,999 dwt), Panamax (50–79,999 dwt), Aframax (80–120,000 dwt), Suezmax (120–199,999 dwt), 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 and 120,000 dwt ships for bulk carriers and 30,000, 70,000, 105,000, 130,000 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, 1997). These results make necessary the analysis of both the bulk carrier and the tanker market at a disaggregate level. As a result, this model can become a useful tool for the shipowners to base their investment decisions since they will be able to know which factors and to what extent affect every different ship size. Furthermore, this model can be an interesting tool for the brokers who will be able to assess the price of a second-hand vessel more accurately and then discount or increase the price according to the specifications of the ship that is marketed for sale.

Owing the number of variables and the problems experienced with data collection, it was decided to use annual data for the estimates. This way fewer discrepancies with the data occurred and the results were more reliable, particularly for the earlier years where data are scarce and unreliable.

Another issue was the starting date of the observations. 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 1960s saw the introduction of VLCCs and Cape size bulk carriers. Despite the fact that data existed for some ship types from mid-1950s 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.

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 1970s but their operational 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 consisting 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 1970s, 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 and their split between the oil and the dry bulk trades was necessary. Fearnleys and Jacobs (SSY) 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, more variables were obtained, such as the orderbook as a percentage of the total fleet and the vessel's profitability, measured as the difference between current and previous year's timecharter rates.

Problems experienced with data

Data collection proved to be the most time consuming and difficult task. This was not due to the lack of information sources, but to the consistency and quality of the data itself. One of the major problems encountered during the 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 was more intense in the earlier years where not all size categories were equally well developed and distinguishable as they are today. For example in the early and mid-1960s, large tankers used to be described as anything above 80,000 dwt, something that is certainly not the case today. Such things can create significant problems with the data series, particularly when one benchmarks against today's size distributions. Take for example newbuilding prices. Until 1975, Fearnleys (1966–2001) 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. Some vessels that some shipbroking houses regard as Aframaxes may be classified as Suezmaxes by others, while some people distinguish between handy, handymax and super-handymax vessels, with the latter being in the same size category with some Panamax vessels. This creates significant discrepancies between the fleet data reported by various shipbroking houses. For example, some 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. Therefore, one 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 of its World Merchant Fleet. This means that some ships previously regarded as bulk carriers are now classified under general cargo vessels. Consequently, fleet statistics pre and after 1995 are even more difficult to compare.

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

Transformation into logarithms

Time-series data were transformed by taking natural logarithms. Several reasons can be mentioned for this. First, in certain circumstances, taking logarithms may stabilise a non-stationary variance. Also, 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

In the course of model estimation, 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 were 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 1970s 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.

MODEL SPECIFICATION

Testing for a unit root

As it has already been discussed, there are many variables that affect second-hand ship prices. In order to avoid multicollinearity as well as variables that exhibit stationarity that may hamper the results, correlations and unit root tests, namely the Augmented Dickey–Fuller stationarity tests were performed. The results are summarised in Table 1 (Dickey and Fuller, 1981).

In dealing with economic and financial data one is often confronted with strongly inert time series, so much so that one could consider that they have a unit root, that is, that the degree of inertia is in fact 1. This hypothesis is not innocuous since it has far-reaching econometric as well as economic implications. Handling strongly inert time series requires special techniques.

Table 1: ADF test results for stationarity

Ship type/variable	Levels	Stationarity	1st Difference	Station-arity	MacKinnon critical values		
					1%	5%	10%
					−4.2826	−3.5614	−3.2138
LNLIBOR	−2.910586	No	−5.158053	Yes			
Bulk carriers							
Handy							
LnNB	−3.169618	Yes	−5.636254	Yes			
Lnfr	−3.816648	Yes	−5.462005	Yes			
Lnorderbook/fleet	−3.625152	Yes	−5.186416	Yes			
LNSECONDHAND	−3.433941	No	−4.653240	Yes			
Panamax							
LnNB	−3.191532	No	−4.057055	Yes			
Lnfr	−4.241085	Yes	−5.551264	Yes			
Lnorderbook/fleet	−2.898470	No	−4.794752	Yes			
LNSECONDHAND	−3.251515	No	−4.498089	Yes			
Capesize							
LnNB	−3.223442	No	−5.073918	Yes			
Lnfr	−4.124810	Yes	−5.843474	Yes			
Lnorderbook/fleet	−1.882862	No	−7.666681	Yes			
LNSECONDHAND	−3.371316	No	−5.001132	Yes			
Tankers							
Handysize							
LnNB	−2.000447	No	−4.779069	Yes			
Lnfr	−3.368731	No	−4.408206	Yes			
Lnorderbook/fleet	−2.786261	No	−3.767966	Yes			
LNSECONDHAND	−2.619826	No	−4.339763	Yes			
Panamax							
LnNB	−3.018837	No	−4.496352	Yes			
Lnfr	−3.493548	No	−4.929942	Yes			
Lnorderbook/fleet	−3.007487	No	−5.381145	Yes			
LNSECONDHAND	−2.709682	No	−3.980877	Yes			
Aframax							
LnNB	−2.513246	No	−3.603109	Yes			
Lnfr	−3.025137	No	−5.096917	Yes			
Lnorderbook/fleet	−2.904352	No	−4.367984	Yes			
LNSECONDHAND	−3.003548	No	−4.318656	Yes			
Suezmax							
LnNB	−2.992179	No	−5.686306	Yes			
Lnfr	−3.132850	No	−4.506962	Yes			
Lnorderbook/fleet	−1.849302	No	−4.953553	Yes			
LNSECONDHAND	−2.252434	No	−4.477216	Yes			
VLCC							
LnNB	−2.936825	No	−3.570359	Yes			
Lnfr	−2.317703	No	−4.881463	Yes			
Lnorderbook/fleet	−3.022314	No	−4.894199	Yes			
LNSECONDHAND	−2.523191	No	−4.612988	Yes			

ADF test models contain an intercept and no 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. The test equation includes a trend and an intercept. Number of lagged first difference terms added to the regression: One(1).

In order to test for a unit root in shipping related variables, this paper applies the Augmented Dickey–Fuller test.

To perform this test the number of lagged first difference terms to add to the test regression need to be specified. The usual advice is to include lags sufficient to remove any serial correlation in the residuals. The number of lags is determined by the order of the AR model one assumes to be valid. An idea about this can be obtained by looking at the Auto correlation (AC) and Partial Auto correlation functions (PAC). A look at these functions for all variables used in this paper (not reported here) indicates that the AR is of order 1. As a result and in addition to the fact that we use annual data we choose to add 1 lagged first difference term to the test regression.

Secondly, we have to decide whether to include other exogenous variables in the test regression. There is the choice of including a constant, a constant and a linear time trend, or neither in the test regression. The choice here is important since the asymptotic distribution of the t-statistic under the null hypothesis depends on our assumptions regarding these deterministic terms.

In this case we chose to run the test with both a constant and a linear trend since the other two cases are just special cases of this more general specification. In case there is no trend in the variable the t-statistic for trend will be statistically insignificant.

The results in Table 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).

The properties of variables with different degrees of integration are markedly different. Contrasting I(1) with I(0) series it is well-known from work in the time series field, that the autocorrelations of an I(0) series decline rapidly as the lag increases, while those for an I(1) series decline slowly, if at all. Innovations of I(1) series affect all subsequent values so they have infinite memories while I(0) series give smaller weight to events in the more distant past.

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.

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' work, 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 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. 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 $y_{t-1} - \gamma x_{t-1}$ 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).

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

Testing for cointegration

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. Taking the Johansen (1991) approach, we find that for all ship types there are at most four relations in our models, which makes us confident with estimating them. What is reported in Appendix A 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 particular characteristics of every ship segment.

Output of estimations and test results

To demonstrate whether a model or equation is rightly selected, the estimation results in the empirical analysis are presented with a number of statistics. The output of estimations and test results contain the following statistics:

- Parameter values, standard error of estimate and corresponding *t*-values.

- Coefficient of determination (R^2), Adjusted R^2, Durbin–Watson statistic (DW), SE 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 tests for heteroscedasticity.
- Ljung–Box (1978) *Q* Statistic and Breusch–Godfrey tests for autocorrelation.

The results are summarised in Table 3 and indicate that neither autocorrelation nor Heteroscedasticity exists. This provides us with confidence to conclude that our OLS estimator is BLUE (Best Linear Unbiased Estimator) and consequently, statistical inferences can be made from it.

MODEL RESULTS

Results for all ship types and reports on standard errors, *t*-statistics, R^2, adjusted R^2 and the Durbin Watson statistic are summarised in Table 2.

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.

Tanker 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 was in the case of Aframax tankers where, due to the fact that it is regarded as the workhorse of the industry, prices rely too much on timecharter rates. Therefore, newbuilding price changes are only significant in the long run.

Table 2: Regression results OLS (series in logarithms)

	Coefficient	SE	*t*-Statistic			Coefficient	SE	*t*-Statistic	
	Handy size bulk carrier					**Panamax bulk carrier**			
C(1)	−4.383875	1.052590	−4.164846		C(1)	−2.411518	0.879041	−2.743353	
(LNFR)	0.808928	0.161227	5.017311		(LNFR)	0.432454	0.139062	3.109796	
(LNNB)	−0.337381	0.240349	−1.403715		(LNNB)	0.573533	0.201378	2.848047	
D(LNLIBOR)	−0.064260	0.052922	−1.214236		D(LNLIBOR)	−0.093507	0.156492	−0.597517	
(LNORDERBOOK/FLEET)	−0.118613	0.091695	−1.293556		D(LNORDERBOOK/FLEET)	0.051508	0.063284	0.813912	
DUMMY	−0.574985	0.086129	−6.675859		DUMMY	−0.230754	0.107801	−2.140561	
LNSECONDHAND(-1)	−0.586247	0.075222	−7.793610		LNSECONDHAND(-1)	−1.031324	0.128787	−8.007962	
LNLIBOR(-1)	−0.199993	0.092625	−2.159171		LNLIBOR(-1)	−0.227950	0.090016	−2.532328	
R^2	0.897470	Adjusted R^2		0.864847	R^2	0.814031	Adjusted R^2		0.754860
SE of regression	0.103370	Sum-squared resid		0.235076	SE of regression	0.167608	Sum-squared resid		0.618034
Durbin–Watson stat	1.957645				Durbin–Watson stat	1.893576			
	Capesize bulk carrier					Handy size tanker			
C(1)	−2.766969	0.855025	−3.236127		C(1)	0.013861	0.267601	0.051798	
(LNFR)	0.633842	0.109445	5.791444		D(LNFR)	0.521381	0.148215	3.517745	
D(LNNB)	0.569612	0.240580	2.367659		D(LNNB)	0.591285	0.226860	2.606383	
D(LNLIBOR)	−0.451611	0.177127	−2.549646		D(LNLIBOR)	−0.032265	0.127800	−0.252465	
D(LNORDERBOOK/FLEET)	−0.125750	0.077173	−1.629459		D(LNORDERBOOK/FLEET)	0.016001	0.081606	0.196081	
DUMMY	−0.358353	0.197331	−1.816001		DUMMY	−0.309288	0.123306	−2.508300	
LNSECONDHAND(-1)	−0.737501	0.121821	−6.053974		LNSECONDHAND(-1)	−0.731054	0.197649	−3.698758	
LNLIBOR(-1)	−0.533302	0.125016	−4.265862		LNNB(-1)	0.841021	0.115496	7.281828	
R^2	0.859445	Adjusted R^2		0.810251	R^2	0.767409	Adjusted R^2		0.686003
SE of regression	0.167717	Sum-squared resid		0.562577	SE regression	0.134678	Sum-squared resid		0.362766
Durbin–Watson stat	1.857334				Durbin–Watson stat	2.015567			
	Panamax tankers					Aframax tankers			
C(1)	−1.160923	0.252129	−4.604475		C(1)	−5.540092	1.485586	−3.729230	
D(LNFR)	0.141960	0.036129	3.929295		D(LNFR)	0.574838	0.194434	2.956466	
D(LNNB)	0.795719	0.096020	8.286981		D(LNNB)	0.484290	0.373448	1.296809	
D(LNLIBOR)	0.115854	0.048667	2.380560		D(LNLIBOR)	0.067353	0.078066	0.862765	

Table 2: *(Continued)*

	Coefficient	SE	*t*-Statistic			Coefficient	SE	*t*-Statistic	
D(LNORDERBOOK/FLEET)	0.002469	0.030804	0.080145		D(LNORDERBOOK/FLEET)	0.133124	0.084527	1.574930	
DUMMY	−0.114689	0.056577	−2.027143		LNSECONDHAND(-1)	−1.129018	0.187182	−6.031655	
LNSECONDHAND(-1)	−0.602795	0.118270	−5.096783		LNFR(-1)	0.581171	0.152742	3.804914	
LNNB(-1)	0.793316	0.127931	6.201142		LNNB(-1)	0.710068	0.202969	3.498409	
LNORDERBOOK/FLEET(-1)	−0.303451	0.065935	−4.602282		R^2	0.817413	Adjusted R^2		0.759317
LNFR(-1)	0.312472	0.088355	3.536549		SE of regression	0.144165	Sum-squared resid		0.457240
R^2	0.948807	Adjusted R^2		0.924557	Durbin–Watson stat	1.623224			
SE of regression	0.054035	Sum–squared resid		0.055476					
Durbin–Watson stat	1.854913								
	Suezmax tankers					VLCC tankers			
C(1)	0.845594	0.613104	1.379201		C(1)	−6.132013	1.964714	−3.121071	
D(LNFR)	0.302893	0.100394	3.017048		D(LNFR)	0.727271	0.240097	3.029072	
D(LNNB)	0.845547	0.224933	3.759098		D(LNNB)	1.978095	0.649283	3.046587	
D(LNLIBOR)	−0.251877	0.157085	−1.603441		D(LNLIBOR)	0.103148	0.247917	0.416060	
D(LNORDERBOOK/FLEET)	0.242642	0.071348	3.400801		D(LNORDERBOOK/FLEET)	0.127926	0.133934	0.955144	
DUMMY	−0.106457	0.079235	−1.343554		DUMMY	−0.330624	0.156736	−2.109439	
LNSECONDHAND(-1)	−0.598061	0.143935	−4.155066		LNSECONDHAND(-1)	−1.174948	0.219023	−5.364502	
LNLIBOR(-1)	−0.620879	0.246056	−2.523328		LNNB(-1)	0.920653	0.207527	4.436313	
LNNB(-1)	0.721973	0.210248	3.433908		LNORDERBOOK/FLEET(-1)	−0.216395	0.065320	−3.312852	
LNORDERBOOK/FLEET(-1)	−0.140932	0.065640	−2.147035		LNFR(-1)	0.450924	0.225092	2.003293	
R^2	0.809332	Adjusted R^2		0.723532	R^2	0.739839	Adjusted R^2		0.622767
SE of regression	0.159511	Sum squared resid		0.508877	SE of regression	0.274820	Sum-squared resid		1.510525
Durbin–Watson stat	2.051026				Durbin–Watson stat	2.140796			

Table 3: Diagnostic tests (*P*-values in parentheses)

Ship type	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)	
			F statistic	Obs*R^2	*F* statistic	Obs*R^2	*F* statistic	Obs*R^2
Handy size bulk carrier	0.0046 (0.946)	0.2956 (0.587)	0.795994 (0.464915)	2.211914 (0.330894)	0.249190 (0.621689)	0.265201 (0.606569)	0.999066 (0.493361)	13.44134 (0.414328)
Panamax bulk carrier	0.0649 (0.799)	0.2446 (0.621)	0.063727 (0.938450)	0.189972 (0.909386)	0.203408 (0.655585)	0.216842 (0.641457)	1.532178 (0.215615)	18.64333 (0.230354)
Cape size bulk carrier	0.0005 (0.981)	0.9625 (0.327)	0.568132 (0.576419)	1.662572 (0.435489)	0.915287 (0.347876)	0.953597 (0.328805)	1.036122 (0.495028)	17.86024 (0.397709)
Handy tanker	0.1720 (0.678)	2.9409 (0.086)	0.305421 (0.740556)	0.919013 (0.631595)	2.955675 (0.097937)	2.854634 (0.091111)	1.002426 (0.531027)	19.71784 (0.411733)
Panamax tanker	0.4579 (0.499)	2.7722 (0.096)	1.098071 (0.393211)	4.789421 (0.091199)	2.477668 (0.127565)	2.436109 (0.118570)	2.374978 (0.092319)	24.17779 (0.189421)
Aframax tanker	0.4222 (0.516)	0.7316 (0.392)	2.018679 (0.159013)	5.038853 (0.080506)	0.744014 (0.395975)	0.777696 (0.377847)	2.919298 (0.307011)	24.80702 (0.130325)
Suezmax tanker	0.0227 (0.88)	0.6488 (0.421)	1.417491 (0.268111)	4.082050 (0.129896)	0.576974 (0.454082)	0.606747 (0.436015)	2.212747 (0.099358)	24.23545 (0.187275)
VLCC	0.2210 (0.638)	1.0072 (0.316)	1.303796 (0.295942)	3.796065 (0.149863)	0.869009 (0.359491)	0.904275 (0.341638)	1.345220 (0.322490)	21.56336 (0.306523)

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.

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, the handy size bulk carrier is the industry's workhorse, relying heavily on timecharter rates (a 10% increase in timecharter rates will make second-hand prices go up by 8%).

While in Handies timecharter rates have a higher effect than newbuilding prices, in cape size vessels 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 has negative effects in 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 the Handy and Panamax orderbooks.

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. 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 5-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 standard shipyard products, as the demand for them is relatively limited. This is because the footprint of a Suezmax is not much smaller than a VLCC in a building dock and this offers shipbuilders little opportunity to maximise output (better 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 size. In other words, Suezmaxes are rarely bargain vessels. Second-hand prices of Suezmaxes could therefore be more closely tied to newbuilding prices than 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 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 tanker owners have more capital than bulk carrier owners. Therefore, an increase in the cost of borrowing money will not affect their investment decisions to the same extent as bulk carrier owners. This argument can be further strengthened by the fact that cash flow 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 this 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 where, as has been explained above, owners base their decision to invest on timecharter fluctuations.

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

- The values of commodities carried by bulkers are far lower than those of crude oil and petroleum products, carried by tankers. This tends to put greater pressure on dry bulk carriers to provide value for money transportation, given that transport 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 compared to those of tankers. Dry bulk shipping is therefore more cost rather than revenue driven.

- The performance of dry bulk carriers, both in terms of absolute earnings and return on investment, has traditionally been much lower than that of 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, bulk carrier owners have tended to be more readily attracted by low newbuilding prices than tanker owners, for the cost of a bulker is more crucial in terms of return on investment. Thus 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 first choice in shipyards building both types of ships. This is because a shipyard, like any other company, needs to maximise 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, it takes place when demand for new tankers has fallen together with shipbuilding prices.

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

Forecast

Based on the model estimated above, forecasts were made for all ship types for the period 1999–2001. In addition to this, 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 Information criterion was used in all cases in order to determine the lag of the model, which for this case is 1. Therefore, our Autoregressive model has the following form:

$$X_{t+1} = \mu + \rho X_t + \eta_{t+1}$$

where $X_t = P(t) = \mathrm{lnsecondhand}(t)$; μ is the mean; $\eta(t)$ denotes the shock at time t and ρ is the autoregressive coefficient.

Table 4 compares the forecasting capabilities of these two different econometric methods. The absolute, percentage and root mean-squared errors

Table 4: SEM-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	0.166690	0.082117	0.149612	0.219726	0.187533	0.061618	0.245304	0.170031
Percentage errors	6.756877	3.025542	4.711866	7.710057	5.500556	1.755294	6.491360	4.078291
Mean squared errors	0.185686	0.083020	0.152600	0.255889	0.224987	0.064628	0.245511	0.170868
AR								
Absolute errors	0.123028	0.047807	0.080333	0.123384	0.268577	0.363906	0.283709	0.317071
Percentage errors	5.007458	1.803812	2.093071	4.273113	7.944779	10.22644	7.440459	7.586094
Mean-squared errors	0.125500	0.061935	0.067665	0.128692	0.283153	0.375982	0.299382	0.323485

are used to compare the performance of the forecasts of the Structured Error Correction Model and the AR models.

From this table, it can be seen that AR forecasts outperform those of the structural equation model (SEM) in all three bulk carrier segments as well as in the Handy Tankers sector. The Structural equation model outperforms AR estimates for Panamax, Aframax, Suezmax and VLCC tankers. These results indicate that Structural Equation Models, the method Tinbergen (1959) adopted, is to be preferred if one wants to achieve the classical objectives of Econometric Business Cycle Research 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 (Vector) Auto Regressive method whose forecasts outperform those of SEM on many occasions.

CONCLUSION

This paper 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 ship 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 of the newbuilding variable are higher than those of the timecharter one. 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. 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.

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 for large (Suezmax, VLCCs) and Panamax tankers.

Finally, the paper compared different econometric methods, that is, Structural Equation Models (SEM) and atheoretical Vector Auto Regressive (VAR) models. It was found that Structural Equation 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 (Vector) Auto Regressive method whose forecasts outperform those of SEM on many occasions.

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Appendix A: Results of Johansen Cointegration Tests

Handy bulk carrier

Series: LNSECONDHAND LNFR LNNB LNORDERBOOK/FLEET LNLIBOR

Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical value
None	0.890199	136.8086	87.31

Cointegrating equation(s): Log likelihood 46.05281

Normalised cointegrating coefficients (SE in parentheses)

LNSECONDHAND	LNFR	LNNB	LNORDERBOOK/FLEET	LNLIBOR	@TREND(69)
1.000000	19.32461	−22.12677	−1.430479	0.457469	−0.049184
	(2.08774)	(2.47808)	(0.59058)	(0.74652)	(0.04271)

Series: LNSECONDHAND LNLIBOR

Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical value
None	0.455024	19.98137	19.96

1 Cointegrating equation(s): Log likelihood 12.18427

Normalised cointegrating coefficients (SE in parentheses)

LNSECONDHAND	LNLIBOR	C
1.000000	1.162716	−4.533177
	(0.31716)	(0.64695)

Panamax bulk carrier

Series: LNSECONDHAND LNFR LNNB LNORDERBOOK/FLEET LNLIBOR

Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical value
None	0.725752	103.6241	87.31

1 Cointegrating equation(s): Log likelihood 49.49890

Normalised cointegrating coefficients (SE in parentheses)

LNSECONDHAND	LNFR	LNNB		LNORDERBOOK/FLEET	LNLIBOR	@TREND(69)
1.000000		0.135420	−1.298483	−0.128638	0.369679	−0.002857
		(0.12069)	(0.15789)	(0.06102)	(0.08013)	(0.00427)

Appendix A: Continued

Series: LNSECONDHAND LNLIBOR

Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical value	
None	0.433431	21.19699	19.96	
1 Cointegrating equation(s):			Log likelihood	2.860650
Normalised cointegrating coefficients (SE in parentheses)				
LNSECONDHAND		LNLIBOR	C	
1.000000		1.018534	−4.617553	
		(0.27047)	(0.55240)	

Capesize bulk carriers

Series: LNSECONDHAND LNFR LNNB LNORDERBOOK/FLEET LNLIBOR

Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical value			
None	0.832095	130.7605	87.31			
1 Cointegrating equation(s):			Log likelihood	48.96268		
Normalised cointegrating coefficients (SE in parentheses)						
LNSECONDHAND	LNFR	LNNB		LNORDERBOOK/FLEET	LNLIBOR	@TREND(69)
1.000000	0.379815	−1.957427		−0.266100	0.343476	−0.024159
	(0.10481)	(0.14719)		(0.04947)	(0.09493)	(0.00610)

Series: LNSECONDHAND LNLIBOR

Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical value	
None	0.430375	21.54256	19.96	
1 Cointegrating equation(s):			Log likelihood	−3.663587
Normalised cointegrating coefficients (SE in parentheses)				
LNSECONDHAND		LNLIBOR	C	
1.000000		1.148078	5.210132	
		(0.27330)	(0.55799)	

Handy tankers

Series: LNSECONDHAND LNFR LNNB LNORDERBOOK/FLEET LNLIBOR

Appendix A: Continued

Hypothesised		Trace	5%			
No. of CE(s)	Eigenvalue	Statistic	Critical value			
None	0.904753	121.1555	87.31			
1 Cointegrating equation(s):			Log likelihood	60.59112		
Normalised cointegrating coefficients (SE in parentheses)						
LNSECONDHAND		LNNB	LNFR	LNLIBOR	LNORDERBOOK/FLEET	@TREND(74)
1.000000		−1.475432	0.680010	−0.219036	−1.116323	0.002115
		(0.19588)	(0.26093)	(0.08267)	(0.10426)	(0.00467)
Series: LNSECONDHAND LNNB						
Hypothesised		Trace	5%			
No. of CE(s)	Eigenvalue	Statistic	Critical value			
None	0.532933	26.15710	25.32			
1 Cointegrating equation(s):			Log likelihood	26.15049		
Normalised cointegrating coefficients (SE in parentheses)						
LNSECONDHAND		LNNB	@TREND(74)			
1.000000		−0.809204	−0.009770			
		(0.08882)	(0.00430)			
Panamax Tankers						
Series: LNSECONDHAND LNFR LNNB LNORDERBOOK/FLEET LNLIBOR						
Hypothesized		Trace	5%			
No. of CE(s)	Eigenvalue	Statistic	Critical value			
None	0.784521	118.7881	87.31			
1 Cointegrating equation(s):			Log likelihood	58.38603		
Normalised cointegrating coefficients (SE in parentheses)						
LNSECONDHAND		LNNB	LNFR	LNORDERBOOK/FLEET	LNLIBOR	@TREND(72)
1.000000		−1.586363	0.946334	−0.079329	0.012750	−0.039782
		(0.16386)	(0.12350)	(0.09300)	(0.09870)	(0.00527)
Series: LNSECONDHAND LNNB LNORDERBOOK/FLEET LNFR						
Hypothesised		Trace	5%			
No. of CE(s)	Eigenvalue	Statistic	Critical value			
None**	0.631954	78.65325	62.99			
1 Cointegrating equation(s):			Log likelihood	40.97737		
Normalised cointegrating coefficients (SE in parentheses)						

Appendix A: Continued

		LNSECONDHAND	LNNB	LNFR		LNORDERBOOK/FLEET@TREND(72)	
1.000000		0.293733	−1.173789	1.170299		0.019193	
		(0.45336)	(0.34287)	(0.21461)		(0.01366)	
Aframax tankers							
Series: LNSECONDHAND LNFR LNNB LNORDERBOOK/FLEET LNLIBOR							
Hypothesised		Trace	5%				
No. of CE(s)	Eigenvalue	Statistic	Critical value				
None	0.878004	145.3748	87.31				
1 Cointegrating equation(s):			Log likelihood	51.96292			
Normalised cointegrating coefficients (SE in parentheses)							
LNSECONDHAND		LNNB	LNORDERBOOK/FLEET		LNFR	LNLIBOR	@TREND(72)
1.000000		−1.350116	−0.559772		0.896563	−0.688476	−0.071434
		(0.13159)	(0.05167)		(0.15765)	(0.07467)	(0.00618)
Series: LNSECONDHAND LNNB LNLIBOR							
Hypothesised		Trace	5%				
No. of CE(s)	Eigenvalue	Statistic	Critical value				
None	0.570486	43.41293	42.44				
1 Cointegrating equation(s):			Log likelihood	34.26266			
Normalised cointegrating coefficients (SE in parentheses)							
LNSECONDHAND		LNNB	LNLIBOR	@TREND(72)			
1.000000		−0.962087	−0.302748	−0.049192			
		(0.24932)	(0.17095)	(0.01291)			
Suezmax tankers							
Series: LNSECONDHAND LNFR LNNB LNORDERBOOK/FLEET LNLIBOR							
Hypothesised		Trace	5%				
No. of CE(s)	Eigenvalue	Statistic	Critical value				
None	0.863338	127.1102	87.31				
1 Cointegrating equation(s):			Log likelihood	39.18583			
Normalised cointegrating coefficients (SE in parentheses)							
LNSECONDHAND		LNFR	LNNB	LNORDERBOOK/FLEET		LNLIBOR	@TREND(72)
1.000000		−0.071718	−0.634232	−0.191825		−0.161640	−0.048502
		(0.07291)	(0.11717)	(0.03096)		(0.09191)	(0.00531)
Series: LNSECONDHAND LNNB LNLIBOR LNORDERBOOK/FLEET							
Hypothesised		Trace	5%				

Appendix A: Continued

No. of CE(s)	Eigenvalue	Statistic	Critical value			
None**	0.768827	76.13751	62.99			
1 Cointegrating equation(s):			Log likelihood	26.27732		
Normalised cointegrating coefficients (SE in parentheses)						
LNSECONDHAND		LNNB	LNLIBOR	LNORDERBOOK/FLEET	@TREND(72)	
1.000000		−0.646259	0.072735	−0.212014	−0.036215	
		(0.10400)	(0.09180)	(0.02409)	(0.00511)	
VLCC						
Series: LNSECONDHAND LNFR LNNB LNORDERBOOK/FLEET LNLIBOR						
Hypothesised		Trace	5%			
No. of CE(s)	Eigenvalue	Statistic	Critical value			
None	0.837564	107.6085	87.31			
1 Cointegrating equation(s):			Log likelihood	34.12056		
Normalised cointegrating coefficients (SE in parentheses)						
LNSECONDHAND	LNNB	LNFR		LNORDERBOOK/FLEET	LNLIBOR	@TREND(72)
1.000000	−1.165590		0.060505	−0.376909	−0.606344	−0.035947
	(0.13452)		(0.13286)	(0.04698)	(0.09879)	(0.00559)
Series: LNSECONDHAND LNNB LNORDERBOOK/FLEET LNFR						
Hypothesised		Trace	5%			
No. of CE(s)	Eigenvalue	Statistic	Critical value			
None	0.711541	72.49328	62.99			
1 Cointegrating equation(s):			Log likelihood	14.96191		
Normalised cointegrating coefficients (SE in parentheses)						
LNSECONDHAND	LNNB			LNORDERBOOK/FLEET	LNFR	@TREND(72)
1.000000	−1.175627			−0.316843	0.062042	−0.018126
	(0.17256)			(0.05634)	(0.16884)	(0.00576)