“Vessel Valuation and Asset Bubbles in Shipping”

Διπλωματική Εργασία για το Μεταπτυχιακό Πρόγραμμα «Ναυτιλία, Μεταφορές και Διεθνές Εμπόριο – Ν.Α.Μ.Ε.»

Χαβιάρας Λεόντιος

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Τμήμα Ναυτιλίας και Επιχειρηματικών Υπηρεσιών

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ΧΙΟΣ
Special Thanks

I dedicate this thesis to my family and especially my grandmother Maria who is not with us anymore, for standing by my side and supporting me in good and hard times.

I would also like to express my gratitude to my supervisor professor Mr Syriopoulos Theodore for his valuable guidance during the preparation of this thesis.
“Price is what you pay. 
Value is what you get.”
Warren Buffett
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Keywords
Second hand dry bulk market, Vessel Valuation, Efficient Market Hypothesis (EMH), Asset Bubbles

Synopsis-Scope

The present study examines the mechanics behind valuation methods of vessels, more specifically of the Long Term Asset Valuation Model, which is assumed to incorporate the largest amount of information available into the final price when compared to other methods. The next part involves an examination between differences in estimated intrinsic values calculated by the model and actual market values. Following that, the analysis is continued with the definition of what exactly is a bubble in general and which are the conditions that need to be present in order for a bubble to form. Being more specific, the prevalent conditions that existed during the period when the vessels prices in the secondhand market presented a large difference with the intrinsic values are examined.

The next part of the analysis involves the empirical research based on the concept of the efficiency in the secondhand ship markets. The Efficient Market Hypothesis is tested based on cointegration tests on the second hand prices of three different size categories in the dry bulk sector; Supramax, Panamax and Capesize as it was used in previous studies. The existence of cointegration between those prices indicates a possible inefficiency of the whole secondhand market for vessels. An extend on the concept of testing efficiency is examined through Engle-Granger cointegration testing as well as the Johansen test. The analysis was based on monthly data for the period 1994-2016 for 10-year-old second-hand vessels. The results from the two tests indicate that there is cointegration among the three variables, although the tests present that there is a different number of cointegrating vectors. This deems the implementation of an error correction model difficult, as well as the fact that there are many exogenous factors that affect the formation of the second hand prices.
1. Introduction

It is widely accepted that the dry bulk shipping, a major component of the world shipping industry, has been recognized as highly risky and volatile, since it is subject to several uncertainties, ranging from geopolitical shocks and the ever-changing world-economy to fleet changes and the sensitive market sentiment. Therefore, it has always been a flaming topic in academic research. The majority of studies that involve dry bulk shipping subjects are found in 1980’s and 1990’s while the interest has slightly dropped in 2000’s. In general, it is a market fueled by peaks and troughs limiting the ability to make sound forecasts about the future. Shipping cycles govern the dry bulk market and its sub markets; the freight market, the second-hand ship market, the new building market and the scrap market. In this study, the focus is given in the second-hand ship market for dry bulk ships. More specifically, the focus is given on the existence of bubbles in the prices of three different size categories in the dry bulk sector; Supramax, Panamax and Capesize. The motivation behind this study is the major upswing in the secondhand prices of all sizes up to a point that 10-year-old secondhand ships cost more than new ones a few months before the world economy shock in May 2008. This rather absurd observation motivated us to analyze whether a bubble was formed. Examining whether an asset bubble exists is not a straightforward procedure as we found out while investigating this particular case. To begin with, the first step is to determine what a bubble is. The definition of a bubble is a topic of research as well, and for the scope of this thesis a particular definition was taken into account, which is based on the difference between the intrinsic value of an asset and its market price. After establishing this definition, the next subject was to find a suitable and accredited way to determine the intrinsic value of the vessel. For this reason, various models and methods were taken into account, concluding to a discount cash flow model. While the model is based on various assumptions, it presents logical results about the approximate value of the vessel during the examined period. After examining the differences between the intrinsic value of the vessels and the market price we approached the subject from another view, focusing on whether the second hand market is efficient or not. Previous researches on the subject of market efficiency concluded that the second hand market for dry bulk ships is inefficient, stressing though that the results are not definite and conclusive. Our method of examining efficiency is based on two cointegration tests among the secondhand prices of three different size categories of dry bulk vessels. The results of our research, although mixed, are in line with previous ones. The need for an alternative approach on the concept of testing market efficiency is apparent as well as the introduction of the other 2 markets in an econometric model in order to present more solid results.
2. Vessel Valuation

Introduction

Up until the global financial crisis in 2008, the valuation of the vessels was pretty much a straightforward procedure of simply using the price of comparable vessels in recent transactions. Since the beginning of the crisis though, when prices in secondhand market dropped to record lows and the overall market volatility was at historical levels, new valuation approaches appeared. The most popular example was the Long Term Asset Value (LTAV) method, proposed by the Hamburg Shipbrokers Association (Vereinigung Hamburger Schiffsmakler und Schiffsagenten e.V or VHSS) in cooperation with PwC and based on the widely accepted Discounted Cash Flow analysis. The reason for the appearance of new valuation methods was the fact that ship market prices before and during the peak of the crisis had a tremendous difference, raising concerns whether market prices reflect the real values of the ships or if they were just inflated prices that created a bubble that subsequently burst.

As stated before, new valuation approaches as the LTAV are based on discounting the estimated cash flows of a vessel in a highly volatile environment. These estimations about the future time-charter or spot rates (which reflect the earnings of the vessel) while prone to errors due to the fact that are based on historical averages have a major advantage. They are based on a long-term view, thus offsetting short-term market imperfections.

2.1 Reasons for valuations

To begin with, it is important to note that the valuation of a vessel is not only important for the shipping industry participants but also for the banking industry and the accounting firms. The premier parties that need those valuations are vessel owners. The main reason is for accounting purposes (to establish the correct depreciation value) but besides accounting it is useful for planning and controlling purposes. Potential buyers and sellers of vessels use valuations to have a sound base before deciding where to invest. In this category, we can include shipbrokers who usually have large expertise on ship values, being more informed and close to the market as they are the ones that advise their respective clients on which investments are the best. Banks are also heavily affected by the changes in market values of ships. Valuations are essential for banks in order to take proper decisions on lending, determine borrower compliance with existing loan covenants, provisions in case of credit loss and to comply with capital adequacy standards.

Most of the times, valuation becomes more important when the market conditions start to become more tough and unpredictable. During the 2008 crisis, the intrinsic values of ships greatly differed from market values, which had plunged into historically low levels. This difference triggered the need of a widely accepted valuation method.
2.2 Valuation Approaches

The majority of the existing valuation techniques take into consideration the future cash flows generated by the vessel that investors expect to receive as of the valuation date. The approaches that are widely accepted by most industry participants can be summarized into three: the market approach, the income approach and the cost approach. The results from these approaches heavily depend on the market conditions during the valuation. When markets have low volatility in the short period and investors’ expectations of future events are similar, all of the above approaches reach to close results. However, when the market environment is characterized by uncertainty, with investors having different expectations concerning future events, these approaches conclude to different, broader results and are primarily used as supporting methods in order to assess the value from different points of view (e.g. from pessimistic to slightly optimistic).

- **Market approach**

  Market approach (also known as the “Last Done”, “Mark to Market” and “Comparative valuation” approach) relies on the basis that the value of a vessel is equal to the market price of comparable vessels in recently completed arm’s-length transactions among willing and knowledgeable buyers and sellers. In order to use the market approach to estimate the value of a vessel, the first thing is to search the most recent completed transactions of vessels that are approximately identical to the one examined. The factors that determine which vessels can be directly compared are generally four: size, type, age and condition. Ideally more factors can be included, although most of the times (even when the market is considered liquid) it can be hard enough to find the basic four. These secondary factors are: the type of the main engine, confirmed charter contracts with creditworthy counterparties, loading equipment (derricks and cranes), shipyard (original builder) and location (at the time of the sale). Furthermore, immediacy is also an important issue. When sellers need to sell quickly, prices usually drop significantly.

- **Income approach**

  In this approach the value of the vessel is determined by discounting all future cash flows that the vessel is expected to generate during its remaining economic useful life including residual scrap value at maturity. This method is the most theoretically rigorous approach available and is widely accepted for estimating the value of assets including vessels. In order to estimate prospective cash flows, there has to be a forecast for the future charter rates. This is where things get a bit blurry as future charter rates are usually estimated based on historical data. For example, in the LTAV method, during the first two years, charter rates are estimated as a forecast based on current charter rates. In order to estimate the long-term cash flows though, the 10-year historical average is used. This approach also known as a “mark-to-model” approach generally requires a financial model with cash flow projections.

- **Replacement Cost Approach**

  According to this approach, the vessel is valued based on how much it would cost to build the exact same vessel in the same condition. The replacement cost is adjusted for depreciation caused by physical deterioration and functional obsolescence. This
approach is mainly used in order to estimate the value of vessels with unique features that cannot be grouped in a broader list (thus excluding them from methods like the market approach). Some examples of these types of vessels are maintenance and research vessels. Critics of this measure focus on the fact that it does not account future cash generating ability of the vessel.

2.3 The LTAV Method

The Long Term Asset Value method, which was introduced by the German Shipbroker’s Association (HSES) and PwC, essentially uses a Discounted Cash Flow (DCF) formula and the concept of weighted average cost of capital (WACC) in order to determine the vessel’s ability to generate financial surpluses for the suppliers of capital (equity and debt). The reason for the appearance of this method as stated before was the major depreciation of the secondhand ship prices.

The basic principles of discounted cash flow analysis are straightforward. For each period or year in the life of the asset, the anticipated revenue and expenditure adjusted for inflation are determined. The net cash flow is then modified by means of a discount factor. This factor converts the net amount into today’s terms by reflecting what the money might otherwise have earned adjusted for risk. The formula of LTAV is the following:

\[
LTAV = \sum_{t=1}^{T} \frac{FCF_t}{(1+WACC)^t} = \sum_{t=1}^{T} \frac{(CT-OPEX_t)}{(1+WACC)^t} + \frac{RV}{(1+WACC)^T}
\]

2.3.1 Determination of Free Cash Flows

- Charter Revenues (Ct)

In order to forecast the charter revenues, we have to take make some assumptions about the future charter rates that can be earned for hiring out the vessel, the future management fees and freight commissions as well as the number of operating days. In order to estimate the prospective cash flows from a vessel a detailed plan is required. In general, there has to be a detailed forecast for the estimated charter rates of the vessel for a time horizon of 3 years when there are no charter agreements in place (if a vessel is on time charter, the DCF is much easier). The forecast about the future charter rates is based on current (time) charter rates which can be provided by various research companies (Clarkson Research Services), ship brokers etc. These data cover a wide variety of vessel types and there are also equivalents for time charter rates for different charter periods. Furthermore, during the estimation of the near future charter rates other factors should be taken into consideration as well. These factors include: the current fleet (age and volume), the expected additional capacity (ordebook), laid-up vessels, scrapping activity and other economic indicators that signal the market demand (Consumer Price Index CPI) etc. Another helpful way that can indicate future charter
rates is to analyze the difference between current charter rates and forward freight agreements (FFAs).

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>ATL</th>
<th>PAC</th>
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<th>PAC</th>
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<td>8,500</td>
<td>8,500</td>
<td>8,800</td>
<td>8,800</td>
</tr>
</tbody>
</table>

Table 1 Example of Dry Time Charter Estimates, Source: Alibra

After estimating in detail the near future cash flows for the vessel, a forecast has to be made for the long term revenues of the vessel. Given the cyclicality of the shipping market and the high volatility of charters rates, especially in the long term, it is usually appropriate to take into account the historical average charter rates of the last decade. In order to offset the extreme values, it could be necessary to widen the period or select the median instead of the mean as a measure of the average value. When forecasting the charter rates, inflation should be taken into account, as it is a reason behind a possible increase in prices. Therefore, it should be considered to assure equivalency between the cash flow and the discount rate applied. The age of the vessel also affects its charter rate. Analyses of charter agreements show that compared to younger vessels, older vessels generate lower charter rates due to disadvantages in terms of efficiency. Usually the charter rates for old bulk carriers are decreased by 30% and 15% for containerships and tankers. The Hamburg Ship Evaluation Standard proposed considering a discount when forecasting charter revenues for the periods when the vessel is over 20 years.

Freight commissions and ship management fees also occur when chartering. They are usually between 1.25% and 5% for freight commissions and 3% to 5% for management fees of the gross charter revenues.

The operating days of a vessel have to be differentiated between the years when the vessel is dry docked in order to renew its class and the regular years that the vessel is fully operative. Usually vessels are dry-docked every 5 years for the first 15 years and afterwards every 2.5 years; during that period the vessels are off-hire. Therefore, the number of operating days should be reduced in that year. LTAV proposes that during the normal years the number of operating days is 358 days and during the years that the vessels are in dry dock the days are lowered at 343. Also in periods when the vessel is off-hire, a further reduction of the utilization rate is applicable.

- Operating Expenses (OPEXt)

Operating expenses include the cost of manning the ship (crew wages), insurance, provisions, lubricants and other stores, spares, maintenance, repairs, dockings, class
renewals as well as the cost for taxes. Adding to that, costs that arise from new regulations (environmental) also have to be considered under operating expenses. Unlike charter revenues, forecasting operating expenses is not an easy task. Taking into account past operating expenses is not recommended as it appears that operating expenses have been constantly increasing throughout the years, thus not providing a solid ground for future estimations. Therefore, current condition should be taken into account as well the previous 2-3 years as the starting point for the forecast. For purposes of simplification, the costs for class renewals can be distributed on an annual basis.

- Residual Value (RV)
To determine the residual value, reference to the scrap value at the end of the expected economic useful life is appropriate (normally 20-25 years). The residual value also considers the costs of disposal, commissions and the costs of voyage to the ship breaking yard. When determining the scrap value, the light displacement weight (LT) of the vessel in tons must be multiplied with the scrap price at the end of its useful life. This scrap price is of course an expected price based on forecasts and it should reflect price increases resulting from inflation.

2.3.2 Determination of the Discount Rate (WACC)

In order to determine the value of a vessel using a method of discounted cash flows such as the LTAV, it is essential to discount the FCF using an appropriate discount rate. That discount rate is the Weighted Average Cost of Capital (WACC) and it represents the required rate of return on an alternative investment, which is equivalent to the investment of the respective vessel with regard to timing, risk, currency and taxation of cash flows. Usually the cash flows of vessels are in USD, therefore the discount rate is determined as well based on US capital market data (D Mayr 2015,). The expression of WACC is

\[ WACC = \frac{\text{E}}{V} \cdot r_E + \frac{\text{D}}{V} \cdot r_D \]

where \( V = \text{D} + \text{E} \)

- Cost of Equity
The Capital Asset Pricing Model is a widely accepted method for estimated the cost of equity (Sharpe 1964, Mossin 1966) which breaks down into the following single equation:

\[ r_E = r_f + \beta \cdot \text{ERP} \]

Where ERP = \( (r_M - r_f) \)
The cost of equity equals to the risk free rate plus the product of the expected market return minus the risk free rate and the beta of the market.

Briefly, the risk free interest rate represents the rate of return of an investment that bears none or minimum risk in the capital market. Usually, investors use government bonds as risk free rates, as they bear minimum risk compared to other alternatives. The Equity Risk Premium (ERP) is the difference between the expected market return and the risk free rate and can be determined on ex-post or ex-ante estimates. Ex post estimates use historical average excess on investment in stocks compared to government bonds while ex-post estimates are based on expected excess returns. The recent empirical studies suggest that the ERP lies between 4.0-7.0%. Finally, the beta measures the asset’s market or systematic risk, which is the sensitivity of the asset’s returns to the returns of the market portfolio. It is equal to the covariance of the asset’s returns with the returns of the market portfolio divided by the market portfolio’s variance of returns.

- Cost of Debt ($D_D$)

Ship financing is usually based in agreements of variable interest rates linked to interbank interest rates such as LIBOR plus a credit risk premium. In general, it represents the cost of financing a project (e.g. purchasing a secondhand vessel) using external finance, either from financial institutions or other resources. Specifically, cost of debt in the shipping business represents the interest rate that banks charge the prospective investors, as bank lending is the most common method shipping companies use in order to acquire external capital.

- Capital Structure (D/E)

Shipping companies usually use a blend of external and internal financing for large capital expenditures. Vessels are usually financed with debt for more than 50% of the total value, reaching to 70%. The capital structure is generally only of subordinate relevance for the amount of the weighted average cost of capital, as a higher level of debt leads on the one hand to a higher beta and to an increased rate for the cost of equity accordingly, while, on the other hand, the relative weight of equity capital in the WACC formula is lower (Modigliani et al 1958)

Example of a Capesize Vessel LTAV calculation

In the following table, we estimate the value of a 10-year old Capesize vessel using the LTAV method. Before continuing with the valuation of the sample vessel, it is important to note the assumptions in detail. First, we assume that the vessel is valued at 30/6/2016. The number of operating days is 358 for normal years (without dry-docking) and during class renewal years (every four years) the maximum operating days can be 343. We assume a 95% utilization rate, which reduces the amount of operating days to 340 and 326 days in normal years and class renewal years accordingly. The current price of charter rates is estimated using the average time-charter rate of 4 routes (Clarkson Research Services) and for the 2 year forecasts, the rates are taken from ALIBRA shipping Ltd. For years 3 and 4 after the forecasts, we use the 10 historical charter rates of the 1-year time charter rate of Capesize bulk carriers (Clarkson Shipping Intelligence Network). In order to offset the extreme values, we use the median which is 22.587 $/Day whereas the average historical rate was approximately $30.000.
Furthermore, when the ship is older than 20 years then the charter rate is discounted by 30% as it is a bulk carrier. The annual operating expenses are $3,011,000 (Moore Stephens estimates) and the inflation rate per annum which affects the charter rate from year 5 an onwards is 2%. An increase of 3% in operating expenses is calculated for the year 2017 and after. Finally, in order to estimate the residual value of the vessel at year 2031, we multiply the light displacement of the vessel with the current scrap value (according to the) and the inflation rate raised to the power 15 (years). The Weighted Average Cost of Capital for shipping finance is estimated at 7.30% according to Gurufocus.

The calculations show that the present discounted value of the 10-year old Capesize vessel is $23,849,625.46 million. Comparing the value of the vessel with the prices of 10-year-old Capesize bulkers in the following chart, we see that the sample Capesize vessel in our example is over the current prices, which average at about $18 million. Historically though, the price of a 10-year old vessel presents major fluctuations, especially during the period from August 2005 to September 2009 when prices climaxed at over $115 million in May 2008 and a few months later dropped by nearly 70% to $36 million.
LTAV calculation for Sample Capesize Bulker

Key Assumptions
Vessel Type: Bulk Carrier
Size: 75 GT
Age: 10 Years
Light Displacement: 2,000 LT
Economic Useful Life: 25 Years

Valuation Date: 30/06/2016
Operating Days: 358
Operating Days in Years with Dry Docking: 343
No Dry Docking at the end of economic useful life due to scrapping of vessel

Gross Charter Rate per day (Current Year: 7474.0 AVERAGE 4 T/C Routes for the Baltic Capesize Index)

Gross Charter Rate per day (CY1): $8,500.00
Gross Charter Rate (CY2): $16,939.63
Gross Charter Rate (CY3): $20,697.88
Gross Charter Rate (CY4): $22,597.00

Gross Charter Rate after 4 years: 22,597.00
30-Year Historical Average: (Source: Clarksons Research Services)

Inflation rate per annum (p.a.): 2%
WACC: 7.30%

Discount Price (WACC)

Scrap Value per long ton as at Valuation Date: 6,128,815.57$ 4,551,532.45$ 7,738,742.95$ 9,316,026.06$ 7.30% 0.3239 3,011,000

LTAV 23,849,625.46$

Table 2: LTAV Example for Capesize vessel (Source: Authors Estimates)
Apart from the Capesize vessels, it is important to analyze the differences between the other major size categories of dry bulk vessels as well as extend the time span of the analysis from 2002 to 2016. More specifically, we examine the Panamax 75,000 dwt and the Supramax 56,000 dwt vessels. The way the formula was used is the same for the other vessel categories, always with the appropriate alterations concerning the light displacement tonnage, scrap prices, charter rates, operation expenses etc. Adjustments to charter rates are explained in the empirical section in chapter 4.

Supramax

In the following figure, we can see the historical price movement between the new building, secondhand and estimated LTAV Values. While new building prices follow are less volatile throughout the 15-year period, secondhand prices rose substantially between January 2004 and September 2008. More specifically during July 2007 and September 2008 the price of a 56k Supramax exceeded the price of a new vessel of the same size. The LTAV values although they follow the same price movement and level as the market prices until 2004, afterwards they constantly below the market prices indicating that the prices in the second hand market are overvalued. However, it is important to note at this point that this specific category of vessels is characterized by constant additions and replacements as well as a longer life span; overage Supramax vessels still compete even when they pass the 15-year threshold. Therefore, secondhand prices tend to remain at relatively close levels to new building ones.

Figure 1 Source: Clarkson SIN

2.4 Comparison between the LTAV and Market Values
Panamax

Following the Supramax, the Panamax category represents a different market. Panamax vessels are primarily used for iron ore, grain and coal trade competing in both long-haul and short-haul routes. What is clear from the following chart is that while secondhand prices for 10-year-old Panamax ships surpassed by more than 20 million USD the prices of newbuilding and by more than 30 million USD the LTAV values during the July 2007 – September 2008 period, afterwards there seems to be mispricing, as LTAV values are above the market values which constantly drop. A major factor behind this price drop and misevaluation is due to declining hire rates and the large inflow of deliveries that affected the overall trade.
Capesize

The Capesize presents nearly identical movement as the Panamax size. The prices though in this second hand market are substantially higher due to the bigger size. The Capesize market is even more restricted in terms of trade, as those vessels are primarily used for ore and coal trade. The pattern is consistent with the previous figures. The LTAV values indicate that from May 2004 until September 2008 the vessels were overvalued, while since then the opposite happens (with a minor exception in late 2010-beginning 2011) where market prices are well below the estimated LTAV values.

![Capesize 170k 10 Year-old Prices](image)

Figure 4 Source: Clarkson SIN, Authors’ Estimations

2.5 Reactions to the LTAV progress and alternative use

2.5.1 Industry Reactions

As we mentioned earlier the LTAV method was primary introduced to provide an alternative approach to the traditional method of valuation using the market approach. After the initial announcement of the proposal by HSES in September 2009 regarding the LTAV method, little progress has been made in its adoption by the industry participants. The critics focused in the basic premise underlying the proposal, the implementation and the barriers to adoption. Considering the basic premise (the idea that value and price could diverge), S&P brokers stated that “Assets have a value. The value is what people will pay for them.” Furthermore, Karsten Wettwitschka of Deutsche Shipping mentioned that although the method would relieve the balance sheets of banks (in 2009 many ship loan covenants were violated due to the sharp decline of vessels’ market prices) as it would increase asset values thereby reducing the Basel II equity requirements, it would be difficult to implement it. The reasoning was the same, market values just reflect the markets and it would be wrong to counter a problem that was
triggered by the banks inadequate risk-bearing strength with a solution that is against the markets logic.

Adding to that, critics also argued that there would be problems with the implementation. While the DCF analysis is widely accepted as a method, the problem lies in the details. The assumptions that are used in the analysis are subjective and may be wrong. For example, the inputs for future charter rates or the utilization rate of the vessel could be different between different brokers that use different data sources for the same vessel. But even if there was agreement on the value, in periods of distress it would be highly unlikely that the market values would match the estimated values. Another obvious problem is the that the model might provide poor basis for valuations due to the fact that, with the exception of the first year, it assumes that the future is going to be exactly like the past. Although it is fair to say that most forecasts about future values are based in some level on historical data, applying it to a model could provide misleading valuations.

Finally, critics shortly after the proposal were questioning the feasibility of a widespread adoption. Since it would be frowned upon if not forbidden by banking regulators to change valuation procedures during the financial crisis in 2009, the method did not receive a widespread adoption although it can be used as an investment tool for industry participants.

2.5.2 Alternative Uses of LTAV

The LTAV can be used to determine attractive investment opportunities by identifying the actual value of a vessel and observing the market prices. Vessel prices that are lower than the values determined by the LTAV method represent attractive buying opportunities for a potential investor (NPV>0) while vessel prices above the LTAV indicate attractive selling prices. The investor decisions (Buying or selling a vessel from owners or potential buyers) are summarized in the following table:

<table>
<thead>
<tr>
<th>Actual market price&gt;LTAV:</th>
<th>market price&lt;LTAV:</th>
<th>Implication for potential buyer</th>
<th>Implication for potential buyer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Implication for vessel owner</td>
<td>Implication for vessel owner</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sell</td>
<td>Don’t sell</td>
</tr>
<tr>
<td>Actual market price&lt;LTAV:</td>
<td></td>
<td>Implication for vessel owner</td>
<td>Implication for vessel owner</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Buy</td>
<td>Don’t sell</td>
</tr>
</tbody>
</table>

Table 3 LTAV as an Investment Tool
Mispriced vessels can also be identified by comparing the internal rate of return (IRR) to the required rate of return (WACC). IRR works out the discount rate which gives a NPV of zero. From the investors point of view, the IRR can be determined by solving the following formula:

\[
NPV = -\text{Actual market price} + \sum_{t=1}^{T} \left( \frac{C_t - OPEX_t}{(1 + IRR)^t} \right) + \frac{RV_T}{(1 + IRR)^T} = 0
\]

\[
\leftrightarrow \sum_{t=1}^{T} \left( \frac{C_t - OPEX_t}{(1 + IRR)^t} \right) + \frac{RV_T}{(1 + IRR)^T} = \text{Actual market price}
\]

If the expected IRR is higher than the equivalent WACC, this means that the assets (vessels) in the market are cheap and that the investor should proceed with the investment. Counter to that, if the IRR of the investment is below the estimated WACC, the investment should not be made.

<table>
<thead>
<tr>
<th>IRR&lt; WACC</th>
<th>Implication for potential buyer</th>
<th>Don’t buy</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Implication for vessel owner</td>
<td>Sell</td>
</tr>
<tr>
<td>IRR&gt;WACC</td>
<td>Implication for potential buyer</td>
<td>Buy</td>
</tr>
<tr>
<td></td>
<td>Implication for vessel owner</td>
<td>Don’t sell</td>
</tr>
</tbody>
</table>

Table 4 Conditions for Investment

2.5.3 LTAV used for Accounting Purposes of Vessel Owners & Banks

Despite the negative sentiment from the accounting firms, the LTAV method is suitable for accounting purposes, especially for impairment testing. The corresponding accounting standards of the company (US GAAP, IFRS etc) must comply with the LTAV method. Special attention should be given on a central assumption of the LTAV formula that is that the focus on the long term earnings potential of the vessel which assumes a going concern scenario until the end of its useful life. In the case of a gone concern scenario, as a rule, valuation methods based on the current market prices are used. The widely accepted International Financial Reporting Standards, use Discount Cash flow (DCF) models in their formulas especially for impairment testing of assets. Impairment of assets (IAS 36) seeks to ensure at each balance sheet that the vessel’s fair amount is not higher than its recoverable amount, which is defined as the higher of the vessel’s fair value less costs to sell and its value in use. Furthermore, the DCF model is used in other accounting standards such as the US GAAP for impairment testing.
Ship-financing banks can also use the LTAV method in order to determine an expected value of the vessels and make provisions for credit losses when the loan covenants are breached due to fluctuations in market prices. The method could be used with some adjustments, particularly in the discount rate, which is defined by accounting standards (IFRS according to IAS 39). The amount of provision for credit losses can be estimated by discounting the remaining loan balance at the end of the vessel’s economic useful life with the respective interest rate. Another way is by comparing the present value of the expected loan payments with the book value of the loan. In general, banks need to know whether the expected earnings of the vessel (the free cash flows) are sufficient to cover interest and principal payment obligations including any additional obligations that may occur.

3. Asset Bubbles

Introduction

The term asset bubble is frequently used to describe a situation in which the price of an asset has increased significantly in such a short period to suggest that the price is susceptible to an equally sudden collapse. Many economists have invoked that particular definition of bubbles, such as Kindleberger (1996) who describes bubbles as an “upward price movement over an extended range that then implodes”. Recent examples of such bubbles are the housing bubble that occurred in the past decade as well as the rise and fall of the NASDAQ-100 (Dot-com bubble) index in 2000-2001. Another example is the U.S. stock market in the 1920s. The Dow Jones Industrial Average had increased by more than 500% in a timespan of eight years from 63.9 in 1921 to 381.2 in September 1929. Shortly after, in just two days it lost 24.5 percent of its value and in the next three years reached its nadir of 41.2. Other commonly cited examples include the “Tulipmania” in Netherlands in the 17th century, where the prices of tulip bulbs have risen to extreme values and then fallen dramatically as well as the quick rise and fall in the price of shares in the South Sea Company and the Mississippi Company in the 18th century. In that context we are going to analyze if the upswing of vessel prices before the 2008 crisis and the sudden fall were in fact bubbles or simply a natural cause of supply and demand forces. But first we need to define more precisely what a bubble is.
While the definition of the bubble in the introduction seems straightforward, many economists would find it problematic. The main complication is that the definition is imprecise. It does not define how much the price of an asset must rise or how quickly it must rise in order to qualify as a bubble. Many large fluctuations in prices are caused by shifts in supply and demand. In that case, while someone could describe that upswing in price as a bubble, it is just the force of raising demand for the product or the lack of supply that pushes the price upwards. When demand falls or the supply is sufficient, the price returns to equilibrium that supposedly reflects the fundamental value of a product. Examples of products with major price swings are the new fashion apparel. When they are introduced, their prices are constantly raising or are even launched at high prices. Shortly after however their prices fall mainly due to the appearance of new apparel and the increase of supply. The increased price of clothing is a strategy that fashion companies implement in order to cope with unknown demand. Not knowing if the product will become a “trend”, they limit their supply. When prices begin to rise they respond by increasing the supply, causing the prices to drop. Such price swings are desirable by economists and would not be considered as bubbles. On the other hand, economists do view dramatic increases in the price of assets as a potential cause for concern. The reason is that such sudden increases do not usually reflect real changes in the value of the underlying asset. Instead of signaling a true need of more such assets raising the demand, a bubble imputes the false impression that an asset is especially valuable when in fact it is not.

In particular, most economists would define a bubble as a situation where the market price of an asset exceeds the fundamental value of the asset. The fundamental value is the value of all the expected cash flows or dividends the asset yields over its life time, discounted to reflect the present-day value plus the value of the asset during the end of its useful life. In vessels valuation, a way to measure the fundamental value is the LTAV method or other relevant methods. If the price of the asset exceeds the fundamental value it can be viewed as overvalued since it would not be worth it for
someone to pay such a price to create an asset on the collective behalf of all future owners of the asset. While in many cases, the fundamental value can be estimated rather easily, there are cases where it is not possible to properly assign a fundamental value. It is important to note that this definition does not presuppose that the price of the asset is rising. It only mentions the difference between market price and fundamental value. However, a rapid increase in the price may be an indicator that the asset is overvalued especially if there is no reason to suppose that the fundamental value of the asset has changed. For example, an upward flick in the prices of second hand vessels would be considered normal if a raise in the charter rates is expected in the future. Higher charter rates would mean higher gains for the vessel, which subsequently would raise the market value of the vessel. This definition also does not take into account that the price of the asset will eventually “crash”. On the other hand, the fact that the price of an asset exceeds its true worth suggests that there is nothing to justify its high price, and so it is always liable to collapse. In other words, there will always be equilibrium, at which the price of the asset falls to its fundamental value. Thus, economists distinguish an asset bubble not by what happens to the asset’s price but what could happen to it.

This difference between fundamental value and market price is what drives astute investors to buy assets, whose market price is above their fundamental value, believing that they might be able to sell it at some point in the future. Otherwise purchasing and keeping an overvalued asset till the end of its useful life without reselling it would mean that he would be paying more for the asset than it would earn him in dividends. This concept is important to understand why bubbles can be ruled out in many occasions. The fundamental value, as we said earlier is many times subjective. While many methods that are used to estimate the current value of an asset have solid basis, the expectations of investors concerning the future price of it are partially based on the information they have and their own instinct and view. If many investors share the same outlook about the future, it is likely that they will proceed on doing the same actions. For example, if everyone expects that in the next few months, charter rates will substantially raise and hold for a certain period (1-2 years) it is sensible that many will turn to the second hand market to acquire vessels to benefit from the future prospective earnings. This will lead to a price increase up to a level that, no matter how good the expectations about the future are, the market price exceeds by far the intrinsic value. But apart from those who acquire vessels to benefit from the chartering of vessels at higher future charter rates, there are some speculative investors that purchase vessels with the expectation that in the future their price will raise even more so they can benefit by selling them in the future at a higher price. This practice is called asset play and it has played a major role in the shipping industry, as nations like Greece and Norway have used extensively this strategy of buying ships at low prices and selling them at high prices when the market was booming. Therefore, as we see from the former example there are different reasons that are behind the creation of bubbles (speculation, expectations about the future) and it is important to determine when do they arise and the overall environment that helps their creation.
3.2 Conditions for bubbles to emerge

3.2.1 General conditions

The idea that asset prices can assume arbitrary values rather than reflect their underlying worth is rather disturbing. To determine if this possibility can be ruled out, a number of conditions have been set that can rule out the existence of bubbles on theoretical grounds. Milgrom and Stokey (1982) in their paper analyze whether it is possible for agents to engage in “speculative trading” in one-shot markets. While in their analysis they use stocks, the overall idea can help to understand the concept of asset value. The main hypothesis is that there are two investors; one that initially owns all the stock -Mark and another one that currently does not have any stock -Jenny. After Jenny does her research on Mark’s company she decides to purchase stock of Mark’s company as she believes that it will be profitable and pay out high dividends. Mark on the other hand believes that it is unlikely for his company to be profitable, so he decides to sell stock to Jenny. It is important that after the sale takes place, Jenny cannot resell the stock therefore it is a one-time offer. The difference in expectations between the two investors means that one will be benefiting at the other’s expense, as there is no possibility of resale. In this example, the sale was carried out because one party failed to consider some information about the asset that the other side has access to. Under certain circumstances the sale would not be possible. These circumstances are:

First, all the traders must share the same initial beliefs about the company before engaging in research. Second, before the trade occurs, the stock is assumed to have been allocated efficiently. Finally, all traders are assumed to be rational and profit maximizing. This means that both parties behave rationally and know that the other one engaging in trade is rational. If these conditions are met, the sale will not occur. Under this set of conditions, Tirole (1982) ruled out the possibility of asset bubbles. The assumption that the initial allocation of resources is efficient implies that there is no mutually advantageous trade between the agents. This means that the investor that agrees to buy an overvalued asset must believe that doing so benefits him at the expense of remaining traders taken as a whole. He expects to benefit at their expense by selling them a stream of dividends for more than it is worth. However, when there are only finitely many traders this is not possible. The reason is that in the end, after many resales of the overvalued asset there will not be anyone to benefit at the expense of others. For an asset bubble to occur, at least one of the primary assumptions has to be violated.

Infinite traders

Assuming the possibility of infinitely many traders, the formation of a bubble is possible. Each investor that buys the overvalued asset believes that can benefit at the expense of all the others by selling it to another investor and exiting the market. This process will continue to happen as long as the participants hold the same expectations about the future. An analogy from Tirole for this concept of investing in a bubble is the
game of “hot potato” as investors try to pass an overvalued asset with a stream of dividends less than they paid to the next one. Samuelson (Samuelson, 1958) also demonstrates the formation of a bubble under this hypothesis in early work on monetary economics.

Differences in initial beliefs and the possibility of irrational traders

When the first hypothesis of rational traders and same initial beliefs is contradicted, bubbles are easier to occur. Harrison and Kreps (Harrison and Kreps, 1978) on their paper on “Speculative investor behavior in a stock market with heterogeneous expectations”, assume that traders begin with different initial beliefs regardless of what others believe and regardless of what they observe about dividends. Their result shows that an asset can be traded for more than any one trader in the economy believes the fundamental value should be, even the most optimistic ones. Many empirical findings support the notion that bubbles are related with the possibility that of systematic mistakes by some traders. The previously mentioned historical episodes of bubbles also coincide with the entry of traders that were not sophisticated. An experiment by Smith et al (Smith et al, 1988) showed while in the former stages when traders were inexperienced there were creating bubbles, after a certain period during which participants gained experience in trading, bubbles did no longer emerge.

Inefficiency

Finally, bubbles can occur if resources are allocated inefficiently in the absence of a bubble. If all the other conditions mentioned in Tirole’s model hold true except the initial efficient allocation between the two investors, with one investor being richer than the other one in the first year, the price of the asset is found to rise year after year. The reason is that the investor who considers buying an overvalued asset no longer has to believe that to gain benefit from trade he must benefit at the expense of another trader. In Tirole’s initial assumptions, bubbles did not occur because all traders simultaneously believed that they were taking advantage of other traders.

3.2.2 Conditions in the Shipping Industry

The shipping industry is an exceptional and rather complex industry, hard to predict and driven by many factors. The four interrelated markets, newbuilding, sale and purchase, freight and demolition do not connect in a harmonious way but rather affect one another in many ways. Supply and demand forces affect in their own way every one of the aforementioned markets with supply of vessels struggling to follow demand of goods around the globe. Balance is strange words in the shipping world as cycles, long or short, govern the industry affecting prices of goods, vessels, charter rates and demolition prices.

Economic Development in the Dry Bulk market

Before we proceed with the analysis of the latest market boom and recession in 2008, we are going to do a quick review of the developments since 2000 from the perspective of shipping economics.

The year 2000 could be characterized as the year of recovery for bulk shipping as well as for the world economy. After 3 years of struggle due to the Asian economic crisis the bulk shipping sector returned and surpassed previous freight rates due to a low order book and an increase in trading which tightened the supply demand balance. However, this upswing in the market did not hold long, as the worldwide economic recession came in 2001 when GDP growth declined in many economic communities, the bubble in the IT industry burst and the World Trade Center was attacked on September 11 2001. The aftermath was a plunge in the dry bulk market which lasted until the end of 2002. In 2001 the growth of the world output fell to 1.3% from 3.8% in 2000. It was the first time since the oil price growth of the late 1970s, that almost all regions in the world experienced an economic slowdown simultaneously. The dry bulk shipping market was also confounded by the recession, suffering from huge deliveries, with time charter rates for all dry bulk vessels dropping and remaining at low levels till the end of 2002. Prices for new building and second hand ships also fell in 2001.

• Period of 2003-2008

Following the slump of 2001, the world economy recovered quickly and begun growing rapidly until 2007. The driver behind the overall boom in seaborne trade was the sound growth of the world economy which gave an annual increase especially in main bulk commodity shipments of more than 7% on average from 2003 to 2006. The freight rates of the dry bulk market were pushed up by the firm demand. More specifically, the largest year to year change on the hire rates was apparent in the Capesize sector where freight rate kept climbing especially after October 2005. The freight rates for the smaller Panamax and Supramax categories followed the same pattern at a smaller scale. This large upswing contradicted the large influx of ships which raised the overall deadweight tonnage.

Figure 6 Source: Clarkson SIN
By examining the second hand prices for Capesize ships as presented in figure 4 we can see that at average a ten-year old Capesize vessel in 2000 was sold for $18,250,000 while in 2007 the price would skyrocket at an average of $83,000,000. The price for a new Capesize vessel in 2001 was at average $38,541,666 and in 2007 its price would rise more than double, to $86,875,000. The freight market also rallied from June 2006 until the end of 2007 from $34,700/day for Capesize 1-year timecharters to a staggering $161,600/day. Laid-up tonnage was also kept at low levels of approximately 0.35 million dwt per year as was demolition which marked a low of 0.41 million dwt in 2007.

While there are many reasons behind this tremendous growth since 2002, the major driver behind this boom was the robust demand. Developing countries such as China, India and other ones were pushing forward the world economy being the main importers of bulk shipping commodities. China’s GDP growth increased from 8.42% in 2000 to 14.2% in 2007 according to WorldBank statistics. The average world GDP growth for the years 2003 to 2007 was approximately 5%. India also showed a substantial increase in the same period while the Euro area and the United States remained below 3%.

The impact of the growth of these developing countries was evident in the increasing demand for steel and other bulk products. The world seaborne iron ore trade nearly doubled from 2000 to 2008 reaching almost 840 million tons. China’s increasing demand for raw materials being the fastest growing economy and the biggest consumer of iron ore and coal can be realized by the amount of seaborne iron ore that the country imported which was 444 million tons, half of the world total in year 2008. Minor bulk trade also presented a raise in this 8-year period.

The booming freight rates were partially caused by port congestion in major bulk terminals. Port congestions affect supply and demand as they create an imbalance between them. Ships could wait for more than 20 days to load, creating a temporary
lack of supply in the market. An example of port congestion is at the Newcastle port of Australia, which is one of the largest coal export terminals. There, the number of ships waiting to load rose from an average of 4 to 73 in 2007. On the other side, importing terminals in China such as Qingdao Port, which was the largest iron ore terminal of the country, Shenzhen and other, also presented delays during that period. The heavy congestion at major terminals though was mediated by a drop in the cost of shipping of the dry bulk products.

![Dry Bulk World Trade](image.png)

Figure 8 Source: Clarksons SIN

- **Period of 2009-2016**

The global financial crisis of 2008-2009 could not leave intact the dry bulk shipping market. As the whole economy followed a downward spiral due to the credit crisis which started in late 2007, the dry bulk shipping demand followed the same pattern. The recession quickly spread from US to Europe and Asia dragging down the economies. The demand of dry bulk cargo as well as for other products plummeted, as there was lack of credit in the markets with China slowing down its steel production.

As demand for dry bulk cargo was constantly reaching lower levels, the supply of ships followed the exact opposite course. With massive orders since 2004, the overall dwt of the bulk carrier fleet had substantially raised and new deliveries were on the way. This massive fleet capacity growth worsened the already devastated charter rates.
The result from the sluggish demand the overcapacity was a sharp decrease on charter rates for dry bulk vessels as well as for second hand and newbuilding vessels after the financial crisis. Time charter rates for Capesize ships dropped in only a few months from $161,000/day in May 2008 to $16,625 in October 2008. A ten-year old secondhand Capesize vessel would cost in May 2008 more than $100 million, would be sold in January below $30 million. Similarly, newbuilding prices followed the same course with a relatively smoother decline.
In the following years after, the demand for dry bulk cargo bounced back, with total seaborne trade of the major 5 dry products (iron ore, coking coal, steam coal, bauxite/alumina and phosphate) and minor summing up to 4544.41 million tons, presenting an overall increase of 42% which can be attributed to the surge in demand for minor bulk, iron ore and steam coal trade.

![Dry Bulk World Trade (2)](image)

Figure 11 Source: Clarkson SIN

However, the overall fleet capacity kept increasing, thus substantially raising the supply of the dry bulk fleet. This overflow was created due to increased newbuilding contracts over the years 2010 and 2014, which accounted for more than 50 million deadweight tons over that period. The sudden drop on Year-to-Year change for the overall bulk carrier fleet is caused by a major increase in demolitions since 2010. While the overall annual capacity driven to demolition was below 1 million deadweight tons before 2010, that number substantially raised above 7 million reaching to a maximum of 35 million deadweight tons in 2012.
This increase in the volume of demolitions has proved not to be sufficient to halt the soaring increase in the total fleet volume thus the total supply has dramatically surpassed the total demand stressing more the overall overcapacity problem. The overcapacity presses the charter rates constantly to lower levels, especially in larger ship categories such as Capsizes and Panamaxes who see their freights plunge to all time low figures in 2016.
3.3 Conditions for Value= Price

Being more specific, and closer to our theme, which is the existence of asset bubbles in shipping, we will take a closer look at the sale and purchase market at 2008-2009, a period during which the prices of secondhand vessel dropped significantly, signaling for many analysts the burst of a long inflated bubble. Before we begin we need to note the basic assumption behind the formation of an asset bubble, which is the difference between the market price and the fundamental price of the asset. With that in mind, we delve into the analysis of the conditions that need to hold true for value to equal price.

a) Willing buyers and sellers

There should be many buyers and sellers in the market who are willing to purchase and sell asset with the purpose of maximizing their profits, ensuring that the assets get put into “best use”. The participants should analyze and value the assets in the market and behave rationally and independently. They should also transact voluntarily without external pressure.

b) Knowledgeable buyers and sellers

There should be accurate and relatively inexpensive or free information about the quality of the asset, the counterparty, future deal flow and future expected cash flows. This means that participants have to be industry insiders with experience and knowledge about the industry. Information also has to be accessible to all participants at the same time at a random manner.

c) “Arm’s length transaction

The buyers and sellers should act independently and have no relationship to each other, acting in good faith.

d) Readily available credit

Figure 14 Source: Clarkson SIN
Credit should be easily accessible to buyers in order to finance their purchases. This criterion is very important since external financing accounts for more than 50% of the investment in the shipping industry.

Apart from these main conditions there are some secondary ones that can be included such as:

- **Homogeneous assets**

Assets should be relatively similar rather than unique or customized and there should be many of each type.

- **Investor sentiment**

Investors should not be characterized by excessive optimism or pessimism, thereby giving them the potential to over- or under-invest.

- **Low search and transaction costs**

As information is easily available and accessible from everyone, the cost of information should be low or free as large fixed costs can prevent parties from being informed, which in turn can prevent arbitrage. Purchase costs should also have low transaction costs. In shipping these costs are usually 3-4% of the vessel value.

This list of conditions is rather indicative and not exhaustive. Basically, these criteria describe a competitive market with good information and functioning credit markets. Under these conditions, competitive pressure in a market comprised of informed, rational and financially robust investors should result in equality between the prices of assets and their fundamental values.

### 3.3.1 Conditions in distressed markets. The example of 2008-2009 sale and purchase market

The most recent example of distressed markets happened during the global financial crisis of 2008. As we saw earlier, vessel prices dropped dramatically in only a few months, signaling the end of a long rally that lasted 7 years. The conditions in that distressed market can be summarized below.

- **a) Distressed Sellers**

While in a healthy market, sellers should not be forced to proceed with sales of their vessels, what happened in late 2008 was the exact opposite. With shipyards and shipowners facing cash flow shortages and potential default, many were compelled to sell. While it cannot be determined if all sales were “fire sales”, it seems that most of them probably were.

- **b) Investor Sentiment**

With charter rates significantly dropping, industry participants were shocked. After the long run of optimism during the last years, they were facing one of the sharpest drops in history, thus they suddenly became excessively pessimistic. This over reaction to bad
news and the lack of rationality violated the hypothesis of investors taking sound
decisions.

c) Lack of credit
With the whole market derailing, credit was not an option. The world’s leading shipping banks were in financial trouble. HSH Nordbank, the world’s largest shipping bank was one of the first banks that requested assistance from the German government. Banks refused to issue letters of credit which are payment guarantees issued to exporters for cargoes that are very critical to foreign trade.

d) Few transactions
At the end of 2008, there were very few transactions resulting in problems finding comparable transactions in order to estimate a market value for a vessel. Clarksons, one of the most important S&P brokers, even stopped to publish price indices for used ships.

e) Industry downturn
Most knowledgeable parties were in financial distress, industry insiders were reluctant to purchase ships and less likely to use those vessels in the best way possible.

While the above conditions would justify the sharp drop of market prices below the fundamental ones, the question is why arbitrage did not push them back to balance. An obvious answer would be that, in the short-term, arbitrage might not work as properly as in the long-term. The reasons why the impact of arbitrage was limited were several. First of all, the shipping industry requires specialized and detailed knowledge of ships and freight markets as well as connections to and relationships with customers, brokers and bankers. Few people have the specialized knowledge to identify mis-valuations. Secondly, the financial constraint was probably the primary reason that arbitrage did not work. Even if investors have identified sound investments, the lack of bank lending constrained willing investors to proceed with buying ships at low prices. Transaction costs worked also as a barrier to small mis-pricings that could be arbitraged away. Finally, the fundamental risk of the crisis getting worse before it gets better as well as risk aversion of the arbitragers to make relatively large undiversified bets on ships in a volatile and unstable period resulted in this gap between fundamental and market prices.
<table>
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<tr>
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Table 5 Comparison of different market conditions
4 Testing the Efficient Pricing of Ships in the Dry Bulk Sector

Introduction

As analyzed in chapter 3, an appropriate way to determine the formation of bubbles in the second hand market of dry bulk ships is by investigating whether the market is efficient and prices equal fundamental values. It is important to investigate the efficiency of a market, especially in the second hand shipping markets since a failure of the Efficient Market Hypothesis (EMH) if not caused by time-varying risk premia, may signal arbitrage opportunities. For example, in an inefficient market for second hand vessels, where prices present high volatility and deviate from their fundamental values, investors may adapt trading strategies to exploit profit-making opportunities. Therefore, if prices are below the fundamental value, they will purchase the vessels and either sell them when the price rises above the fundamental price or keep them and operate them if the freight market is high. The exact opposite would happen when the prices were above the fundamental values. Investors would likely charter the vessels or even sell them if their price is well above their value since they are overpriced in comparison to their expected future probability. Therefore, it is important to understand the pricing mechanism as well as the efficiency of the market for ships.

The scope of this chapter is to describe the research approach that is used in order to test the efficiency of the second hand dry bulk vessel market from two different angles. The first one is based on previous studies by Glen using Johansen’s cointegration test for three different vessel sizes and the other one is based on Hale and Vanags approach using the Engle-Granger cointegration test. Before proceeding with the empirical analysis, the theoretical background of the Efficient Market Hypothesis and previous studies on the subject will be presented in the second section of this chapter. In the subsequent section, the data and the research methodology will be explained. In the final paragraph, the results will be presented along with the conclusions.

4.1 Theoretical Background and Empirical Studies

The efficient market hypothesis was first developed by Eugene Fama in 1965 and concerns the stock market. Since then, numerous studies in the literature on testing the EMH were conducted but mainly in capital and financial markets leaving on the side only a few on real (physical) assets such as the estate market or the market for ships. The EMH can be summarized by a phrase in Fama’s first paper where he states that a market is efficient if “…, given the available information, actual prices at every point in time represent very good estimates of intrinsic values”. Therefore, it should be impossible for investors to outperform the overall market through market timing or other techniques. The hypothesis is broken down to three variants: the weak-form efficiency, the semi-strong form efficiency and the strong-form efficiency, each of which has different implications about how markets work.
• Weak-form Efficiency

In weak form, future prices cannot be predicted by analyzing prices from the past, therefore investors cannot earn excess returns in the long run by implementing strategies that are based in historical prices or other historical data. Prices are serially independent which means that there are no “patterns” to asset prices. Future price movements are determined by information that has not been included in the price series. Therefore, prices follow a random walk. This form does not require that prices should remain near or at equilibrium but rather requires that market participants, who behave rationally, should not be able to systematically profit from market inefficiencies. According to this form, actual prices in an efficient market should reflect the rational value of the underlying asset.

• Semi-Strong-form Efficiency

In semi-strong-form efficiency market prices adjust to publicly available information quickly and in unbiased fashion therefore excluding the possibility of excess return on that information. This approach is related to the concept of rational valuation of assets that was mentioned in the weak form.

• Strong form Efficiency

In strong-form efficiency prices reflect all information (public and private) and excess returns cannot be made. If there are legal barriers to insider private information becoming public, this form is impossible except when these laws are ignored by everyone.

In the last 25 years, the efficiency in the markets of second hand vessels has been a subject rather neglected. Only during first 10 years the test of the validity of the Efficient Market Hypothesis was examined, while in the remaining period until today the focus has shifted on micro-economic valuation of the vessel including specifics such as deadweight tonnage, age, speed, horsepower and others. While all implications of the EMH have been thoroughly researched, it is a hypothesis that is difficult to test using traditional statistical interference. The reason is that it is a combined test of the existence of time varying risk premium with the applicability of the rational expectations and a particular asset pricing model.

The starting point in the analysis about efficient pricing of second hand vessels dates back to 1993. Beenstock and Vergottis (Beenstock and Vergottis, 1993), published a book on maritime economics presenting complete structural models which overviewed modelling efforts from approximately 60 years before the publication of their book. In their analysis, they used asset value models to estimate ship values although they treated new build prices the same as second hand prices, something that was largely debated afterwards. The same period that Beenstock and Vergottis published their book, the focus was shifting from determining second hand prices to whether the market for second hand vessels was efficient. This is where Fama’s EMH theory was first applied by Hale and Vanags (Hale and Vanags, 1992) who criticized Beenstock and Vergottis for assuming that markets were efficient in their book. They investigated the EMH on second hand bulkers of three different sizes (30.000 DWT, 70.000 DWT and 120.000 DWT) testing for co-integration. The main argument in their paper was that if co-
integration exists then according to Granger causality one price causes the other therefore it can be expressed as a function of the other with an error correction. Using data from Lloyd’s Shipping Economists from 1979 until 1988, they find that the time series are stationary at first differences, pair-wise co-integration presented negative results, while Granger causality tests could not be rejected (at 5 per cent) for the smaller two ships. A co-integration test for a three-variable regression was also conducted where the results were positive. Hale and Vanags concluded that there are two outside forces that affect the vessel prices although there is no proof that they cause the movements in prices. This was considered a proof that the second-hand market is not efficient.

Another study took place in 1997 by Glen, which was based on the Johansen cointegration test. The series were also stationary at first differences, an essential condition for the former analysis. The data were also derived from Lloyd’s Shipping Economist for 2 different types of ships (tanker and bulker) as well as for 3 different sizes (30.000 DWT, 70.000 DWT, 120.000 DWT for bulkers for the period 1979-1995 and 32.000 DWT, 80.000 DWT, 250.000 DWT for tankers for the period 1979-1988). Glen investigates the EMH using the Johansen’s maximum likelihood (Johansen, 1988) as it was formulated by Fama which states that a market is efficient if prices fully and instantly reflect all available information. The autoregressive models of the bulk vessel prices present acceptable results whereas the results for tankers are not satisfying. Using the Johansen theory, the results from testing the co-integration present a strong pair-wise co-integration for all pairs, rejecting the existence of co-integrating vectors which were proposed by Hale and Vanags. In summary, Glen’s results were inconclusive; EMH was rejected, strong co-integration exists probably due to an external stochastic form rather than an integration of prices. The theory of an external form driving the maritime industry was presented by Veenstra and Franses (Veenstra and Franses, 1995) in their research on freight rates in bulker and tanker markets, where they conclude that there is an unpredictable stochastic factor that drives freight rates.

The succeeding work on the EMH in second hand prices was from Kavussanos and Alizadeh (Kavussanos and Alizadeh, 2002). However, there was a shift in the way EMH was described, focusing on latter papers of Fama in which EMH assumes rational behavior, meaning that the price of an asset should reflect the discounted future earnings. Therefore, when EMH holds, arbitrage profit is not possible by buying below rational value and selling above it. Another difference between Kavussanos and Alizadeh’s paper and the previous ones, is that they focus on four methods in order to test the hypothesis, by extending the methodology of Cambell and Shiller (Cambell and Shiller, 1988) of using excess profits, to make it applicable for assets with finite economic life as well as extending the data series from 1976 to 1997. The first method that they use is to test the restrictions on the VAR model as it would be imposed by the EMH. Then a variance ratio test would check if the predicted and real price variances are similar. Finally, the last two tests would check whether the excess holding periods returns are unpredictable and if a time varying risk premium is present. In order to estimate the excess return they also included newbuilding and scrapping prices. The source of the data was also Lloyd’s Shipping Economist and the size of the vessels, although not determined in detail, were Handysize, Panamax and Capesize. In order to estimate the profit, they used time charter rates from Clarkson and operating costs were assumed to grow at an inflationary rate with little short-term variance. All series were
stationary at first differences. The three scenarios that were used to perform the first two
tests were a) buying a newbuilding and selling a 5-year second hand vessel, b) buying a
newbuilding and selling a 20-year scrap and c) buying a 5-year second hand and selling
a 20-year scrap. The EMH is rejected at 5% confidence for all vessels in the third case
while it holds in the second case at 5% confidence level. The variance tests rejected the
EMH hypothesis in all cases except from the 5-year Panamax sold and scraped when it
reaches 20 years. The next test for one and three-month excess holding, lead to a
rejection of the EMH which is explained by the time-varying risk perception of the
investors. This is proved by using GARCH-M models and specifically GARCH-M (1,1)
in all cases. The risk premium is increasing with size and holding period in all cases
except for Capesize ships. Finally, the autocorrelation that is present in the excess
returns is explained by the possible aggregation of stochastic data as well as from thin
trading, meaning that the sale of one vessel affects the sale price of the next.

The idea of no excess profit as proof of the EMH is also tested by Adland and
Koekebakker (Adland and Koekebakker, 2004), though it is investigated through 693
technical trading rules based on resistance levels, moving averages and filter rules in
order to predict the future. In this approach, the EMH would essentially mean that
predictions for the future, based on all available information from the past, cannot be
made. If any trading rule is able to predict the future, then the EMH cannot hold.
Adland and Koekebakker introduced also the transaction costs and market illiquidity.
They focus on the larger bulk carriers, VLCC, Aframax, Capesize and Panamax with
observations from 1976 until 2003 for average spot earnings, operating costs, scrap
prices and 5-year old secondhand prices. Their model is based on four assumptions:
1) Investors have cash equal to the vessel value at start time, which is set to be the 18th
month. 2) Short sales are not possible. 3) Brokers’ commission is 1 per cent upon
selling. 4) If there is surplus of cash it is invested at 1-month LIBOR in the money
market. It is worth mentioning that in their treatment of profits, the waiting time and
off-hire time is purposively ignored, therefore biased towards the buy and hold (B&H)
strategy. Their results present that the trading rules outperform the market in the
selection period. Due to the fact that the second hand market, while it is active, it has
limited transactions every month, they conduct a second test to correct this illiquidity.
They also argue that there is a lag in transactions as buyers might face difficulties in
purchasing the vessel immediately and sellers from their side cannot get rid of their
vessel right away; the whole transaction could delay for a month. The best trading rules
are selected on the basis of the selection period and are also tested against the out of
sample period. The only category which outperforms the B&H strategy by a trading rule
is the Panamax. Their paper concludes that the results in general are in favor of the
EMH considering however that while the selection of trading rules is based on
cumulative wealth in the test period it also includes operating profit in out-of-the sample
test. Furthermore, these profits are overestimated, which means that their results could
be overturned.

Another paper published on the subject was by Sødal et al (Sødal et al, 2006),
investigating whether the EMH holds when comparing investments in tankers and dry
bulkers. They approach the subject by applying a theoretical model of real options, as
used by McDonald and Siegel (McDonald and Siegel, 1986) in order to test the possible
benefits of market switching between dry and wet market. In their analysis, the concept
of relative pricing as well as an empirical study on pairs trading (Gatev et al, 2005) is
used. The idea of pairs trading was studied by Gatev et al, and is essentially a strategy according to which, the investor selects two items that historically have followed the same movement and after finding a minimum threshold in their movements, they proceed with buying the cheap one and selling the expensive one, once it is exceeded. Supposing that history is to repeat itself, prices will close in on again and profit is to be made. In Sødal et al paper this concept was applied to the bulker and tanker markets which they consider integrated, referring to Beenstock and Vergottis who argued that these markets were united via a common newbuild and scrap market. Adding to that, the integration of the two markets is strengthened by the existence of Oil-Bulk-Ore (OBO) carriers which operate in both markets. This flexibility indicates that freight rates cannot considerably fluctuate and the differential between the two freight rates is used as a key parameter in their model through a mean-reverting process. When the market is efficient and competitive, the freight rate differential will remain inside the hysteresis band. The transaction costs that exist help this band exist as they form an irreversible fee for switching. Once the freight rates transcend this band, there is room for excess profit.

Among the assumptions in their model were the following ones: a) an investor owns exactly one vessel; a Capesize bulker or a Suezmax tanker (which are both approximately 150,000 DWT), b) Buying and selling takes place exclusively in the second-hand market, c) All ships have infinite life time (e.g. all ships can be sold at 5-year value), d) Discount rate and brokerage fee are constant. The spot rate data used in the analysis covered the period from 1990 until 2004 and were of weekly frequency. Along with monthly newbuilding and second hand prices they estimate the upper and lower barriers for the spot rate differential, considering the volatility of the spot rates in their estimation. During the examined period, there were three times that the spot rate exceeded the barriers which were in line with different booms in the two markets, which would indicate that the market reacted with a slight delay, allowing excess profits to be made. In their conclusions, they present their concerns about the validity of the model results stressing that there was no test to determine the significance of a switch, that the spot rate might not adequately pick up uncertainty and that the mean-reverting representation might not aptly describe the spot rate differential.
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Method</th>
<th>Markets</th>
<th>Date Period</th>
<th>Data Source</th>
<th>EMH Holds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hale and Vana</td>
<td>1992</td>
<td>Testing for cointegration (Granger Causality)</td>
<td>Dry bulk: 30.000, 70.000, 120.000</td>
<td>October 1979 - July 1988</td>
<td>Lloyd’s Shipping Economist</td>
<td>Not for the 30.000-70.000 and three variable regression</td>
</tr>
<tr>
<td>Glen</td>
<td>1997</td>
<td>Testing for cointegration (Johansen’s Maximum likelihood)</td>
<td>Dry bulk: 30.000, 70.000, 120.000 Tankers: 32.000, 80.000, 250.000</td>
<td>Dry Bulk: October 1979 - July 1995 Tankers: October 1979 - August 1988</td>
<td>Lloyd’s Shipping Economist</td>
<td>Co-integration is present for all pairs though no clear rejection of the EMH</td>
</tr>
<tr>
<td>Kavussanos and Alizadeh</td>
<td>2002</td>
<td>Buy and hold with variance ratio test</td>
<td>Handysize, Panamax and Capesize</td>
<td>January 1976 - December 1997</td>
<td>Lloyd’s Shipping Economist and Clarkson</td>
<td>EMH holds only for Handysize vessels</td>
</tr>
<tr>
<td>Adland and Koekebakker</td>
<td>2004</td>
<td>Evaluation of excess profit achieved by technical trading</td>
<td>VLCC, Aframax, Capesize and Panamax</td>
<td>January 1976 - May 2003</td>
<td>Lloyd’s Shipping Economist and Clarkson</td>
<td>EMH holds in the tanker markets but fails in the bulker markets. EMH fails only for Panamax vessels</td>
</tr>
<tr>
<td>Sodal et al</td>
<td>2006</td>
<td>Excess profit through tanker-bulker pairs trading</td>
<td>Tanker and bulker market (150,000)</td>
<td>January 1990 - January 2004</td>
<td>Lloyd’s Shipping Economist</td>
<td>EMH failed for three short periods</td>
</tr>
</tbody>
</table>
4.2 Empirical Analysis

This section explains the research approach and the variables used in determining the models used in the following models.

4.2.1 Data

The majority of the Shipping related data used in the models are obtained from Clarkson Shipping Intelligence Network (SIN). The time series cover the largest period available for each category. Second hand ship prices cover nearly 22 years while one-year time charter rates start from 1977, however, due to some adjustments the period was restrained to a shorter sample. The data for the calculation of LTAV vessel values were from various sources which will be presented in the following paragraphs.

A. Second-hand market prices

As mentioned before, the focus is on the dry bulk shipping industry. The monthly second hand market prices for vessels were obtained from Clarkson Shipping Intelligence Network and start from March 1994 until July 2016. The focus was given on three vessel sizes: Supramax, Capesize and Panamax. All prices were for 10-year old vessels, which were considered as a logical medium age for a vessel to be sold and purchased without this being the standard.

<table>
<thead>
<tr>
<th>Vessel Type</th>
<th>DWT used in paper</th>
<th>Main Cargo</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supramax</td>
<td>56 k</td>
<td>Grains and Bulk</td>
<td>Usually geared, cover geographically diverse areas. Few port constraints</td>
</tr>
<tr>
<td>Panamax</td>
<td>75-77k</td>
<td>Iron ore, Coal, Grains</td>
<td>Most vessels are gearless.</td>
</tr>
<tr>
<td>Capesize</td>
<td>170k</td>
<td>Iron Ore, Coal</td>
<td>Only the largest ports are able to accommodate them. Commonly used in long-haul routes</td>
</tr>
</tbody>
</table>

B. Data Adjustments

At this point, it is important to note that due to lack of data for the one-year time charter rates for Panamax and the Supramax categories, several adjustments were made in order to be more precise. While the TC rates were available for Capesize ships through the period January 1992 until July 2016, the data available in the other two categories did not span the entire analysis period. For instance, there is Panamax data for both a 65k
DWT and 75k DWT vessel 1-year TC rates, with both series having a commonly observable period and a time when only one is available. Both sets of data are necessary to analyze the longest possible time-series. For the 65k DWT vessel, the data are accessible until September 2012 and the data for the 75k DWT series is available from 2001. In order to adjust the data to cover a longer span the average ratio during the period when both data were available was taken and the 75k DWT series was adjusted to that.

4.2.2 Research approach

After examining the previous studies on the subject of efficient markets, we concluded that an interesting way to investigate the hypothesis is by using the concept that was used in Hale and Vanags paper: “The market for second hand ships some results on efficiency using cointegration” as well as in D. R. Glen’s paper: “The market for second-hand ships: Further results on efficiency using cointegration analysis for a more recent period and see what would be the effects of the boom and bust of the period 2002-2008 would be. The methodology that is used in their paper is based on a former paper of Macdonald and Taylor who investigate the efficiency in the London Metal Exchange. In their paper they note that prices in an efficient speculative market cannot be cointegrated. This is because if two prices are cointegrated then at least one of them must Granger cause the other. This happens due to the fact that cointegration implies that at least one of the two prices can be written in terms of the other using an error correction formulation (Granger Representation Theorem). These ideas are applied to test the efficiency on the second-hand market for dry bulk carriers. As mentioned in section 4.2, Market efficiency implies that the ship price at any point in time for each category should incorporate all available information. Except from past prices there should be no other information that could be used in order to predict future prices. The fact that the prices are not cointegrated does not imply that the markets are efficient but it can justify testing for Granger causality in the usual vector autoregressive framework. In the following paragraph we are going to analyze the definition of the level of integration of a time series and how to test for it, therefore reviewing cointegration analysis. On the basis of that discussion, we are going to examine whether second-hand prices for dry bulk carriers of three different weights are cointegrated using the more advanced test, the Johansen test which was applied in Glen’s paper, whose analysis we are going to follow in the next paragraphs. Then we are going to compare the results of the Johansen method with the Engle-Granger and analyze the differences.

A. Testing the Hypothesis

The first step in order to proceed to the analysis is to examine the data series for their time series properties, in order to establish the order of integration. In general according to the previous studies we expect to see that the series will be I(1), that is require differencing once only to achieve stationarity. The existence of stationarity has to be established in order to validate the use of either Engle and Granger cointegration analysis (as employed by Hale and Vanags) or the Johansen method. A brief definition on stationarity is given below
Definition of a stationary time series

If a time series \( X_1, X_2, \ldots, X_t \) has

i) A constant mean, \( E(X_t) = \theta \) for all \( t \);

ii) Constant variance, \( E((X_t - \theta)^2) = \sigma^2 \), for all \( t \);

iii) Lagged covariances (or autocovariances) depend only on the lag

then the series is said to be weakly stationary.

A time series \( X_t \) is said to be integrated of order \( d \), denoted by \( X_t = I(d) \) if \((1-L)^d X_t = D^d X_t = Z_t \) is stationary. A stationary series is said to be \( I(0) \). If a series \( X_t = I(d) \) is differenced \( b \) times the resulting series \( D^b X_t \) is \( I(d-b) \).

If cointegration is absent, Granger causality tests can be employed to see whether the addition of data on past prices of other assets can improve the forecastability of the larger series. For example, if data for a 75000 DWT dry cargo vessel was being examined, the Granger causality test would involve the addition of past prices for 170000 DWT vessels or smaller ones, to see if the price predictions for the 75000 DWT vessels were improved. A simple F-test on the addition of one lagged value could deem sufficient.

If cointegration does exist it would appear that it is possible to improve on the prediction of the price movements of one asset by use of the long run link between one or more such assets. This implies that second hand ship markets cannot be efficient, the way Fama proposes.

The following step after exploring if the series are \( I(1) \) is to obtain the most efficient autoregressive model of the differenced price series for each series. In order to obtain the most efficient model we take different lag levels starting from a 12 length lag which is reduced in order to arrive at a model that is small and satisfies the usual statistical tests (AIC, SIC). This procedure is based upon the maintained hypothesis that the markets are efficient. The incorporation of information about other asset price behavior would be irrelevant if this were the case, and would justify the use of such models if the assumption is well founded. Afterwards the Johansen procedure is employed to search for cointegration between the series for dry bulk series. While Glen proceeds to a re-estimation of the original models with the error correction mechanism, after finding that cointegration exists, our study is limited to simply test that cointegration exists in the first place, after observing that in Glen’s paper the results after the input of the error correction mechanism were inconclusive for the dry bulk market.

Drawbacks of the Engle-Granger method.

Before continuing with the Johansen method it is important to stress why this method was chosen over the Engle-Granger approach. While the Engle-Granger approach is very easy to understand and implement there are several shortcomings, which are resolved by using the Johansen method.

First, an important issue has to do with the order of the variables. When estimating the long-run relationship, one has to place on variable in the left-hand side and use the others as regressors. The test does not say anything about which of the variables can be used as regressor and why. While in a two variable relationship, the procedure is rather
easy with the residuals being equivalent whether we take $X_t$ or $Y_t$ as the regressor. For more than two variables though (as in our case with 3 different ship sizes) the problem becomes more complicated.

Secondly, the problem when there are more than two variables is that there may be more than one cointegrating relationship, and the Engle-Granger procedure using residuals cannot treat this possibility. So the most important problem is that it does not give us the number of cointegrating vectors.

Finally, the fact that it relies on a two-step estimator is an important problem. The first step is to generate the series and the second step is to estimate a regression for this series in order to see if the series is stationary or not. Hence, any error introduced in the first step is carried into the second one.

Cointegration Analysis: The Johansen Method

Let the $S^i_t$ denote the second-hand price at time $t$ of a vessel size class $i$ and $D$ the first difference operator, $D=S^i_{t-1} - S^i_{t-1}$. Then two or more asset price series, if integrated of order 1, i.e. $I(1)$, are said to be cointegrated if a linear combination of the levels of the asset prices acts as a significant explanatory term in a regression of the first differences of asset prices. The linear combination of $I(1)$ series are normally $I(1)$ themselves. A cointegrating vector has the property that it is $I(0)$, i.e. stationary in levels, even though each individual component item is non-stationary in levels. This cointegrating term provides the basis for establishing the existence of a long term permanent relationship between the series contained within it. The first difference formulation models the dynamics of asset price changes over time.

The Johansen technique proceeds by transforming a vector autoregressive model in levels into an equivalent differenced form, including lagged differences and an implied set of cointegrating vectors as the right hand explanatory variables. The differenced version is then estimated using maximum likelihood methods. The implied cointegration vectors, if any exist at all, are then extracted using reduced rank regression techniques. The transformation from levels to first differences depends on the order of lags assumed in the model. Taking for example two lags in a three variable model the original model would be the one below.

$$
\begin{align*}
S^1_t &= C_1 + \pi_{11}S^1_{t-1} + \pi_{12}S^2_{t-1} + \pi_{13}S^3_{t-1} + \pi_{14}S^1_{t-2} + \pi_{15}S^2_{t-2} + \pi_{16}S^3_{t-2} + \epsilon_1 \\
S^2_t &= C_2 + \pi_{21}S^1_{t-1} + \pi_{22}S^2_{t-1} + \pi_{23}S^3_{t-1} + \pi_{24}S^1_{t-2} + \pi_{25}S^2_{t-2} + \pi_{26}S^3_{t-2} + \epsilon_2 \\
S^3_t &= C_3 + \pi_{31}S^1_{t-1} + \pi_{32}S^2_{t-1} + \pi_{33}S^3_{t-1} + \pi_{34}S^1_{t-2} + \pi_{35}S^2_{t-2} + \pi_{36}S^3_{t-2} + \epsilon_3
\end{align*}
$$

As it stands the model could not be estimated by Ordinary Least Squares as the series are non-stationary and the requirements for a proper application of the OLS are not met. On the other hand, the model can be reparametrized into the following equivalent form
Ds = \( c + \Pi Ds_{-1} + \Lambda s_{-2} + \varepsilon \)  

Where \( s \) is a 3x1 vector of ship prices, \( c \) a 3x1 vector of constants, \( D \) is the difference operator and \( \Pi \) and \( \Lambda \) are 3x3 matrices of structural terms laid out in equation (1) and \( \varepsilon \) a vector of error terms. In this form, the model is stationary, because of the assumption that the original variables are all I(1). The first differenced forms are stationary. However, the lagged levels require a little more explanation. They form a 3x3 matrix, which if cointegration exists must have a rank of less than three but more than zero. Supposing that the matrix is of zero rank, then the matrix is null and the series are independent of each other; no cointegration exists. If the matrix is of full rank, the vector of levels of the series must be stationary. This, though comes in contrast with the assumption that all data series are I(1). The other possibilities imply the existence of one or more cointegrating vectors, the number depending on the rank.

Step 1: Stationarity results

Testing for stationarity and cointegration was carried out using Eviews 8. The results of each data series are presented in the following table

<table>
<thead>
<tr>
<th>Stationarity Test Results Dry Bulk Vessel Data (March 1994- July 2016)</th>
<th>Levels data</th>
<th>Differenced Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size Class (000 DWT)</td>
<td>56</td>
<td>75</td>
</tr>
<tr>
<td>Augmented Dickey Fuller</td>
<td>-2.52</td>
<td>-2.53</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Critical Values</th>
<th>5%</th>
<th>1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey Fuller</td>
<td>-3.42</td>
<td>-3.99</td>
</tr>
<tr>
<td>Phillips-Perron</td>
<td>-3.42</td>
<td>-3.99</td>
</tr>
</tbody>
</table>

The results from the test indicate non stationary behavior in levels for all three different sizes as measured by two tests: Augmented Dickey-Fuller (ADF) and Phillips Perron (PP, Based on Dickey-Fuller test). In first differences the results are as expected and the series are stationary. The null hypothesis in the ADF as well as the PP test is that there is a unit root. In order to reject the null hypothesis, the test statistics need to be more than the corresponding critical values of the respective tests. Therefore, the results are rather emphatic both for levels and differences, leaving no doubt that the series are I(1). This means that autoregressive models of the differenced data are based in stationarity data and OLS estimation will be valid. Furthermore, the series may be combined into a vector autoregressive system and modeled using the Johansen method.
Step 2 Setting the appropriate lag length of the model

The issue of finding the appropriate (optimal) lag length is very important because we want to have Gaussian error terms (i.e. standard normal error terms that do not suffer from non-normality, autocorrelation, heteroscedacity etc.). Setting the value of the lag length is affected by the omission of variables that might affect only the short run behavior of the model. This is because omitted variables instantly become part of the error term. Therefore, careful inspection of the data and the functional relationship is necessary before proceeding with the estimation in order to decide whether to include additional variables. The most common procedure in choosing the optimal lag length is to estimate the VAR model including all variables in levels (non-differentiated data). This VAR model in our case is estimated for 12 number of lags then it is reduced to 11, 10 and so on until we reach to zero lags. While this procedure is done, in each model the values of Akaike Information Criterion (AIC), Schwarz Information Criterion (SC), Final Prediction Error (FPE), Hannan-Quinn (HQ) as well as diagnostics concerning autocorrelation, heteroscedacity, possible ARCH effects and the normality of the residuals are inspected. The model that minimizes all the former criteria is the one with the optimal lag length. After reducing the number of lags gradually from twelve to zero we found a certain pattern. While the SC and the HQ criteria were consistent and suggested a two lag optimum model, the remaining three criteria constantly suggested the longest or penultimate longest lag through the entire procedure. A test for 25 lags showed the same pattern. Considering the previous researches, and the degrees of freedom lost if a longer lag model was selected, the two lag was preferred. An example of the test is presented in the following table.
VAR Lag Order Selection Criteria

Endogenous variables: SHPCAP_170K10Y SHPPMX_75K_10_Y SHPHMX_56K_10_Y

Exogenous variables: C

VAR Lag Order Selection Criteria

Endogenous variables: CAPE_SHP PMX_SHP HMX_SHP

Exogenous variables: C

Included observations: 257

<table>
<thead>
<tr>
<th>Lag</th>
<th>LogL</th>
<th>LR</th>
<th>FPE</th>
<th>AIC</th>
<th>SC</th>
<th>HQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-2.262</td>
<td>NA</td>
<td>9.080</td>
<td>17.627</td>
<td>17.669</td>
<td>17.644</td>
</tr>
<tr>
<td>1</td>
<td>-1.495</td>
<td>1,509</td>
<td>24.979</td>
<td>11.731</td>
<td>11.897</td>
<td>11.798</td>
</tr>
<tr>
<td>2</td>
<td>-1.439</td>
<td>109.44</td>
<td>17.293</td>
<td>11.364</td>
<td>11.6539*</td>
<td>11.48057*</td>
</tr>
<tr>
<td>3</td>
<td>-1.429</td>
<td>18.512</td>
<td>17.2105</td>
<td>11.359</td>
<td>11.7733</td>
<td>11.5256</td>
</tr>
<tr>
<td>4</td>
<td>-1.426</td>
<td>5.4625</td>
<td>18.0530</td>
<td>11.4067</td>
<td>11.9453</td>
<td>11.6233</td>
</tr>
<tr>
<td>5</td>
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<td>30.7465</td>
<td>17.0474</td>
<td>11.3492</td>
<td>12.0120</td>
<td>11.6157</td>
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<td>6</td>
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<td>15.6989</td>
<td>11.2664</td>
<td>12.0536</td>
<td>11.5830</td>
</tr>
<tr>
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<td>-1.380</td>
<td>18.8296</td>
<td>15.5483</td>
<td>11.2563</td>
<td>12.1678</td>
<td>11.6229</td>
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<tr>
<td>8</td>
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<td>25.2162</td>
<td>14.9677</td>
<td>11.2177</td>
<td>12.2534</td>
<td>11.6342</td>
</tr>
<tr>
<td>9</td>
<td>-1.359</td>
<td>13.2657</td>
<td>15.1615</td>
<td>11.2298</td>
<td>12.3898</td>
<td>11.6963</td>
</tr>
<tr>
<td>12</td>
<td>-1.331</td>
<td>10.6731</td>
<td>15.1999</td>
<td>11.2289</td>
<td>12.7618</td>
<td>11.8453</td>
</tr>
</tbody>
</table>

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

Table 8 Lag Order Selection Criteria
The above models were all estimated using untransformed, i.e., linear data. This is in fact the same procedure as employed by Hale and Vanags. Many studies of cointegration relations appear to use log-linear models instead. In Glen’s paper, an attempt to transform asset price data was made though the results were mixed. Therefore, we continued with untransformed data throughout the analysis.

Step 3 Choosing the appropriate model regarding the deterministic components in the multivariate system

The next important aspect in the formulation of the dynamic model, is whether an intercept and/or trend should enter the model. In general, there are 5 models provided by Eviews that can be selected. The first and the fifth model were excluded since they are not that realistic. The following three models with their results are presented below. Only the Trace statistic will be presented, as the results were the same as the Max-Eigen statistics.

Model 2: Intercept (no trend) in cointegrating equation (CE), no intercept or trend in VAR. This is the case where there are no linear trends in the data and therefore the differenced series have a zero mean. In this case the intercept is restricted to the long-run model (i.e., the CE) to account for the unit of measurement of the variables.

---

**Model 2**

**Sample (adjusted): 1994M06 2016M07**

**Included observations: 266 after adjustments**

**Trend assumption: No deterministic trend (restricted constant)**

**Series:** supramax\_56K\_10\_Y\_SHP, CAPESIZE\_170K\_10\_Y\_SHP, PANAMAX\_75K\_10\_Y\_SHP

**Lags interval (in first differences): 1 to 2**

**Unrestricted Cointegration Rank Test (Trace)**

<table>
<thead>
<tr>
<th>Hypothesized</th>
<th>Trace</th>
<th>0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of CE(s)</td>
<td>Eigenvalue</td>
<td>Statistic</td>
</tr>
<tr>
<td>None *</td>
<td>0.100795</td>
<td>42.40553</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.035021</td>
<td>14.14455</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.017374</td>
<td>4.662055</td>
</tr>
</tbody>
</table>

* Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values**

Table 9 Second Model
Model 3: Intercept in CE and VAR, no trends in CE. In this case there are no linear trends in the levels of the data, but we allow both specifications to drift around an intercept. In this case it is assumed that the intercept in the CE is cancelled out by intercept in the VAR, leaving out just one intercept in the short run model.

---

**Model 3**

Sample (adjusted): 1994M06 2016M07

Included observations: 266 after adjustments

Trend assumption: Linear deterministic trend

Series: supramax_56K_10_Y_SHP CAPESIZE_170K_10_Y_SHP PANAMAX_75K_10_Y_SHP

Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

<table>
<thead>
<tr>
<th>Hypothesized</th>
<th>Trace</th>
<th>0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of CE(s)</td>
<td>Eigenvalue</td>
<td>Statistic</td>
</tr>
<tr>
<td>None *</td>
<td>0.10073</td>
<td>42.31909</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.034807</td>
<td>14.07743</td>
</tr>
<tr>
<td>At most 2 *</td>
<td>0.017343</td>
<td>4.653768</td>
</tr>
</tbody>
</table>

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Table 10 Model 3

---

Model 4 Intercept in CE and VAR, linear trend in CE, no trend in VAR. In thus model we include a trend in the CE as a trend-stationary variable in order to take into account exogenous growth. We also allow for intercepts in both specifications while there is no trend in the short run relationship.
Model 4

Sample (adjusted): 1994M06 2016M07

Included observations: 266 after adjustments

Trend assumption: Linear deterministic trend (restricted)

Series: supramax_56K_10_Y_SHP CAPESIZE_170K_10_Y_SHP PANAMAX_75K_10_Y_SHP

Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

<table>
<thead>
<tr>
<th>Hypothesized</th>
<th>Trace</th>
<th>0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of CE(s)</td>
<td>Eigenvalue</td>
<td>Statistic</td>
</tr>
<tr>
<td>None *</td>
<td>0.11161</td>
<td>46.85924</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.039403</td>
<td>15.37966</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.017464</td>
<td>4.686434</td>
</tr>
</tbody>
</table>

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Table 11 Model 4

The problem of deciding which model is the appropriate one is solved by what Johansen suggests as the Pantula principle. The Pantula principle involves estimating all the models and collecting the trace statistics for all three models together as in the following table to choose which model is appropriate. We start with the smaller number of cointegrating vectors r=0 and check whether trace statistic for model 2 rejects the null, if yes we proceed to the right checking if the third model rejects the null, and so on. In our case, all models reject the null hypothesis that there is no cointegration between the three variables.
Results from the Johansen test

The results are rather clear. In models 2, 3 and 4 the null hypothesis of no cointegration between the 3 variables is rejected, indicating that there are at most 2 cointegration equations especially in the models 2 and 4. Model 3 however, which is the most appropriate in our situation, indicates that there is at most one cointegrating vector. This implies that one can re-estimate the autoregressive model using Engle-Granger two-step technique, knowing that the error correction term is likely to be unique.

<table>
<thead>
<tr>
<th>r</th>
<th>n-r</th>
<th>Trace Critical Values</th>
<th>Model 2 Trace Critical Values</th>
<th>Model 3 Trace Critical Values</th>
<th>Model 4 Trace Critical Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3</td>
<td>35.19275 *42.40553</td>
<td>29.79707 *42.31909</td>
<td>42.91525 *46.85924</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>20.26184 14.14455</td>
<td>15.49471 14.07743</td>
<td>25.87211 15.37966</td>
<td></td>
</tr>
</tbody>
</table>

Table 12 Johansen Test Final Results

*Denotes rejection of the null hypothesis at 95%

Cointegration using the Engle-Granger approach

In order to understand the Engle-Granger approach we will consider a series, in our case the series of two different vessel sizes, X_t and Y_t and the following cases:

a) If Y_t ~ I (0) and X_t~I (1), then every linear combination of those two series

\[ 0_1 Y_t + 0_2 X_t \]

will result in a series that will always be I (1) or non-stationary. This will happen because the behavior of the non-stationary I (1) series will dominate the behavior of the I (0) one.

b) If we have that both X_t and Y_t, then in general any linear combination of the two series, say

\[ 0_1 Y_t + 0_2 X_t \]

will also be I (1). However, although this us the more likely case, there are exceptions to this rule, and we might find in rare cases that there is a unique combination of the series above that is I (0). If this is the case, then we say that X_t and Y_t are cointegrated of order (1,1).
Step 1 Test the variables for their order of integration.

The first step is again to test the order of integration. We have though already estimated the order of integration during the Johansen test, therefore the results are the same. The variables are all integrated at order 1, i.e. I(1).

Step 2 Check for cointegration the order of integration of the residuals.

Given that the variables are all I(1) justifies us in testing to see whether or not pairs of them are cointegrated. Essentially this involves testing whether the residuals of the level of one variable upon a constant and the level of a second (the cointegrating regression) are stationary. If they are the variables are cointegrated. In our case we take three pairs: Supramax with Panamax, Panamax with Capesize and Capesize with Supramax and the reverted ones i.e. Panamax with Supramax. The results of this procedure are presented in the following table.

Results from the Engle-Granger Approach

<table>
<thead>
<tr>
<th>Pairs</th>
<th>ADF results (t stats)</th>
</tr>
</thead>
<tbody>
<tr>
<td>56k dwt - 75k dwt</td>
<td>-5.576*</td>
</tr>
<tr>
<td>75k dwt - 170k dwt</td>
<td>-4.464*</td>
</tr>
<tr>
<td>170k dwt - 56k dwt</td>
<td>-3.796</td>
</tr>
<tr>
<td>75k dwt - 56k dwt</td>
<td>-5.621*</td>
</tr>
<tr>
<td>170k dwt - 75k dwt</td>
<td>-4.397*</td>
</tr>
<tr>
<td>56k dwt - 170k dwt</td>
<td>-3.812</td>
</tr>
<tr>
<td>Critical value 1%</td>
<td>-4.07</td>
</tr>
<tr>
<td>Critical value 5%</td>
<td>-3.37</td>
</tr>
</tbody>
</table>

Table 13 Pairwise cointegration tests

* Indicates rejection of Null Hypothesis at 1%

** Indicates rejection of Null Hypothesis at 5%
Results from the Engle Granger test indicate that at 5%, cointegration exists among all pairs. This contradicts the results from the Johansen test which indicates that there is only one cointegrating vector among the three variables.

5 Conclusion - Future Work

The scope of this study was to examine the existence of asset bubbles in the second hand dry bulk ship market during the period of 2002-2016. In order to examine whether a bubble was formed, we proceeded by analyzing what an asset bubble is, and what are the conditions under which a bubble is formed. The results from this analysis indicated that there are two ways to define whether a bubble exists. The first one is based on analyzing the difference between the intrinsic value of a vessel in conjunction with the prevalent conditions in the market. The other approach that we used was based on the famous topic of market efficiency. We examined the concept of market efficiency based on previous empirical researches that tested the cointegration between different size categories. The idea was that if the second hand market prices of three different vessel sizes (Supramax, Panamax, Capesize) were cointegrated then the market is not efficient.

In order to analyze the difference between the intrinsic values and the market prices we needed to determine the intrinsic value. For that reason we used the LTAV method for all three vessel categories. While the LTAV model that was used suffered from lack of data and from several assumptions that needed to be made, the results indicated that there were major differences between market and intrinsic value during the period examined.

More specifically the results indicated that the Capesize, Panamax and Supramax vessels were significantly overvalued during the 2007-2008 period. The Supramax vessels were found overvalued over the whole sample period that we examined, the biggest difference though which indicates the existence of a bubble was through the period from September 2004 until September 2008. For the Panamax category the results were different. While the results for the period September 2004 -October 2010 present that the vessels were overvalued, as of 2012 they remain constantly undervalued. The Capesize ships presented identical results as the Panamax category. However, in the Capesize category, the difference between the market prices and the LTAV values was significantly smaller in the boom period of 2008-2008. From the valuation analysis and the comparison with market prices, we concluded that the LTAV model might not be used as a valuation method as it heavily relies on assumptions about the future that could be wrong. The dependency on historical freight rates in order to predict the long-term ones is also something that raises concerns. These concerns, along with the overall rejection of the LTAV method from the maritime industry pushed us into looking into the actual secondhand markets and examine if they are efficient.

As we said before the Efficient Market Hypothesis was examined by conducting cointegration tests. Two tests were employed; the Johansen cointegration test and
the Engle-Granger test. The sample used in this analysis covered a longer period from 1994 until 2016 for the same three size categories. The results from both tests concluded that there is indeed cointegration among the different size markets. However, the cointegrating vectors were found to be different. The Johansen test indicated that there is a single cointegrating vector between two markets. On the other hand, the Engle-Granger test indicated that cointegration exists among all pairs. On both cases, we attempted to create a vector error correction model (VECM), the results though were not correct. The findings of this research are in line with previous ones. More specifically the existence of a single cointegrating vector using the Johansen test is in line with Glen’s research on the matter of efficiency in the second hand dry bulk vessel market. The question of the efficiency of second hand markets for dry cargo, though remains unresolved. There is a need for more research on this issue, perhaps linking rates, trade growth and costs to asset price behavior in order to examine properly the subject.
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