NHH – Norwegian School of Economics

Is dry bulk shipping a rational market?

Historical analysis from an *intrinsic value* perspective.

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Abstract

Dry bulk shipping is unique due to its near “perfect-competition” market characteristics. To complicate matters further, there is a significant supply side delivery delay in case of unexpected demand changes. Both of these factors contribute to the high volatility inherent in the sector. This paper aims to test whether dry bulk shipping exhibits irrationality in the pricing of second-hand vessels using data from 1977-2014. Two distinct valuation models are employed for identifying the intrinsic value of bulkers and compare these to the market price of the vessels. The purpose of the paper is to test for the presence of irrational investment behavior during the last three decades in the dry bulk space. Equally important is testing whether intrinsic value measures introduced are able to predict investment returns. Findings reject the presence of irrational investment behavior in the overall sector. Nevertheless, the intrinsic value models are able to rank subsequent investor returns depending on the level of under- / overvaluation. Through applying fundamental valuation in the dry bulk sector, this research provides worthy tools for decision-makers to achieve superior returns on investment.

Acknowledgements

The author is grateful to everybody involved in making this thesis possible. Primarily, I would like thank Roar Os Adland for his feedback and his suggestions in the supervision of this thesis striking a balance between academia and investment practice. Almost as important is the support of friends and family in whole writing process – thank you for your patience.

1. Introduction

Global dry bulk shipping is an extremely volatile and cyclical industry. To illustrate, Figure 1 displays the year-over-year price changes for a benchmark second-hand vessel. The S&P500 Index annualized return are added for comparison. Generally, the stock market is regarded as relatively unpredictable and risky. However, securities pale in comparison with the volatility in the dry bulk space.

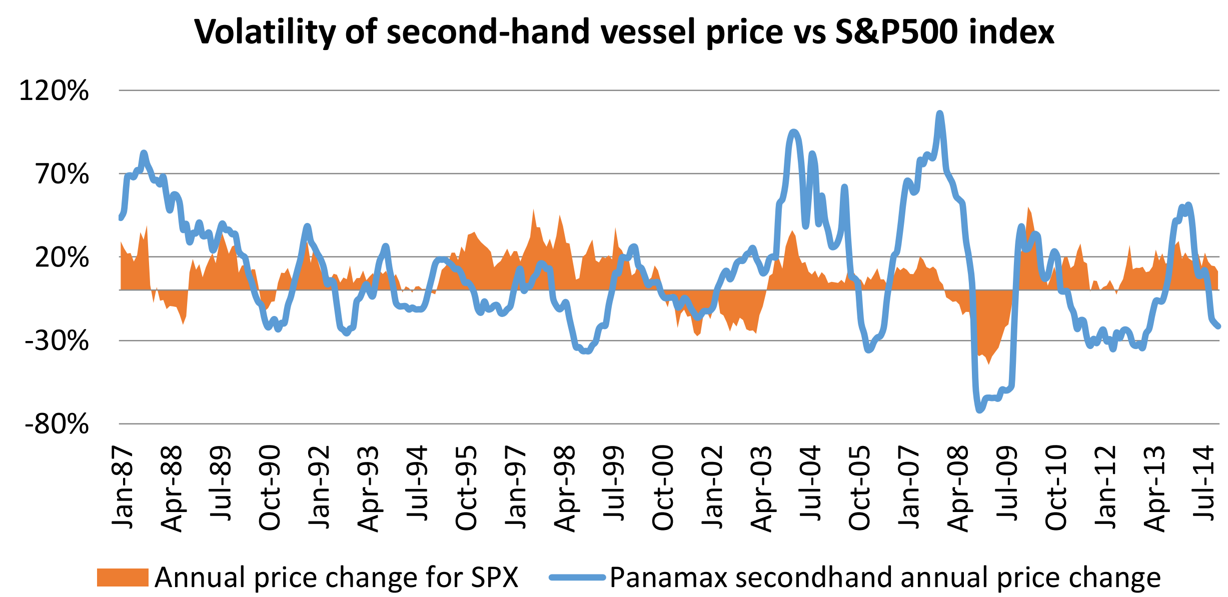

Figure 1. 5-year Panamax second-hand vessel price annual change vs S&P 500 Index, 1987-2014
Source: Clarksons, Bloomberg

Admittedly, an index of the largest companies in the world is likely to exhibit less volatility than the reference value for a particular vessel. Nevertheless, it is evident that the dry bulk sector is subject to large price swings. What is more, this volatility hasn't arisen post 2003, i.e. after the unexpected rise of China and a surge in demand for shipping as a result. Periods prior and subsequent to Chinese globalization have displayed boom-bust cycles of comparable magnitude. Thus, volatility has been an inseparable part of the dry bulk space for the last 30 years.

There are a number of reasons for the large swings in pricing and profitability:

- Vessel capacity is *non-storable:* one cannot "save" the carrying capacity of a vessel for future date either the ship is in use carrying goods or stands empty.
- *Lack of alternatives: s*hipping is by far the most cost-effective means of transportation for bulk goods.
- Dry bulk shipping is *highly fragmented (+ low entry barriers):* the largest ship owners account for a few percent of total global capacity. As of 2014 there were 1716 independent dry bulk carrier owners (Navios Maritime, 2014).

Given these characteristics, shipping is among the few markets in the world that closely follows the rules of *perfect competition,* i.e. everyone is a price-taker and in the long-run nobody can earn an economic profit (Arrow, 1959). To complicate matters further, the supply is relatively constant in the short-term and capacity additions have a long lead time. Hence, the ordering of new vessels exhibits even more cyclicality than price levels.

In order to successfully navigate between investing during periods of unsustainable prices and deferring purchases in times of stress, ship owners are required to maintain a long-term perspective. Hence, the quest for establishing *intrinsic value* or the true asset value based on fundamentals – which may not always equal its market value – is paramount for profitability throughout the business cycle.

Are ship owners making systematic investment errors and are there patterns in a seemingly unpredictable market? The goal of this thesis is to study whether dry bulk shipping exhibits *irrational* investment behavior. In addition, the paper develops and empirically tests valuation models that would provide a reasonably accurate estimate of the intrinsic value of a dry bulk vessel.

This paper is partly inspired by the work of Greenwood & Hanson (2014). They conclude that companies operating in the dry bulk space make consistent forecasting errors in investment decisions, i.e. overinvest during times of high earnings, generating excess volatility. This gives rise to predictable returns on capital given the stage of the dry bulk cycle. However, there were a number of shortcomings that this paper improves upon. The primary goal is to test whether similar findings hold after use of more elaborate intrinsic value models / assumptions.

This paper aims to answer the following research questions:

1. *Is there evidence of a systematic bias in second-hand vessel pricing in dry bulk shipping?*
2. *Is it possible to predict the return on investment from owning a second-hand bulker based on intrinsic value?*

The direct contribution of the paper to existing literature is fourfold. To begin with, the author uses two inherently different valuation approaches in establishing intrinsic value. This enables the comparison between outputs of both methods and whether they support each other. Second, the whole spectrum of bulkers (Handymax, Panamax, Capesize) are analyzed. Thus, allowing determining differences in the accuracy of the methods and their predictive powers across size-classes and testing whether similar cyclicality and investment behavior corresponds to each vessel type. Third, measuring actual investment returns for a given valuation level, enabling the pairing of *ex-ante* expected outcome with *ex-post* actual returns. Finally, the paper introduces empirical findings to appropriately account for vessel age in achieved time charter rates. The effects of which turn out to be significantly different from the research consensus.

The next section provides a brief overview of the published literature in the area of dry bulk vessel valuation. Section 3 explains the methodology and the assumptions behind the intrinsic value models and realized return calculation. Section 4 presents the analysis results. The penultimate part will interpret the findings, provide potential explanations to the results and discuss possible implications for ship owners. The last section concludes.

2. Literature Review

Most of the papers written in pricing of second-hand vessels rely on econometric modelling. The main focus of early research was devoted to testing whether the Efficient Market Hypothesis (EMH) holds for second-hand vessels (Pruyn *et al*, 2011). EMH states that given the available information, market values at all times represent very good estimates of intrinsic value (Fama, 1965). Early research focused on tests of co-integration between various size bulkers, i.e. if one price Granger causes the other then this can be seen as an inefficient market as one commodity determines the price of the other. Hale and Vanags (1992) and Glen (1997) both find the data series to be cointegrated, i.e. rejecting EMH. Alizadeh and Kavussanos (2002), Adland and Koekebakker (2004) and Adland *et al* (2006b) use various trading strategies to test whether the market is efficient against multiple trading rules with the latter two papers also employing transaction costs in their analysis. In most cases the EMH is shown to have failed for bulkers, which means that one was able to earn excess profits by using certain trading strategies. Therefore, the general research consensus has in most cases rejected the proposition of EMH for shipping sector.

Tsolakis (2005) proposes a structural market model where demand is dependent on TC rate, second-hand price, newbuild cost, LIBOR and supply is influenced by the size of the orderbook compared to current fleet and second-hand price. Assuming market equilibrium (supply = demand) one can derive a function for a second-hand price. The newbuilding price and TC rate were found as the most important determinants of second-hand values.

Adland and Koekebakker (2007) also employ a structural model for determining actual sales prices of second-hand vessels using size, TC rate and age as sole determinants and conclude that their models is less volatile that the broker estimates for second-hand values. In a similar line of though Köhn (2008) finds that for chemical tankers the newbuild price, earnings, size and age are most significant determinants of value.

Another stream of research focuses on explaining second-hand values in relation to the newbuild price. Strandenes (1986) defines long-run expected earnings of a vessel based on the newbuilding price and assumes the second-hand value is a weighted average of short- and long-term freight rates. Tsolakis *et al* (2003) investigate second-hand prices in an Error Correction Model and find that the most important variables are newbuilding prices and TC rates. Adland and Jia (2014) find a close correlation between newbuilding and second-hand prices after adjusting for differences in delivery lag and payment schedules.

The last stream of research falls into explaining bubbles / extreme market events using theories borrowed from the field of psychology, where boom-bust cycles have long been a favored area of research. Kydland and Prescott (1982) showed that investment cycles are more pronounced in settings where there is a lag between investment plans and their realization, e.g. dry bulk shipping. This is especially prevalent during periods of high demand. Barberis *et al* (1998) found that market participants over extrapolate current profits levels, which is regarded as a common fallacy in behavioural finance.

In light of these findings, Merikas *et al* (2008) introduce the relative price ratio between second-hand / newbuild values as an investment indicator. The conclusions support the usefulness of the indicator in the timing of investment decisions. Greenwood and Hansen (2014) analyze the value of Panamax second-hand vessels from 1976-2011 with their own *intrinsic value* measure. Their results indicate that firms overinvest during good times and have to suffer from subsequent low returns as a result. However, their approach was overly simplified, suffering from look-ahead bias and not taking into account changing financial conditions. The following section will describe how to improve on these shortcomings.

3. Methodology

This section explains the research approach and the variables used in determining the model for intrinsic value analysis in the dry bulk sector.

I. Data

All the shipping-related data is obtained from Clarksons Shipping Intelligence Network. The time series date back to the earliest available date. All time series are available from Jan 1987 onwards, Capesize and Panamax TC rates are accessible from Jan 1977.

A. Time charter rate

A common way for ship owners to earn money on their vessels is by leasing them out for a defined period on the time charter (TC) market. These periods can vary from a few months till 5 years. The idea behind the TC is to ensure a predictable stream of earnings for both the ship owner and charterer over a specified time (Stopford, 2009).

TC rates are exposed to counterparty risk. Given the motivation for default by the charterer the employed valuation methods might suffer from unrealized TC rates for contracts that were signed during times of high TC rates and subsequently the market rate declined below the contracted rate. Similarly a ship owner is tempted to cancel a contract where the rate is significantly below the current spot level. Therefore, it is likely that some of the counterparty risk will be netted-out on the overall market level such that the bias to the analysis is reduced. Nevertheless, the author is unable to quantify neither the effect nor the sign of the bias. Due to the limited scope of the thesis, counterparty risk is not accounted for throughout the analysis.

This paper will use the 3 year time charter rate, i.e. the cost of leasing a vessel for a period of 3 years, as the basis for analysis. Most of the previous research has focused on shorter fixtures, e.g. 1-year, 6-month or spot. However, here a 3-year benchmark was chosen as it more properly reflects the average of TC rate curve and captures both the short- and medium term market expectations, i.e. it comprises of the individual implied annual forward TC rates for years 1, 2 and 3.

According to a time charter the owner of the vessel is responsible for covering the financing and operating expenses, e.g. crew, maintenance. Charterer is responsible for the remaining costs, including bunkers. Therefore, the cost of fuel does not directly influence the earnings of the ship owners. However, it does mean that newer more fuel-efficient vessels ought to earn higher time charter rates. However, Adland *et al* (2015) find that there is a lack of empirical evidence for a fuel-efficiency premium. The appropriate age-adjustment is described in later parts of the methodology section.

In order to calculate the net earnings from leasing out a ship, one must deduct the owner's expenses from the time charter rate. The next section will describe the way operating costs are accounted for.

To arrive at the income available to the vessel owner one must deduct the expenses he has to cover:

$$(1): Net\ earnings = 3\ year\ timecharter\ rate - operating\ costs$$

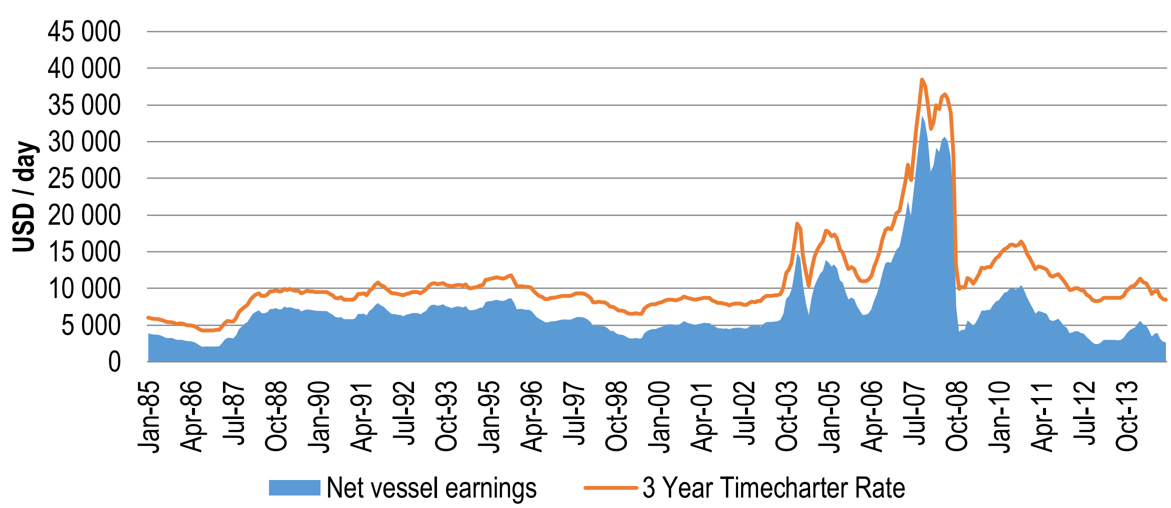

Figure 2. Handymax 3-year time charter rate and net vessel earnings
Source: Clarksons; Moore Stephens; St. Louis Fed

B. Operating costs

In order to find the earnings attributable to the ship owner, one must deduct the operating costs from the time charter rate. The owner of the ship is required to cover the manning, insurance, repairs and maintenance (Stopford, 2009). There is no official data about the operating cost levels and development over time. Prior research has either excluded the operating expenses from the analysis or assumed them to be flat in real terms in their analysis (Pruyn, van de Voorde and Meersman, 2011; Greenwood and Hanson, 2014).

The closest estimates to actual operating costs are provided by surveys among ship owners. This paper will use data gathered by Moore Stephens, which conducts an annual survey among ship owners starting from 2000. The advantage of using actual survey data is that instead of relying on a general inflation index, the survey results should provide more accurate and industry-specific figures.

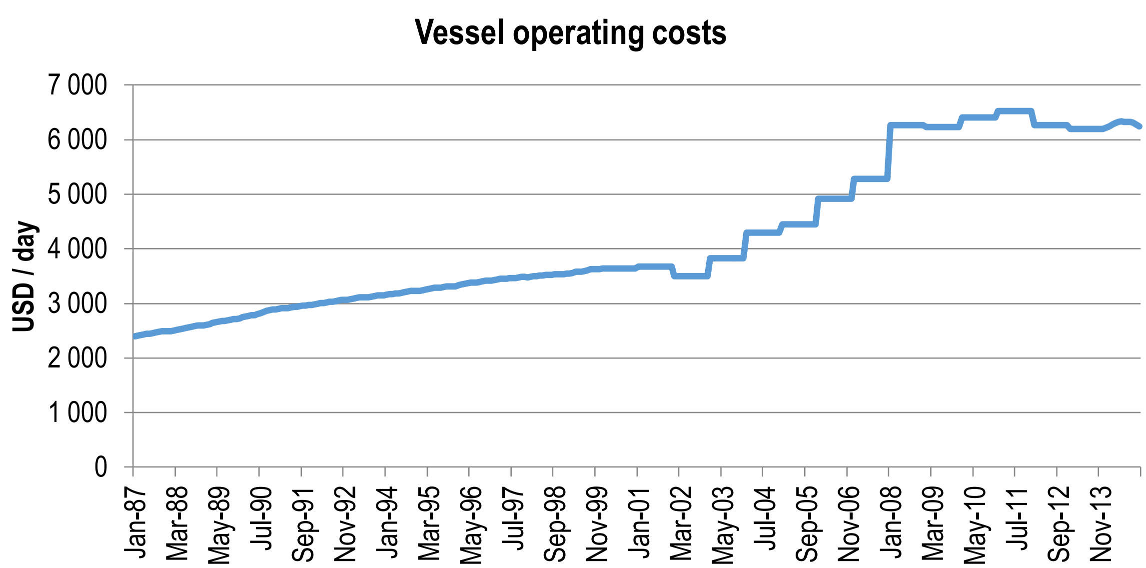

Figure 3. Panamax historical operating costs
Source: Federal Reserve Bank of St. Louis; Moore Stephens

The data for 2000-14 data is obtained from the Moore Stephens annual cost survey and is deflated by US inflation for prior periods. As can be observed from the graph, the costs have grown significantly above historical trend during 2003-08. The most likely explanation for the cost surge is the shipping super-cycle starting from 2003, where the above-average demand growth and TC rates prompted above-inflation rises in operating expenses. The flattening of operating expenses after 2008 also supports this reasoning.

C. Discount rate

Vessel values are determined by the amount of cash flows they will generate over their economic life. Discount rate allows bringing the value of future cash flows into the present. Previous research has often assumed a constant discount rate of the whole examined period. The author finds that this fails to account for differences in the financing environment for ships. The paper will use a time-varying weighted average cost of capital (WACC) approach to account for differences in the financing markets over the studied period.

Traditionally ships are financed by a mix of debt and equity. The leverage varies among companies and vessels. Based on SEC filings around 2/3 are financed with debt and the remaining 1/3 with equity (Navios Maritime, 2014; Safe Bulkers Inc, 2014). The appropriate discount rate for the value of a vessel is its weighted average cost of capital. Due to large differences in international tax rates, interest expense is assumed to be non-tax-deductible.

$$(2): WACC = \frac{1}{3} * cost\ of\ equity + \frac{2}{3} * cost\ of\ debt$$

Cost of equity is usually viewed from the context of a premium over the long-term risk-free / government bond yield. There is no research consensus on the size of an equity risk premium. Multiple empirical studies refer to a range of 3-6% among various time periods and countries. In addition, due to limited years and geographies of data availability there are substantial statistical errors to take into account. (Goetzmann and Ibbotson, 2005; Damodaran, 2015)

The risk premium estimate used is based on longest available time-series on the US market, dating from 1928-2014. During this period the geometric equity risk premium, i.e. S&P500 returns over long-term government bond returns, has been 4.6% (Damodaran, 2015). Accounting for the higher systematic risk a dry bulk beta of 1.1 is applied, which is found by averaging the beta estimates for transportation and marine sector (Damodaran Online, 2015). These assumptions yield a cost of equity = 10-year US treasury + 5% risk premium. The 10-year treasury rate serves as a reasonable estimate for the risk-free rate as all the shipping data is quoted in USD. Also, as shipping is a very international business, there is little reason to expect significant country-specific variations in financing terms.

Cost of debt is equal to the US treasury rate + a risk premium to account for the possibility of default. Similarly to cost of equity, there is little empirical research conducted on debt financing conditions in the shipping sector. Given that shipping is generally regarded as a volatile and highly leveraged business, the Barclay Capital High Yield Corporate bond index will be the benchmark for cost of debt in the shipping sector.

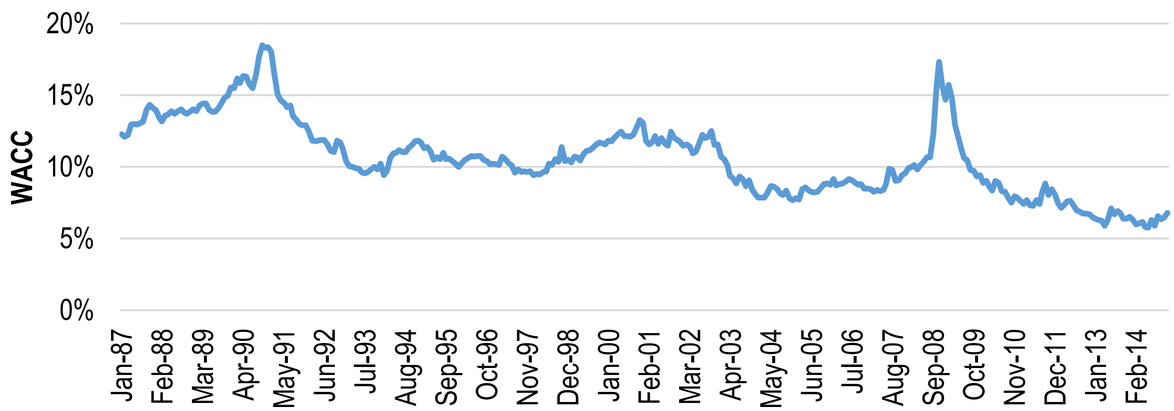

Figure 4. WACC for dry bulk ship owners
Source: Bloomberg, author's calculations

Due to the high beta nature of high yield bonds, the discount rate is very much affected by financial crises, e.g. the spike during the beginning of 90s and 2008-09 is a reflection of the volatility in the credit conditions. The graph also illustrates how financing costs have steadily declined over the observable 29 year period. The lower discount rates have significant implications for the present value of ships, i.e. ships will need to earn less future income to justify their current second-hand value. The implications from spiking discount rates during crises and a steadily declining WACC will be further analyzed in the discussion section.

Unfortunately, there is minimal research available on financing of the shipping sector, industry leverage or industry betas. Hence, this paper is unable to rely on previous relevant research and will make the above-mentioned approximations to arrive at a discount rate.

The data for 2000-14 data is obtained from the Moore Stephens annual cost survey and is deflated by US inflation for prior periods. As can be observed from the graph, the costs have grown significantly above historical trend during 2003-08. The most likely explanation for the cost surge is the shipping super-cycle starting from 2003, where the above-average demand growth and TC rates prompted above-inflation rises in operating expenses. The flattening of operating expenses after 2008 also supports this reasoning.

D. Types of ships

As mentioned in the introductory section, the paper is focused on the dry bulk shipping industry. The main differentiator among vessel characteristics is their size or Dead-weight tonnage (DWT). Focus will be on the 3 main size categories for bulkers: Handymax, Panamax and Capesize.

Table 1. Dry bulk vessel types

Vessel type	DWT / used in paper	Main cargo	Comments
Handymax	40-59k / 45k	Grains and minor bulks	Used in large number or geographically diverse areas. Few port constraints.
Panamax	60-99k / 75k	Iron ore, coals, grains	Most vessels are gearless, i.e. need approapriate port infrastructure for on-/offloading.
Capesize	100k + / 150k	Iron ore, coal	Only the largest ports are able to accommodate such large vessels. Primarily used in long-haul routes.

Source: Ariston Shipping, 2015; Bornozis, 2006

E. Data adjustments across time-series

This section relates to the data modifications among the different time-series within a particular bulker class. As the period under study spans for almost 40-years, there are relatively few fully consistent time-series available and data for TC rates, second-hand values and newbuilding prices provided by Clarksons change over time. For instance, there is Panamax data for both a 65k DWT and a 75k DWT vessel, 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 instance, the Panamax 65k DWT 3-year TC rate is accessible until September 2012 and the data for subsequent periods is only available for 75k DWT series (for which data starts in 2001). This requires adjusting the data, so that the whole time-series is consistent throughout the period analyzed (1977-2014).

The most typical approach to the adjustment is to observe the historical relationship between the *old* and *new* data during the period when both are available. This method assumes that the market has historically priced the relative spread between the two types of vessels correctly.

Returning to the example above, then obviously a 75k DWT vessel is able to carry more cargo and hence should trade at higher TC rate. However, a "75/65" multiplier adjustment would be too simplistic given the difference in the fuel consumption, crew costs, accessible ports and other considerations. To account for all of the factors determining the price between two different-sized vessels, this paper use the information of the market to correctly account for the differences between the 65k and 75k vessels during their commonly observable period (2001-2012). Using the average ratio for the period when rates for both vessel classes were published is expected to yield an accurate adjustment.

In one case the newbuilding price was adjusted using the *OECD Compensated Gross Ton System* due to lack of prior comparable data (OECD, 2007).

F. Data adjustments within time-series

The previous section explained the data adjustments taken for time-series that do not span the entire analysis period. This part will explain why an individual time-series for a particular class of ship (i.e. Handymax 45k DWT, Panamax 75k DWT, Capesize 150k DWT) will not be adjusted.

In conducting an analysis spanning for nearly 4 decades it is inevitable that technological and industry standards change. Due to these reasons Clarkson updates its *reference vessel* for a particular time-series approximately once a decade or so. Therefore, the time-series for a 45k vessel uses data for a 40k DWT vessel during the 80s and early 90s vs 56k DWT today. It is clear that the economic fundamentals for a 40k DWT ships are very different from a 56k DWT bulker. However, this paper will not adjust for such reference vessel updates due to the inaccuracy of the available adjustment methods and changes in the dry bulk sector.

To begin with, Clarksons does not provide reference vessel specification changes for periods prior to 1990s, making the adjustment inconsistent across the whole period. Secondly, during the majority of dates when the reference vessel changes there are insignificant changes to the TC, second-hand values and/or newbuilding prices. Therefore, it seems that for most of the time changing the reference vessel does not significantly impact the time-series.

In addition, it can be argued that over time changes in ship design and construction methods have made evolved such that construction of a 65k DWT Panamax in the 80s is as expensive as 75k DWT in the 2000s. Finally, while the adjustments for TC rates, second-hand values and newbuilding prices usually do not take place at identical dates, they do tend to track each other rather closely, i.e. the increase in one of the variables (e.g. TC rate, second-hand and newbuilding price) is usually followed by an adjustment in the accompanying vessel values.

The author finds that is better to leave the data unadjusted and be aware of its possible shortcomings instead of using somewhat questionable adjustments based on imperfect data and assumptions.

II. Intrinsic Value Calculation

This paper will approach intrinsic value from two distinct perspectives:

1. Cyclically-adjusted intrinsic value
2. *Replacement cost* or *newbuild equivalent* value

Both valuation models are based on a number of assumptions. The following part explains the primary assumptions shared across the two methods. Approach-specific inputs will be explained in later parts.

A. Assumptions

It is difficult to value something that provides income in the future. Valuation is the tool that financial economics uses to set a price for all assets given a set of assumptions. This section covers the primary inputs used in valuing dry bulk vessels.

Table 2 Intrinsic value calculation assumptions

Item	***Assumption***
Asset life	Based on Clarksons (2014) data the average age of the vessel is dependent on vessel type – Handymax: 25, Panamax: 25 and Capesize: 22 years.
Second-hand vessel economic life	Clarksons provides second-hand pricing data for vessels that are 5 years old. Hence the usable economic life of such a vessel is: average lifetime -5 years, i.e. 20 years for Panamax and Handy, 17 years for Capesize
Discount rate	The discount rate consists of: 2/3 x *monthly US Corp High Yield interest rate* + 1/3 x *(monthly Treasury 10Y bond + 5% equity risk premium* (see discount rate section)
Scrap value	Scrap value is taken from Clarksons database. Data only becomes available in the beginning of the 90s; however, no adjustment is made in prior years due to the impact on total Net Present Value being approximately 1%. Therefore, the lack of scrap value data for a few years at the beginning of the study is does not significantly change the final outcome.
Days of operation	On average the ships spends 8 days a year in maintenance; for the rest of the days 100% utilization assumed, i.e. 357 days of operations per annum
Inflation	All figures used are in nominal terms. Difficult to justify any particular inflation rate for global shipping sector.
TC rate adjustment for older vessels	The discount to market reference is vessel dependent (see Appendix II).

Source: Stopford, 2009; Clarksons, 2014

Under both cyclical earnings valuation methods the first 3 years of earnings are calculated based on the prevailing 3-year TC rate, i.e. the market quote that ship owners are able to lock in. Only after the 3-year *locked-in TC* rates have been exhausted will the CAE be used in the intrinsic value calculations.

The newbuilding approach does not incorporate the prevailing 3-year TC rate in its model due to a number of reasons. First, the delivery lag from ordering to delivery is neither constant nor available for the whole period under analysis. The prevailing 3-year TC rates could only be incorporated into newbuilding valuation model if the delivery lag is below three years. In addition, proper incorporation would require boot-strapping the rate into annual periods, e.g. extract the 3rd year TC rate using 1 and 2-year TC rates etc. Clarksons does not provide data at sufficient granularity to undergo should such analysis.

The age of a specific type of vessel is taken as a constant during the whole analysis period. This allows avoiding endogenizing the market conditions into the intrinsic value of a vessel. For instance, during periods of high TC rates, ship owners are more likely to delay scrapping their old fleet and continue earning good income even on ships that are past their normal economic life. Similarly during distressed periods scrapping might take place many years before normally would occur. However, from an intrinsic / cyclically adjusted value perspective there is no justification behind varying the age of a vessel. Furthermore, there is little academic support to the notion that the average age of a vessel has increased due to trends in shipbuilding or advances in ship design.

B. Age effect on vessel time charter rate

Old vessels receive discounted TC rates compared to newer ones. Most often this is connected to fuel-efficiency, smaller crews costs for a given DWT and other miscellaneous advantages of younger ships. Traditionally it has been assumed that older vessels receive a discount of around 15% due to above-mentioned reasons (Stopford, 2009; Greenwood and Hanson, 2014). However, Adland *et al* (2015) found that the impact of fuel-efficiency is almost negligible in determining TC rates, but age does significantly influence the obtained TC rate in relation to the market reference value.

In order to investigate the issue further this paper uses a panel data set comprising of 8600 individual time charter fixtures for bulkers dating from Jan 2001-Apr 2014. The regression analysis uses OLS with the actual fixture TC rate as dependent and a set of ship-specific independent variables to estimate their effect on the actual obtained TC rate (see Appendix I). A number of interesting findings arose from the analysis:

- The age effect is considerably larger and non-linear in comparison to previously held beliefs.
- The relationship between vessel age and obtained TC rates changes significantly during the shipping boom (Jan 2003-Nov 2008). The age effect is significantly reduced during the periods of very high earnings. Most likely this is due to the relatively small cost of bunkers and crew in relation to the willingness to pay to move goods during periods of high demand.

The results from Jan 2003 – Nov 2008 (boom interaction dummy) are not taken into account in adjusting the earnings power of vessels for the purposes of the intrinsic value model. The author believes that the extremely high rates experienced during the shipping boom are not reflective of a normal market and therefore should not be utilized in the analysis.

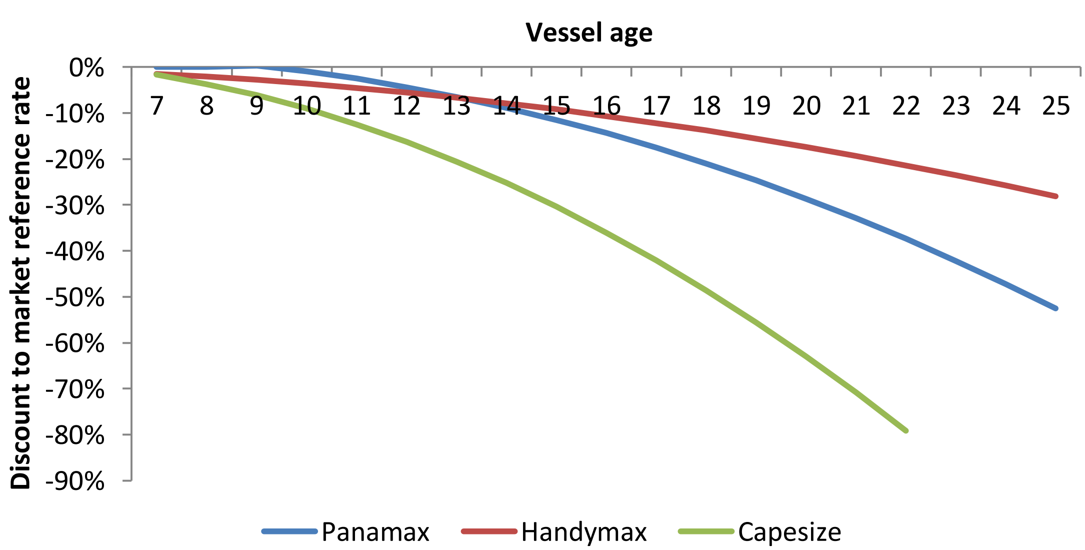

Figure 5 Age-related TC rate discount to reference market value (see Appendix II)
Source: author's calculations

Due to the non-linear specification of the regression, the starting point for the age-related discount is 7 years. Premiums over the reference rates are not considered as relevant. The lines are drawn until the end of the average vessel life, i.e. 25 years for Handy- and Panamax, 22 years for Capesize.

Surprisingly, the discount varies significantly between size categories with the largest vessel type receiving less than 50% of the reference rate quoted by Clarksons after only 18 years of service. This partly explains the relatively early scrapping age for Capesize bulkers. The smallest segment seems to be aging the least with a 28% discount by the end of its average scrapping age.

It has to be emphasized that these results exclude the time period from Jan 2003-Nov 2008, i.e. the *great shipping boom*. Had the regression not used the boom interaction dummy, the results would have been significantly less pronounced as during periods of high earnings the age of the vessel starts to play a much smaller role. Most likely this is explained by the relatively smaller weight of bulkers, crew, maintenance etc. in the total cost of transportation / income to ship user.

III. Cyclically Adjusted Time Charter approach

In 1998, Shiller and Campbell published a ground-breaking article titled "Valuation Ratios and the Long-Run Stock Market Outlook". The conclusion of the research paper was the predictability of long-run stock market returns using a Cyclically Adjusted Price-Earnings ratio (CAPE), which is calculated by dividing the average ten year index earnings with its price (Campbell & Shiller, 1998).

This paper derives its first intrinsic value method using the same approach, i.e. by looking at the average time charter rates over the preceding 10 year time horizon. In accordance with Shiller's theory, this should average out the cyclicality of earnings and provide a more reliable and accurate picture of the earnings power of a dry bulk vessel over long time horizons.

This approach differs somewhat from the one employed by Greenwood and Hansen (2014), who used the average earnings during the total period under study. Ideologically the two methods are very similar, with differences arising from the historical earnings data that is considered relevant, i.e. past 10 years vs all available years.

A. 10-year Average TC earnings approach

In accordance with the method proposed by Campbell and Shiller (1998), the Cyclically Adjusted Earnings (CAE) for a dry bulk vessel is calculated by taking the 10 year average of the 3-year time charter rate available monthly for each vessel type. The earnings data is available from Jan 1977 for Panamax and Capesize, hence the 10y average can be calculated from 1987. Handymax 3-year time charter rate is available from 1985, i.e. intrinsic value measurement can start from Jan 1995.

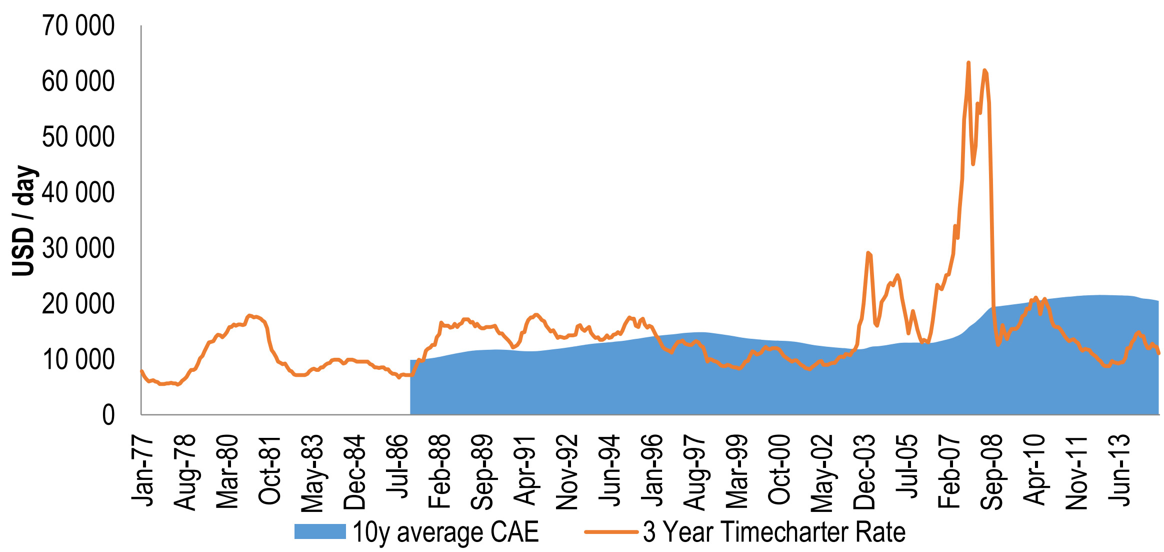

Figure 6. Panamax Cyclically Adjusted Time Charter rate and monthly 3-year time charter rate
Source: Clarksons, author's calculations

It is evident from the graph that the average earnings are much smoother and stable than the monthly quotes that fluctuate above and below the CAE. The 10-year average provides a more stable estimate of a vessel's earnings, which is used for finding the fundamental value of the vessel.

B. 10-year Median TC earnings approach

There is a caveat to the approach though. The *super-boom* from Jan 2007 – Aug '08 significantly inflates the average for the whole 10-year period. Hence, this paper proposes using the 10-year median time charter rates to arrive at a better cyclically adjusted rate. Taking the median takes away the extreme values from both ends and takes the 50th percentile value from the whole 10-year time series. Taking averages is agreeable with relatively stable data (e.g.

S&P500 Index earnings). With volatile data the extreme values can tilt the average considerably, providing misleading results. Figure 7 illustrates that 10-year median earnings are significantly below the 10-year average measure, especially during and after the 2003-08 period.

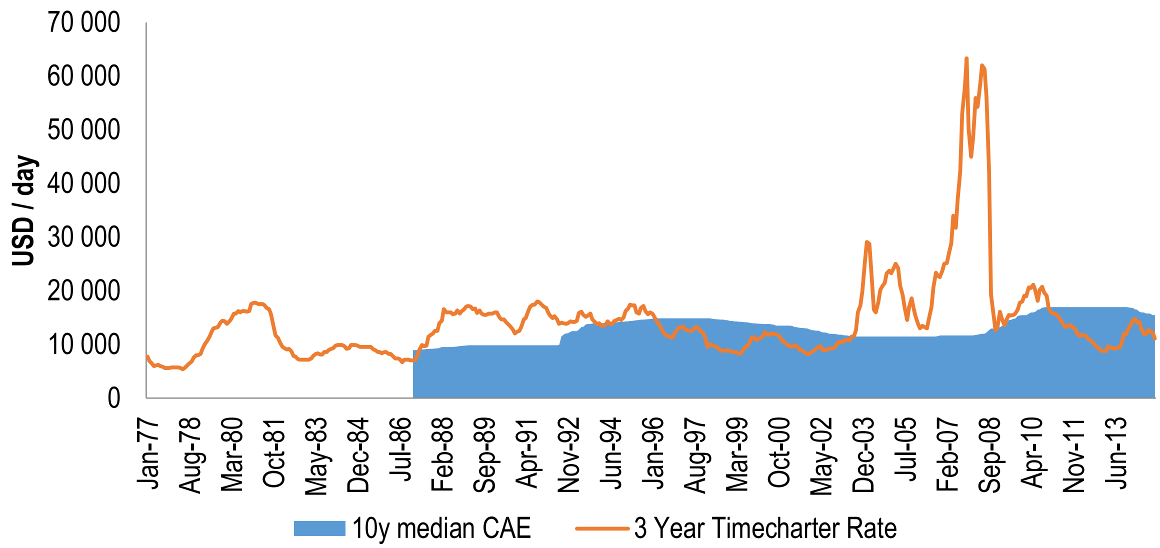

Figure 7. Panamax 10-year median vessels earnings and 3-year time charter rate
Source: Clarksons; author's calculations

IV. Replacement cost / newbuild equivalent approach

The *replacement cost* approach relies on the premise that a new dry bulk vessel will be constructed *only* when it earns a reasonable return on capital. The idea was first employed by Strandenes (1986) who studied whether long-term time charter rates follow the level required to justify building a new ship and earn a reasonable return on capital through-out its economic life. In other words, time charter rate should average out such that the vessel owner earns a reasonable return on investment over the life-time of the ship.

This is related to the concept of *q ratio* which is an asset's market value divided by its replacement value. The measure was introduced by Tobin and Brainard (1968), and implies that the value of the stock market cannot exceed its replacement cost over the long-term and should revert to parity over time. In fact, Harney and Tower (2003) provide evidence that the q ratio is among the most reliable predictors of stock market return over both short- and long-term investment horizons.

The stock market results can be inferred to dry bulk shipping. When the market value of a second-hand dry bulk ship exceeds the value of the replacement cost of a vessel having adjusted for differences in age and earning power, more ships will be ordered that ultimately lower the return from owning a ship and brings the market back to equilibrium. A similar dynamic applies to the situation where the second-hand price is significantly below the purchase cost of a new vessel, i.e. people will stop ordering new ships. The scrapping of old fleet will bring the demand-supply into balance over time.

However, the self-correcting mechanism is more complex as the adjustment process is exacerbated by the lag-time between ordering a vessel and receiving it, i.e. during normal market environments it takes approximately 18-months from handing in an order to the delivery of a vessel (Stopford, 2009). During cyclical peaks the lead times can extend up to 5 years (Clarksons, 2015). Given the volatility of the industry and the delivery lag, the situation in the dry bulk market can change considerably by the time one receives the vessel and deploys it for cargo haulage. Despite this, over multiple years the rates earned on vessels should be converging towards a rate that provides buyers of new vessels with a decent return on capital invested. Large divergences from this rate are unsustainable for longer periods of time from an economics perspective.

The newbuild equivalent TC rate is the level that would allow the ship to cover its operating expenses and earn a reasonable return to its capital provides (both debt- and shareholders). The formula for finding this equilibrium TC rate is the following:

$$(3): Newbuilding\ cost = \sum_{n=1}^{age} \frac{(required\ time\ charter\ rate - operating\ costs)}{(1 + discount\ rate)^n} + \frac{scrap\ value}{(1 + discount\ rate)^{age}}$$

The un-known in the equation is the *required time charter / newbuild equivalent TC rate*

All the other variables are given:

- *Newbuilding cost:* obtained from Clarksons
- *age(economic life of vessel):* taken to be 25 years for Panamax and Handymax, 22 for Capesize
- *operating costs:* taken from Moore Stephens survey and prior to 2000 based on US inflation
- *discount rate:* the weighted average cost of capital (see discount rate)

The model is solved with the objective that the ship's discounted cash flows using the *required time charter rate* equal the cost of building a new vessel.

The method used is relatively simplistic and suffers from few potential sources of error. The caveats of the replacement cost approach are discussed more thoroughly in the discussion section.

Figure 8 illustrates the TC rates obtained from Equation (3) and contrasts them with the actual 3-year rate. As expected the most significant deviation from market rates takes place during 2007-08 which marked the height of the dry bulk boom. The reason for the newbuild equivalent TC rate peaking right after the shipping bubble had burst and its subsequent slow adjustment is due to the stickiness of the newbuilding price. The theories and justifications for such mispricing will be further explored in the discussion section.

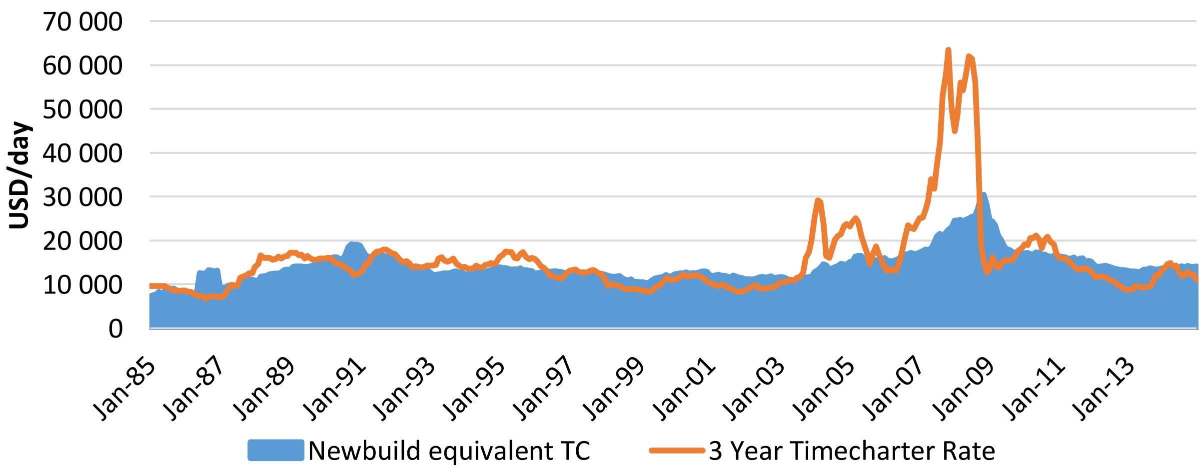

Figure 8. Panamax replacement cost equivalent TC rates and 3-year time charter rate
Source: Clarksons; author's calculations

V. Predictability of actual subsequent returns

The first research question asks whether there is a noticeable cyclical component in the valuation of second-hand vessels. The second tests whether the valuation models developed are able to forecast subsequent outcomes, i.e. will the *ex-ante* predicted return correlate with the *ex-post* actual returns from owning a vessel.

The litmus test of a valuation model is to measure the forecasted results against actual returns. This segment explains how the test will be conducted, the methodology behind valuation *buckets* and their ability to predict the subsequent return on second-hand bulkers. The approach is inspired by GMO LLC which every month publishes a 7-year return forecasts for various securities (e.g. US / International stocks, bonds and real assets). Their predictions are based on the current valuation of the asset and its historical earnings power (Economist, 2013). According to Barry et al (2014) their forecasts have been accurate over the medium term. Although, this paper will not follow their valuation method, it employs the gist of their approach, i.e. how does the current valuation translate to future returns. The following section will explain the details of the return calculation and the basis of the division into valuation *buckets.*

A. Valuation "buckets"

Each valuation *bucket* relates to a range of under- / overvaluation of a second-hand vessel against a measure of intrinsic value. Therefore, all the data points that belong to a specific range of valuation are grouped together and the average is taken to indicate the average return outcome while belonging into a specific valuation *bucket.* Depending on the valuation measures obtained they range from more than 40% overvalued to over 60% undervalued. In order to save space the ">40% overvalued" bucket contains all the observation that were more than 40% overvalued, i.e. the range of possible outcomes is more than the 20% for other *buckets*. Similarly, the ">60% overvalued" contains all observations above this valuation measure.

Table 3. Valuation "buckets"

>40% overvalued	40-20% overvalued	20-0% overvalued	0-20% undervalued	20-40% undervalued	40-60% undervalued	>60% undervalued
According to the intrinsic value model the second-hand vessel is very expensive – SELL second-hand vessels	*According to the intrinsic value model the second-hand vessel is expensive – SELL / DO NOT BUY second-hand vessels*	*According to the intrinsic value model the second-hand vessel is somewhat expensive*	*According to the intrinsic value model the second-hand vessel is somewhat cheap*	*According to the intrinsic value model the second-hand vessel is cheap – consider buying second-hand vessels*	*According to the intrinsic value model the second-hand vessel is very cheap – BUY second-hand vessels*	*According to the intrinsic value model the second-hand vessel is REALLY cheap – BUY second-hand vessels*

B. 7-year IRR calculation

Equation (4) calculates the investor IRR earned from ownership of a second-hand vessel for a period of 7 years. The return calculation involves the following steps. At the start of the 7-year period a 5-year old second-hand vessel is purchased using the prevailing market value provided by Clarksons. The vessel is deployed using the currently prevailing 3-year TC rates for a period of 3 years after which a new 3-year TC is locked in for the subsequent 3-years etc. until the end of the contract. End of year 7, the vessel is sold for the depreciation adjusted second-hand price prevailing at that time.

(4): $IRR\ calculation$:

$$-Purchase\ price + \sum_{i=1}^{7} \frac{(3year\ timecharter\ rate - operating\ costs)}{(1+IRR)^{i}} + \frac{Selling\ price}{(1+IRR)^{7}}$$

The following equation is solved for the correct IRR to arrive at the actual return generated during the 7-year holding period. Afterwards actual IRR and valuation *bucket* are paired. This allows arriving at average IRRs per each valuation *bucket.*

The actual return earned on a second-hand vessel is dependent on a number of factors. The assumptions used for this paper are outlined below.

Table 4. Assumptions behind actual 7-year return calculation

Item	***Assumption***
Holding period	7-year period is chosen as it is approximate the average duration of an economic cycle (OECD, 2005). One of the pioneers of the approach – GMO LLC – also uses a 7y period.
Purchase price	The second-hand vessel value at the beginning of a 7-year period. Obtained from Clarksons database.
Selling price	The second-hand vessel price at end of the 7-year holding period. During its ownership the original ship has become 7 year older. Linear depreciation is the industry practice. However, linear depreciation fails to account for the scrap value of a vessel. The joint effect is linear depreciation down to scrap value Simple linear approximation yields that a 12-year old vessel is 65% of the value of a 5-year old Handy-, Panamax and 59% of a Capesize second-hand vessel.
Net vessel earnings	Calculation method is similar to *Equation (1)*. The time charter rate used for the first 3-year period is the currently prevailing 3 TC rate. For years 4-6 the prevailing 3 TC rate at the start of year 4 is used. Similar logic applies to year 7. The operating costs are adjusted annually.
TC rate adjustment for older vessels	In similar fashion to the intrinsic value calculation, the TC rate is adjusted downward for older vessels (see Appendix II).
Days of operation	On average the ships spend around 8 days a year in maintenance; 100% utilization; 357 operating days
Inflation	All figures used are in nominal terms. Difficult to justify any particular inflation rate to apply.
Maintenance expenses	Maintenance and repair expenses, which are not accounted under opex, are not taken into account that is likely to overstate the IRRs. However, there is little reason to expect that the ranking between valuation buckets would be impacted by the exclusion.

Sources: Navios Maritime, 2014; Barry *et al*, 2014

4. Results

I. Cyclically adjusted vessel value vs second-hand price

This section will describe the results from the CAE approach using average and median 10-year trailing time charter rates as basis for intrinsic value calculation. For sake of conciseness results for only selected vessels types will be shown.

A. Average 10-year trailing cyclically adjusted earnings approach

The first thing to note about the cyclically adjusted average approach is the volatility of the net vessel earnings development over time. Even after using 10-year trailing time charter rates there is considerable variation in rates earned.

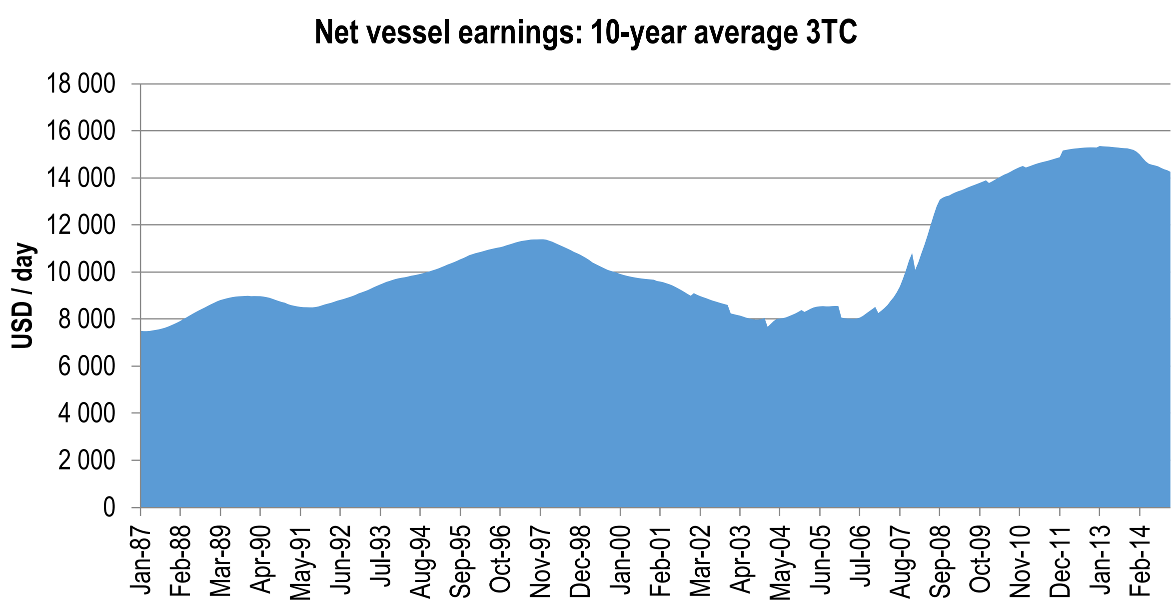

Figure 9. Panamax 10-year average net vessel earnings
Source: Clarksons, author's calculations

Figure 9 illustrates that using smoothed 10-year average does not stop the earnings stream from vessel ownership fluctuating in a wide band. The jump in the 10-year average from 2008 also makes the CAE intrinsic value of vessels to change significantly within a period of a few years.

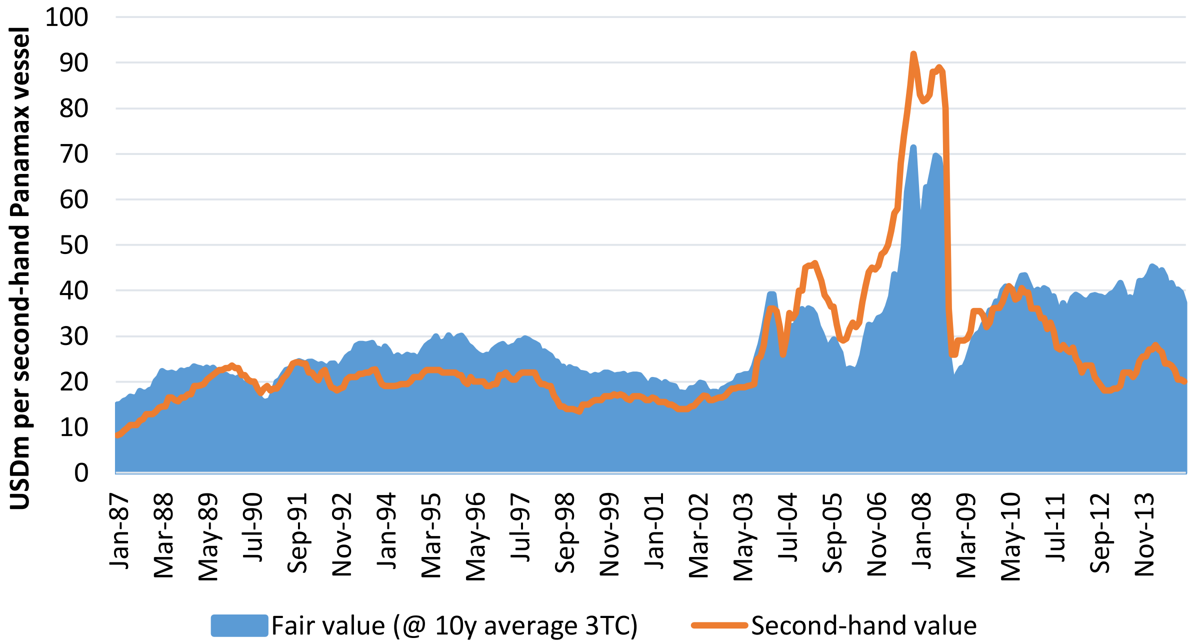

Figure 10. Panamax Intrinsic value using 10-year CAE and second-hand value of vessel
Source: Clarksons; authors calculations

Figure 10 illustrates the magnitude of price changes in dry bulk shipping sector with second-hand vessel prices tripling in value in a few years and then dropping down to their previous level within a few months. The intrinsic value measure is less volatile but still moves significantly during certain periods. This is driven by three factors:

1. Cyclically Adjusted Earnings (CAE) change from the latest TC rates entering the average calculation and from the rates older than 10 years being removed from the average measure.

2. The first three years of earnings for *intrinsic value* is obtained from the currently prevailing 3-year time charter rate, i.e. a high (low) current rate will mean that the ship will earn high (low) returns for a period of 3 years after which the average will be used.

3. Discount rates change within the economic cycle. Generally during economic expansions (recessions), the perceived risks of lending decline (increase) which results in a lower (higher) cost of debt. Lower (higher) interest costs translate to decreasing (increasing) WACC that boosts (reduces) intrinsic value.

Each of the three factors either increases or lowers the intrinsic value measure. For instance, from Jan – Nov 2007 the Panamax intrinsic value measure doubled, despite the fact that the discount rate and CAE almost did not change. However, due to the prevailing very high 3-year time charter rates, ships were able to earn extremely high incomes during the first three years, which doubled their discounted cash flow value.

Similarly, the sharp subsequent drop at the end of 2008 was driven by both reduced prevailing TC rates and significantly higher discount rates. The large gap between the intrinsic value and second-hand vessel post 2010 is a combination of high CAE from boom years and declining discount rate.

The following graph intends to make the extent of deviation between intrinsic value and actual second-hand prices in the market easier to follow. It shows the undervaluation / (overvaluation) of second-hand vessel in relation to the intrinsic value measure for all three vessel types.

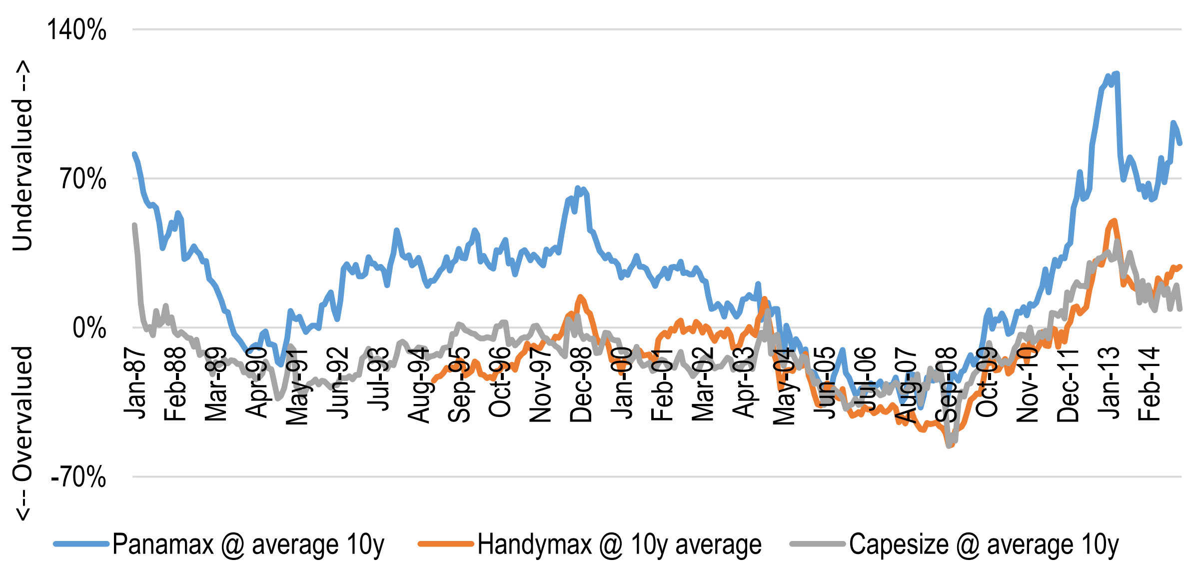

Figure 11. Cheapness / (expensiveness) of second-hand vessel vs *intrinsic value* using average 10-year CAE
Source: Clarksons; author's calculations

The measure for Handymax vessel starts from Jan 1995 as the reference rate is only published from Jan 1985 and the intrinsic value measure requires at least 10 year of earnings data before it can provide an accurate valuation. According to the 10-year average CAE approach the second-hand price has deviated significantly for all 3 types of vessels during the past 28 years.

The 3 vessel types are following similar under- and overvaluation patterns for the observable period. However, it seems that the Panamax vessel type has generally remained more undervalued than the other two vessel categories.

B. Median 10-year trailing cyclically adjusted earnings approach

As mentioned in the methodology section, the simple average is significantly impacted by extreme values, e.g. during a shipping boom. Using the median CAE allows to smooth the data and get a better approximation of intrinsic value across the cycle.

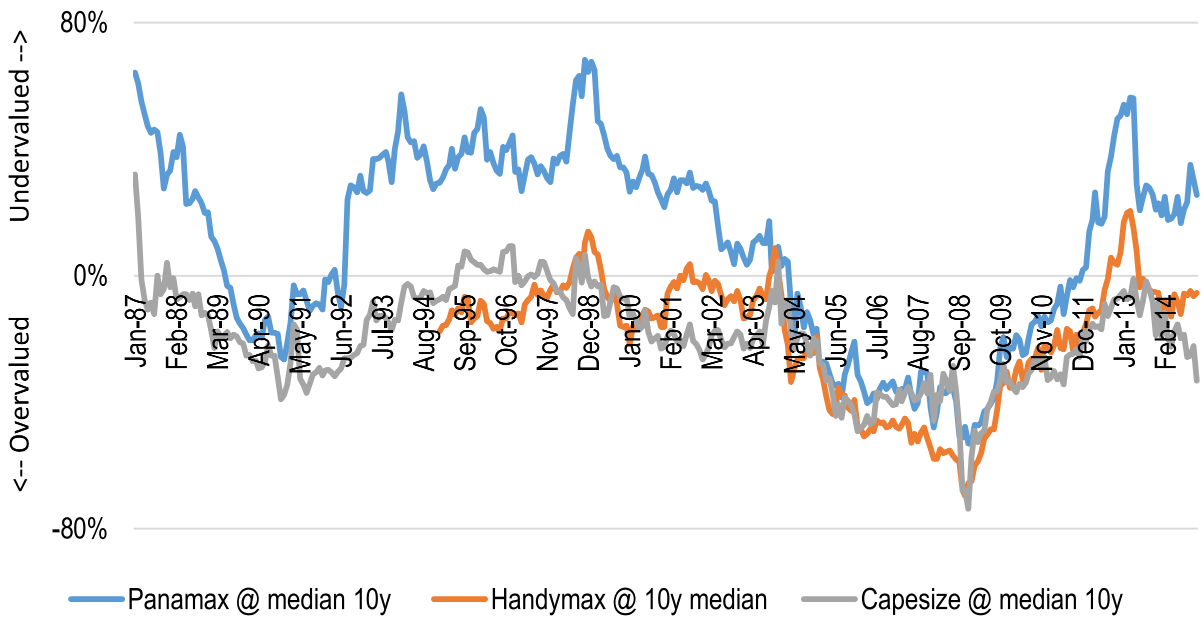

Figure 12. Cheapness / (expensiveness) of second-hand vessel vs *intrinsic value* using median 10-year CAE
Source: author's calculations

In comparison to the 10-year average intrinsic values the median approach significantly reduces the extent of the undervaluation. In addition, the overvaluation is made even more evident during 2005-09. This result provides basis to believe that median values serve as a better predictor of intrinsic value in shipping.

II. *Newbuild equivalent* value vs second-hand price

This paragraph will describe the outcome from the *replacement cost* approach. Here the data will be displayed from 1987 onwards for all vessel types (i.e. including Handymax) as past earnings data are not required for the computation.

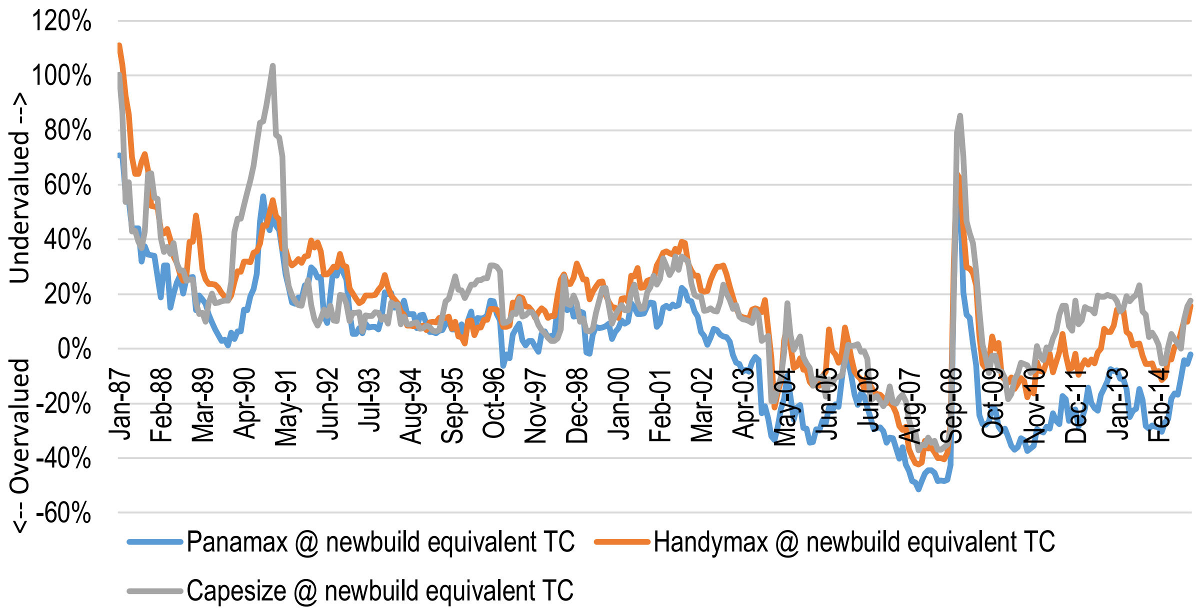

Figure 13. Cheapness / (expensiveness) of second-hand vessel vs *intrinsic value* using *newbuild equivalent TC rates*
Source: Clarksons; author's calculations

Figure 13 illustrates an almost constant underpricing of second-hand ships until 2003. This is a surprising outcome, given that for almost two decades the industry decided to order new ships instead of purchasing a 5-year old second-hand vessel from the open market. Ignoring the fact that used ships would have earned significantly higher rates on capital than newbuildings.

A possible explanation is the inability of the relatively simplistic valuation model to accurately account for all relevant factors. For instance, it might be that before the new millennium *newbuild* technology was far more superior and/or cost-efficient than other vessel and continued rapidly evolving during the whole period. However, it does not seem plausible as the TC rate discounts and fuel-efficiency adjustment have been researched empirically and incorporated into the model. A possible cause is regulation or similar constraints that put second-hand vessels at a significant disadvantage, e.g. similar to a double-hull requirement for tankers (Brown & Savage, 1996). However, the author is not aware of any regulation that might impact the value of second-hand vessels to such an extent.

One realistic explanation might be that similarly to the used car market, second-hand vessel market is a *lemons market* and a result second-hand vessels trade at significant discounts. Another issue might be the lack of transparent and well-functioning markets for second-hand vessels prior to 2003. Hence, it was more convenient to order new rather than buy used.

The large jump from under- to overvaluation in end of 2008 is a product of the disconnect between second-hand and newbuilding prices, i.e. second-hand values declined significantly faster and in greater magnitude than newbuilding prices. Hence, from Oct-08 till May-09 the newbuild equivalent approach shows significant undervaluation. In hindsight, it is fairly obvious that newbuilding price was slow to react to the changed market conditions. Therefore, the amount of overvaluation according to the newbuild equivalent approach is not representative of the underlying economic fundamentals. Proper adjustment in the newbuilding price using delivery lag and payment schedules would eliminate or significantly reduce the jump observed on the graph. The discussion part will further explain caveats and possible remedies for using the newbuilding price as an exogenous variable.

III. Predicted vs actual returns

Given the multiple valuation methods and multiple asset classes it is impractical to show all the *valuation-vessel type* pairs. Hence, a few examples from each will be presented. As previously, the results will be divided according to CAE and newbuild equivalent approach.

A. Cyclically Adjusted Earning valuation and 7-year IRR

The direct output from the valuation vs actual 7-year returns is the following matrix.

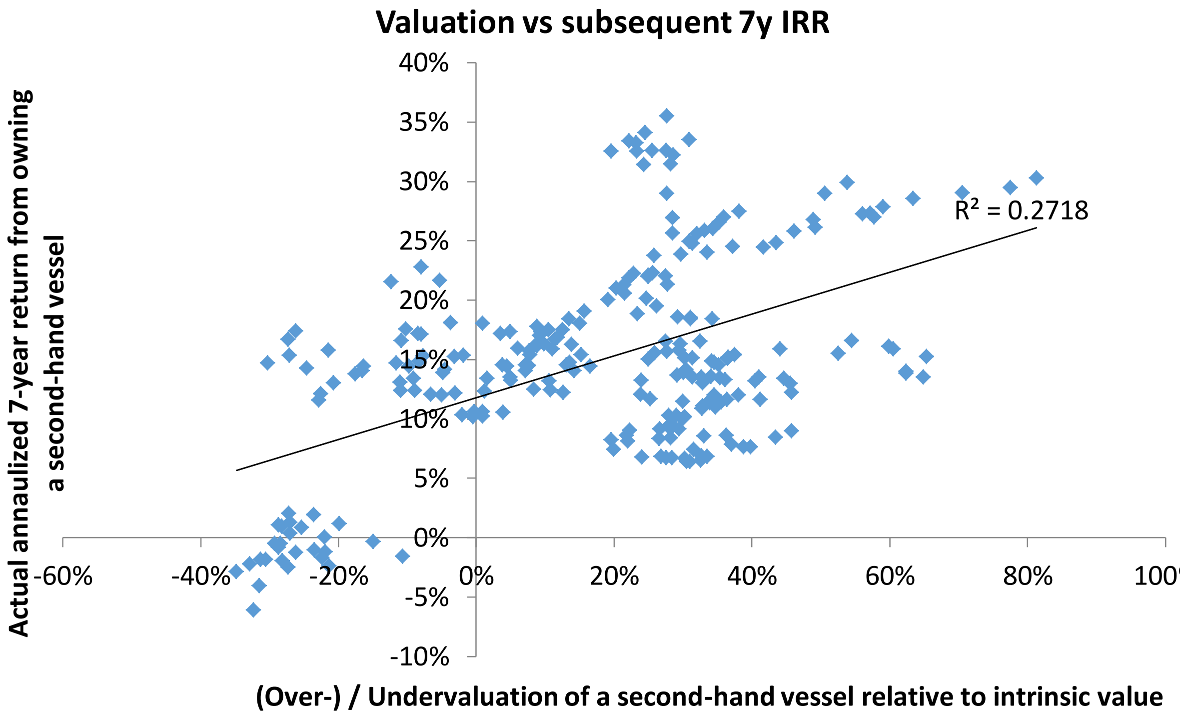

Figure 14. Second-hand Panamax return and valuation matrix using the 10-y average earnings approach
Source: author's calculations

Each data point in this graph represents a monthly observation of the valuation level for a second-hand vessel and its subsequent 7-year return. In total there are 252 observations spanning from Jan 1987 – Dec 2007, i.e. 21 years of data. The linear regression yields an R-squared of 27%, which is not particularly high. However, looking at the graph you can observe a trend where annualized returns grow as the second-hand vessel becomes more undervalued. However the return data is far from ideal with large clustering around specific areas. This is due to the usage of overlapping data periods. Also, there are large variations within the areas with similar valuation levels.

The relationship between valuation level and actual returns is made easier to spot using the following graph:

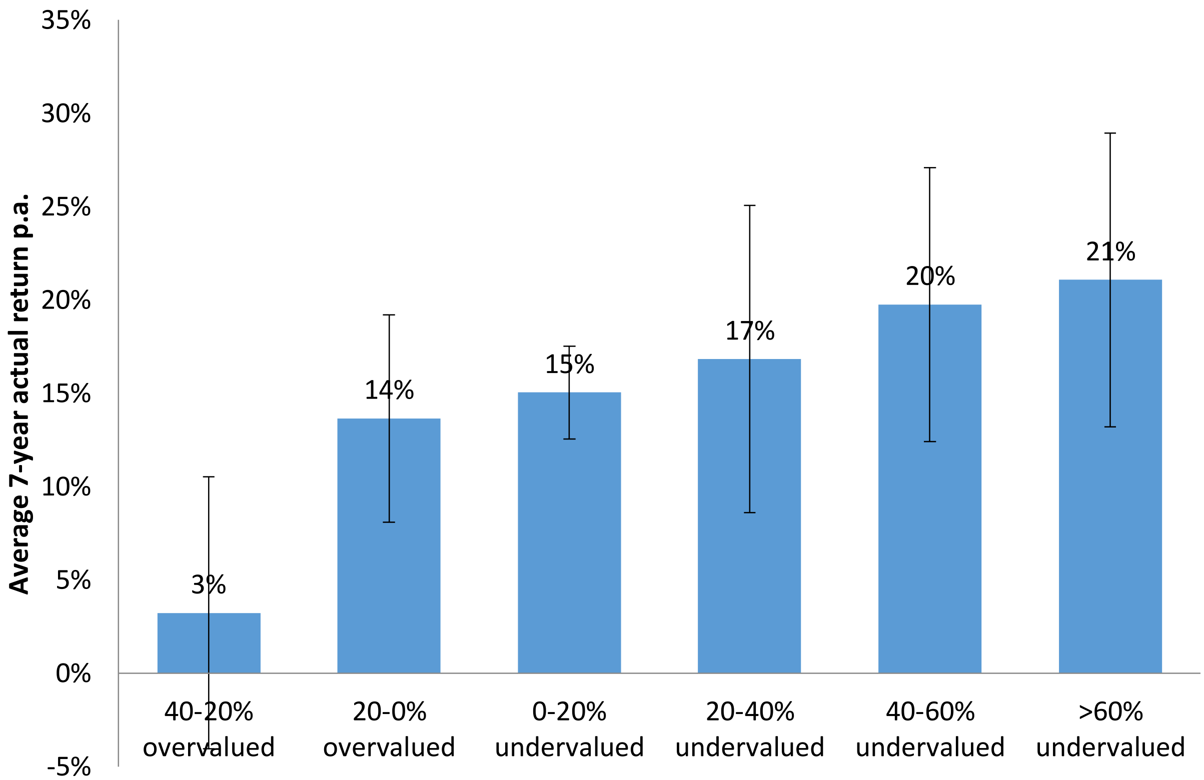

Figure 15. Annualized returns according to valuation rankings for Panamax vessel using 10-y average earnings; black bars represent one standard deviation of returns
Source: author's calculations

Figure 15 was compiled by taking the average 7-year IRRs according to valuation *buckets*. There is a clear distinction between actual returns and bulker's valuation level, which serves as compelling evidence for the model's ability to predict subsequent returns. This particular graph corresponds to the Panamax vessel using the 10-y average CAE valuation approach. Similar results apply to median CAE approach**.** The results obtained for the Handymax class vessel are very similar to the Panamax' results indicated above. However, for Capesize the R-squared is significantly smaller and the valuation and actual return ranking is not as accurate as for other vessel types.

Nevertheless, looking at the black bars which represent +/- one standard deviation from the returns sample, it becomes evident that there is considerable return variation within each valuation bucket.

It is important to remember that the data employs overlapping 7-year return periods in the construction of the statistical estimates. Presence of strong autocorrelation creates a moving average error term which yields inefficient and biased parameter estimates (Hansen & Hodrick, 1980). This paper will refrain from using more advanced methods to adjust for the possible biases due to lack of numerical hypothesis testing. However, the reader should be aware that the unbiased standard errors are expected to be larger than presented here.

B. *Newbuild equivalent* approach and 7-y IRR

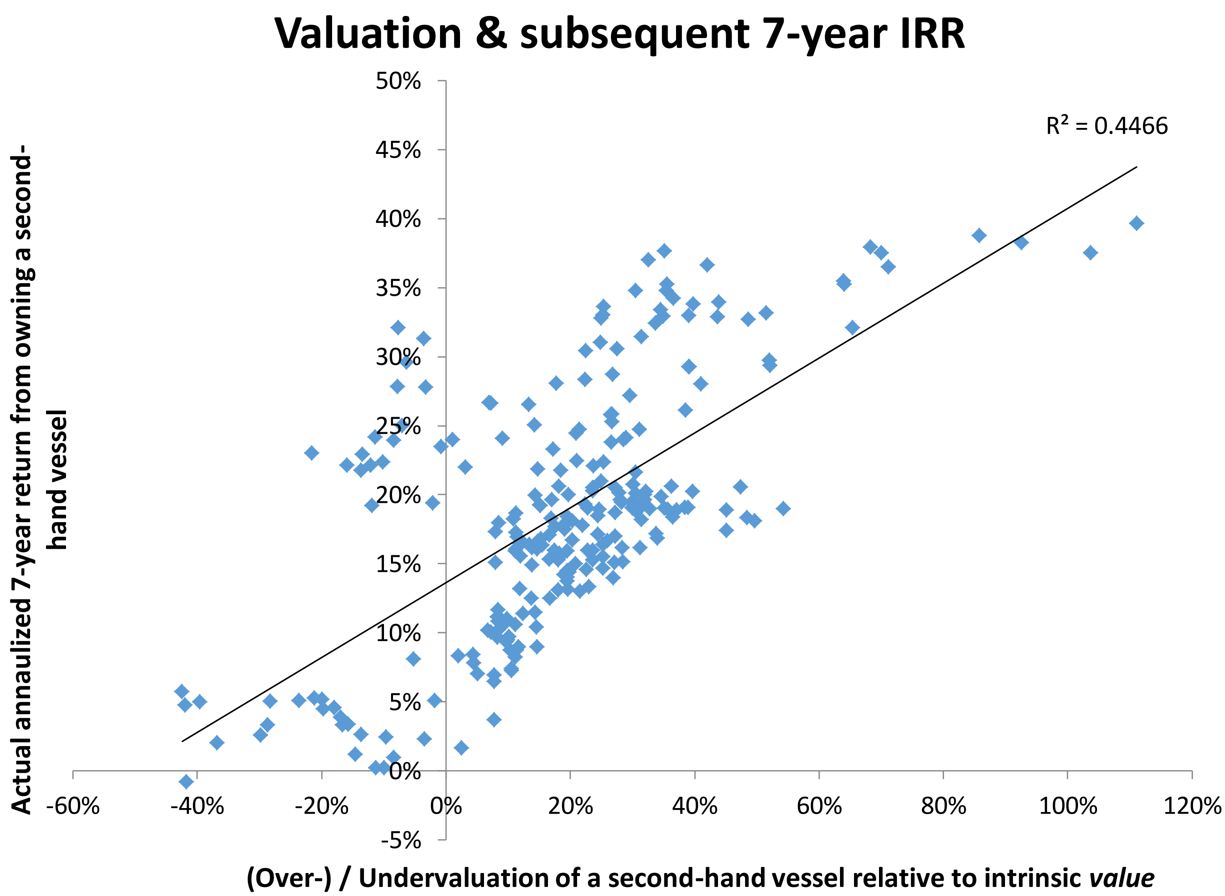

Figure 16 Second-hand Handymax return and valuation matrix using the newbuild equivalent earnings approach
Source: author's calculation

Figure 16 displays the matrix for *newbuild equivalent* approach also consisting of 252 data points. The R-squared is 44% and visual analysis also confirms a good linear fit. Compared to the average CAE approach the data is less clustered, which provides reasons to believe the model is less dependent on a specific period return pattern. A visual inspection confirms that the return distribution within valuation buckets is much less dispersed as well.

A surprising outcome in comparison to other vessel types is the almost complete lack of negative 7-year annual returns. Similarly there are fewer years of extremely high returns, suggesting that Handymax vessel have a more stable return profile. Also the average 7-year return of 19% is significantly higher than the average IRR for Panamax (15%) and Capesize (13%).

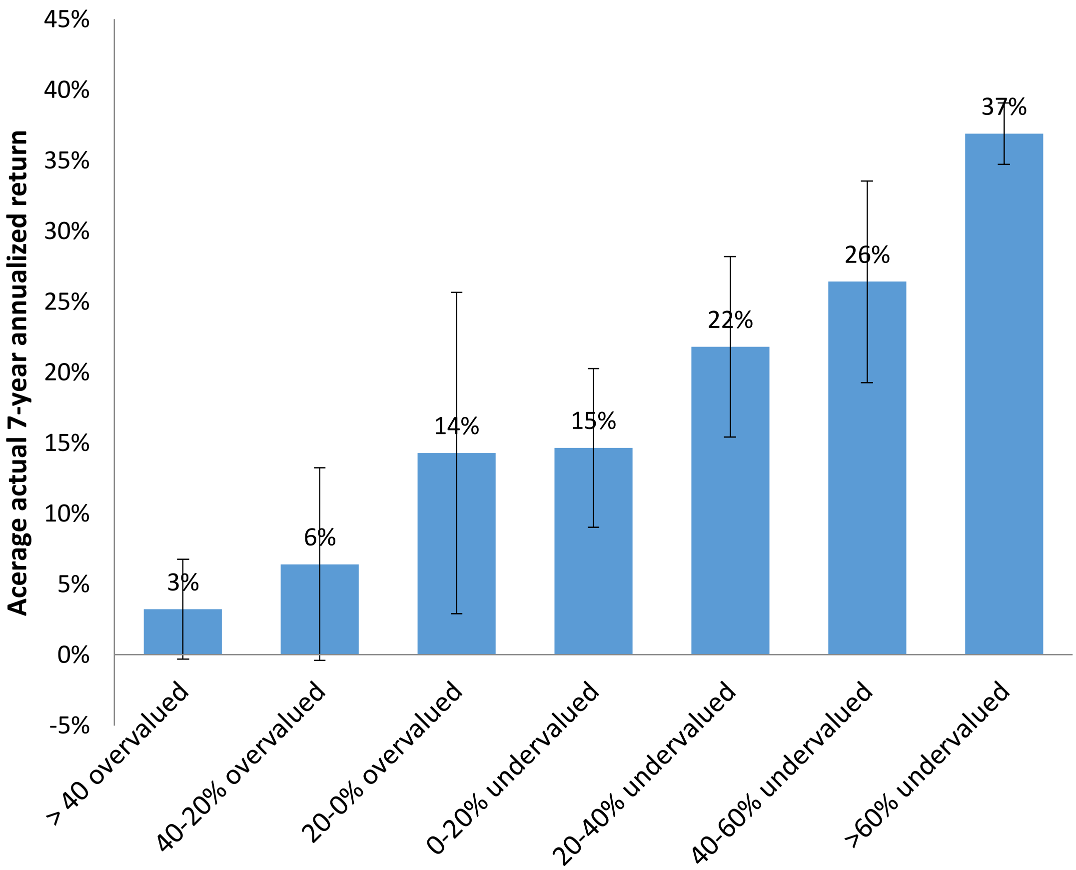

Figure 17. Annualized returns according to valuation rankings for Handymax vessel using 10-y newbuild equivalent earnings; black bars represent one standard deviation of returns
Source: author's calculations

The graph above was compiled by taking the average 7-year IRRs according to valuation clusters. There is a clear ranking between actual returns and bulker's valuation level moving from over- to undervaluation. This outcome provides support evidence for the newbuild equivalent intrinsic value method being able to predict future return outcomes with reasonable accuracy.

In general both Panamax and Capesize results are similar to the ones presented for Handymax above. However, in all methods the predicting power and R-squared for Capesize vessels is significantly less than for the 2 smaller vessel classes. Most likely the Capesize valuation contains other factors that are not correctly accounted for by the valuation methods or this vessel category is simply less predictable. The discussion section will explore possible explanations for this phenomenon.

5. Discussion

I. Is there evidence of systematic bias in second-hand vessel pricing in dry bulk shipping?

To answer the research question a definition of systematic bias is required. This paper considers a systematic bias to be relatively accurately predictable with significant deviations from a measure of intrinsic value cycling between under- and overvaluation (and rarely staying close to its fundamental value).

There is no clear quantitative criterion to test for the presence of a systematic bias. One can mainly rely on observational assessment. The matter is further complicated by the different outputs from each valuation method. For instance, according to the newbuild equivalent approach the second-hand market has been undervalued for most of the observable period. The cyclically adjusted measures provide a more balanced picture between under- and overvaluation. This outcome is expected as the underlying driver of performance for the two methods differs. The newbuild equivalent approach is based on the newbuilding price and its relationship to the second-hand value. Whereas the CAE approach uses historical TC rates to gauge the intrinsic value of a vessel.

The evidence for cyclicality also varies by vessel type. The Panamax vessel class is displaying a significant degree of cyclicality and assessing the whole sector based on this particular size-class would lead to the conclusion of irrational investment behavior. However, the remaining types of vessels display much less cyclicality when using the three valuation methods.

Therefore, there is little evidence that would indicate a predictable cycle of over- and undervaluation across the whole dry bulk sector. However, the author understands why the original research conducted by Greenwood and Hansen (2014) on the Panamax vessel alone lead them to conclusion of investment irrationality.

A. Differences with prior research

As mentioned in the introduction, one of the aims of this paper was to either find supporting or contradicting evidence to the findings of Greenwood and Hansen (2014). Their paper concludes that the variation in returns on capital is predictable and that companies operating in the dry bulk space make modest expectation errors which lead to excess volatility in investment and prices.

Among the motivations of this paper was to refine the simplistic valuation method used and see whether the results still hold. The primary shortcomings eliminated for vessel intrinsic value calculation were the following:

- *Eliminate look-ahead bias in TC rates*: Greenwood and Hansen (2014) use constant real gross earnings estimate of 5.4$m per year for the whole sample period, which is the sample average rate. This is an unrealistic assumption given that nobody has knowledge about future TC rates.
  This paper uses the 10-year average available until the moment of the valuation. For instance, in estimating the CAE intrinsic value of a Panamax vessel in 1995, the cyclical earnings are taken from years 1985-1995, i.e. the necessary data that is available at the time of the evaluation.

- *Use time-varying discount rate*: Their paper uses a constant 13% real discount rate over the entire sample, calculated such that the average model-based price is close to time-series average. First, this is another example of look-ahead bias, were authors are using information that was not available at the time of the valuation. Secondly, capital market conditions have changed considerably over the past decades with a general decline in interest rates / discount rates (see Figure 3). Failing to account for this will overvalue vessels during earlier high interest rate periods and undervalue them during periods of low interest rates, such as the last 5 years.

- *Adjustment for TC rates given vessel age*: They together with previous authors have used the assumption that once a vessel is 15 years old its earnings are reduced by 15%. Empirical results indicate a non-linear relationship between market reference rate and vessel age, with significantly larger discounts to the reference rate occurring in later stages of a vessels life (see Figure 5).

- *3-year time charter rate vs 1-year*: Using a longer-term time charter fixture is a better gauge of the medium-term market expectation, acting as "weighted-average" time charter curve. Therefore, the 3-year TC rate is generally smoother and less volatile providing a better proxy of the market medium-term view. Although, the counterparty risk aspect is more pertinent for longer-term than for a short term charter, which was not taken into account in either research methodology.
- *Use three different vessel size-classes:* They performed intrinsic value calculations only on the Panamax ship type. As was discovered in this paper, there are substantial differences in vessel valuations using CAE approach between the vessel classes. In addition, the return achieved on smaller vessels significantly outperformed larger ship classes. According to this paper's findings the Panamax displayed the highest level of cyclicality and based on the CAE approach would provide sufficient evidence to claim investment irrationality. However, it is dangerous to make arguments about the whole sector based on only one type of vessel.

The addition of the above-mentioned adjustments provides a significantly different picture for a cyclically adjusted NPV value of a vessel, i.e. the dry bulk market is not predictably irrational as previously found.

II. Is it possible to predict returns from owning a dry bulk vessel?

The second research question asks whether the valuation methods are able to predict the future profitability from vessel ownership. The findings show that all three models are able to forecast the average return given a particular valuation level for a second-hand vessel in relation to the models intrinsic value. However, it is important to note that the predicting power is model and vessel dependent.

Figure 18 indicates that despite slight differences in the predicting accuracy and clarity of actual return ranking, all three methods provide relatively similar results. Comparable outcomes apply to Handymax and Capesize vessel classes as well.

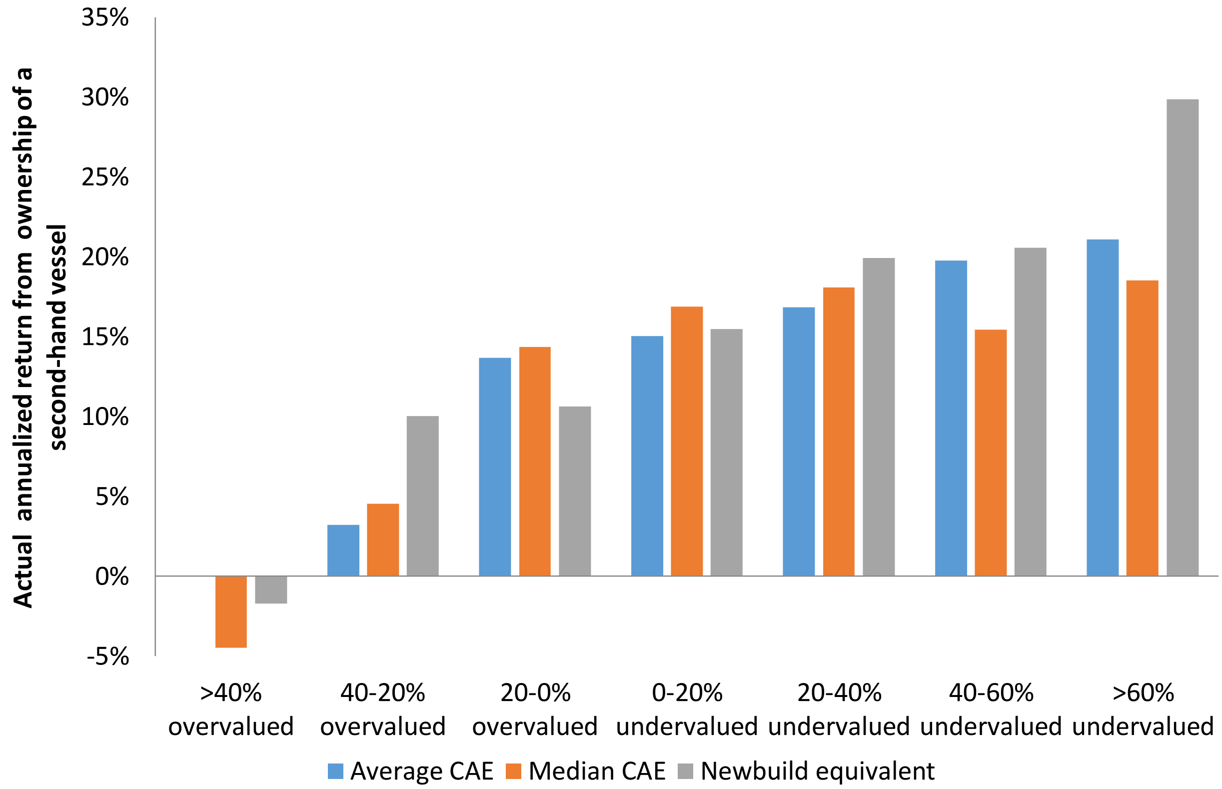

Figure 18 Valuation bucket and subsequent 7-year annual return for Panamax vessel for the three valuation methods
Source: author's calculations

The graph illustrates that the extent of overvaluation is methodology dependent. For instance, the average CAE approache does not have observations that are over 40% overvalued. The valuation buckets were mainly chosen for the sake of clarity and better visualization of the results.

Generally, the *newbuild equivalent* approach is most capable in ranking and forecasting actual future returns across all three vessel categories. As previously mentioned there is considerable variation among each size category. What clearly stands out from Figure 19 is the fact that 7-year annualized earnings have been substantially higher for smaller vessels with Handymax earnings the highest returns and Capesize the smallest. In addition, the range of expected returns seem to be influenced by the size of vessel classes as well. The starting valuation level influences subsequent returns most for Handymax category and least for the Capesize segment.

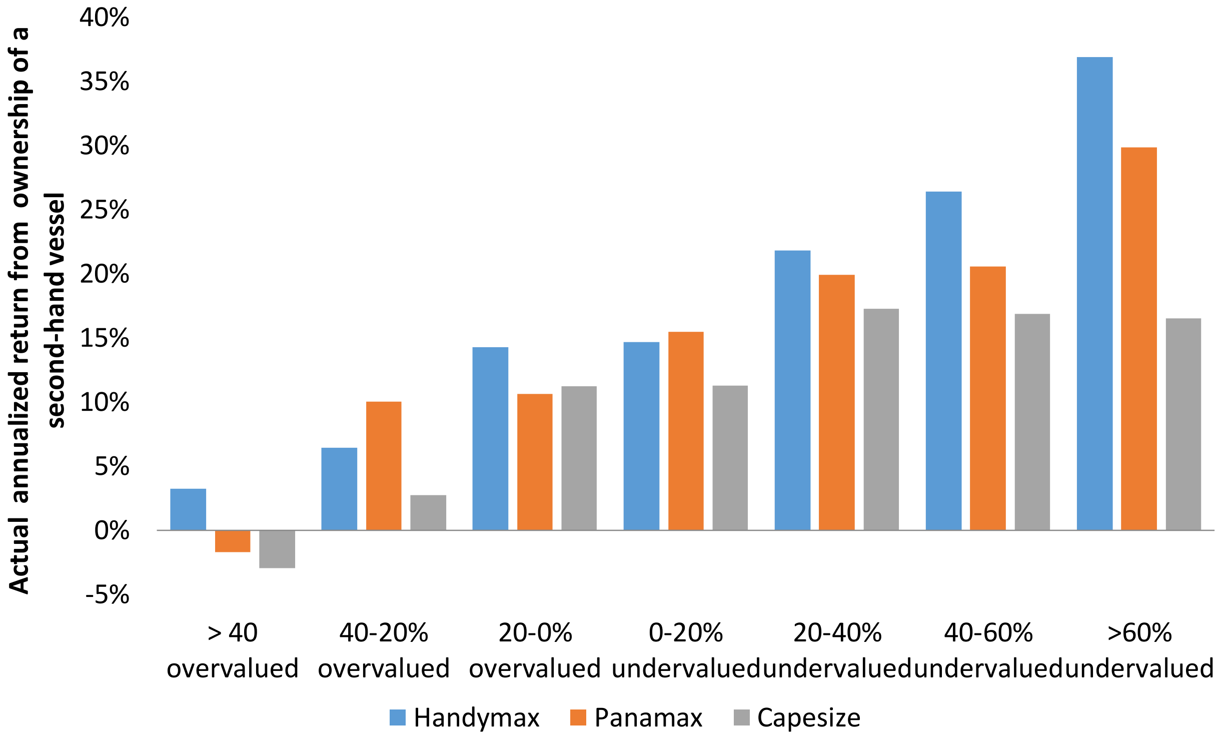

Figure 19 Newbuild equivalent method valuation bucket and subsequent 7-year IRRs for all three vessel types
Source: author's calculations

As previously mentioned, the 150 th DWT segment seems to be least predictable by any of the valuation methods. The most likely explanation is the extreme volatility in the TC rates and very low earnings for sustained periods. Most likely the inaccuracy stems from the stickiness of the newbuild prices to adjust to new market conditions. On the other hand, the extreme variability should favor cyclically adjusted measures making under- and overvaluation even more pronounced.

In conclusion, the answer to the second research question is affirmative: the valuation methods are on able to predict average subsequent investment returns from owning a bulker.

III. *Replacement cost* approach higher explanatory power

For all three types of bulkers, the *newbuild equivalent* approach was most capable in predicting and ranking subsequent 7-year ship owner IRRs. This adds to the literature on the applicability of the *replacement cost* approach not only in stock markets but also in dry bulk shipping.

It seems that in bulk shipping *replacement value* is also among the best predictors of expected returns. The fundamental logic of purchasing second-hand vessels from the market if it is more expensive to build, and vice versa, still holds.

One of most surprising outcomes from the research has been the constant underpricing of second-hand vessels is relation to newbuilds. For most of the analyzable period and especially before the new millenium, buying a second-hand was considerably less expensive than purchasing an appropriately age-adjusted newbuilding. This fact is also supported by the high actual returns achieved across all three vessel categories, i.e. average IRRs for Handymax 19%, Panamax 15% Capesize 13%. Average returns on newbuilds are substantially lower due to their relative expensiveness compared to second-hand ships, which results in lower return on investment.

A. Cyclically Adjusted Earnings relatively low explanatory power

It seems that the cyclically adjusted measures are less capable in predicting returns due to long spells of very low earnings and a few years of extremely high earnings which is characteristics to the dry bulk sector. Earnings volatility in the securities markets is comparatively smaller; especially as most research is conducted on the overall market instead of a particular sector. Basing earnings on a wider more diversified sample evens out earnings and sector cycles. On the other hand, this paper is concentrated on a single inherently volatile market, which explains why CAE approach is less capable in predicting returns in the dry bulk industry.

Another possible explanation for the weak performance is the selection of the evaluation period. The 10-year earnings period was based on Campbell and Shiller (1998) and the 7-year actual return period was based on GMO asset forecast methodology. However, it might be that a longer period might be appropriate to properly capture the whole cycle in dry bulk shipping.

The author tested whether the exclusion of the boom period of 2003-2008 would change the results. Leaving out these years reduced the predicting power of the valuation models, suggesting that extreme volatility actually improves the model’s accuracy. This finding supports the notion that the predicting power of the model is period-specific.

B. Caveats of the newbuild equivalent method

Despite its superior forecasting performance, there are a number of issues that the model in its current form is unable to account for.

Adland and Jia (2014) found that newbuilding prices are not comparable across time due the variation in the delivery lag and payment schedules of the vessels. They conclude that newbuilding prices and second-hand values are connected and differ only in the time they generate revenue. Hence, newbuilding prices are not *exogenous* and not based on fixed assumptions throughout the time-series analyzed which can significantly impact the predicting power of the newbuilding approach model. Kalouptsidi (2014) similarly finds that shortening the delivery lag reduces the prices of newbuilings, which indicates newbuilding price is not driven by the underlying cost of the vessel. These results provide a basis to believe that the accuracy of the *replacement cost* method is impaired in its current form.

The deviation between actual construction cost and the quoted newbuilding price is the strongest when shipbuilding capacity is fully utilized. Due to lack of additional shipbuilding capacity the newbuilding price becomes a function of the second-hand value and is removed from actual vessel construction costs. Disconnect from fundamentals can last for multiple years as shipbuilding capacity takes a long time to add. For instance, the period from 2003- 08 saw large growth in the demand for various types of ships in addition to bulkers, i.e. LNG transportation, containers etc. Clarksons (2015) estimates that the *forward cover* for shipyards stood above 4 years from 2005-09, which indicates that newbuild capacity was fully utilized, i.e. exogeneity of newbuilding price is questionable during this time-window.

In order to improve upon the current results, the impact of the delivery schedules and payment terms ought to be stripped from the quoted newbuilding price to arrive at a "clean" figure. This logic might be among the potential reasons for the better forecasting accuracy of the Handymax *newbuild equivalent* method as smaller shipyards were less overbooked and the newbuilding cost was closer to its "clean" price. Similarly, it might be among the reasons for the low predictability in the Capesize segment. Unfortunately, testing for this and making adjustments for the delivery lag are outside the scope of this paper.

IV. What expectations would justify shipping bubble pricing?

For numerous times this paper has referred to the extremely high pricing during the shipping boom from 2007-08. This section will try to see what expectation would justify the pricing witnessed during these years.

In the history of dry bulk shipping there are brief periods where second-hand vessels are priced above *newbuilds*, i.e. the market is valuing a 5-year old used ship more than a brand new vessel. The only reasonable justification is the excess profits earned during the time the newbuild is being delivered, as the return will be identical (after adjusting for the age effect) once both of the vessels are operational.

According to Danish Ship Finance (2007) the delivery time of a newbuild vessel during the peak year was in excess of 3 years. Therefore, a newbuild vessel would not be able to earn the high market rates for a whole 3-year TC period and possibly longer. Given the extremely high 3-year TC rates witnessed during the second half of 2007 till august 2008 the actual rates that you can earn by deploying a vessel immediately to the market – instead of waiting over three years for delivery – would justify the premium of second-hand vessels over newbuilds.

Therefore, one cannot conclude irrational pricing based on the notion that second-hand prices stood significantly above those of new ships. Adland *et al* (2006a) arrived at similar conclusions for the years 2003-05. Their findings even suggest that second-hand vessels were undervalued relative to the prevailing freight market fundamentals.

V. Implications for shipping investors

Despite failing to prove the existence of a predictable cycle of under- and overvaluation within dry bulk shipping, the models developed are able to predict and rank average investment returns in accordance with the valuation level. As a result the study has a strong message to deliver to ship owners – valuation does matter for future returns.

However, it is important to bear in mind that the approach only works under longer investment horizons, i.e. 7-years and possibly even longer are required. For instance, in the first half of 2005 all three valuation measures indicated a significant overvaluation suggesting a ship owner to sell or at least stop buying second-hand dry bulk vessels. By 2008 the market value of these ships had almost doubled, by which time the *intrinsic value* measures were indicating even more overvaluation. During the subsequent years the prices at which second-hand vessels changed owners dropped fourfold. Therefore, the results presented above are only relevant for longer investment horizons and short-term returns can display extreme variation. Due to this reason, the ability to stick to an investment strategy becomes paramount to achieve superior returns on invested capital. The worst course of action is to change tactics at the top of a cycle at highly overvalued levels.

Another consideration to take into account with this investment tool is the fact that over- or undervaluation tends to persist for a long time. Therefore, it might take up to a decade before an overvalued market becomes cheap again. Staying on the sidelines can be psychologically extremely difficult for a ship owner, especially as peers are making large profits. Similar to value investors in the stock market who decide to stay in cash during boom periods (e.g. the dot-com era), it is emotionally very hard to stick to your strategy if the overvaluation endures. The career risk of being replaced due to underperformance is very much present with this strategy. Hence, this approach is suggested mainly for investors who are investing their own funds or whose investor base shares a long-term investment perspective.

All in all, given the relatively strong predicting power of the models presented in this paper, it would be highly valuable to develop even more elaborate intrinsic value models for decision-makers in dry bulk shipping. This would provide an additional tool and a gauge for the long-term perspective for investment managers in dry bulk segment.

The prospect for outperformance by using intrinsic valuation tools is significant. For instance, based on the newbuild equivalent approach the difference between expected average IRRs of purchasing a Handymax vessel in times of over- vs. undervaluation is approximately 8% p.a., for Panamax & Capesize the return differential is 5% p.a. Over a 7-year holding period it translates to earning 1.7x and 1.4x times more on your investment, respectively.

VI. Limitations of the study

Despite the comprehensive approach taken to cover as many potential shortcomings as possible there are a number of areas where the author was required to make assumption due to lack of better data or limitations of the thesis format.

First, the study covers the period from Jan 1977 - Dec 2014. Preferably the time analyzed would be even longer, however that was the longest data obtainable from Clarksons database. In addition, the valuation models start from Jan 1987 due to the intricacies of the valuation models used, i.e. need 10-years of earnings data and lack of newbuilding price and/or second-hand prices for the relevant classes of vessels.
The analysis between the valuation level and actual returns relationship spans from Jan 1987 to Dec 2007. The last second-hand price point of Dec 2014 does not allow comparing 7-year returns of earlier periods. Hence, although the study covers at a minimum a period of 21 years, it might prove too short to confirm whether this pattern exists over all dry bulk market conditions.

Second, the study assumes a constant leverage ratio of 1/3 equity and 2/3 debt; this together with the assumption about the cost of debt, required return on equity make the estimation of the WACC highly assumption-dependent. Most likely the financing terms and the average leverage levels have changed over the studied period. However, due to lack of suitable research and industry data there were no good alternative measures to use.

Finally, the study assumes that a ship owner is always able to earn the quoted time charter rate. However, there is significant counterparty risk from the side of the charterer who can turn down a time charter fixture if it is not favorable to the company. This paper will neglect the presence of a risk premium or TC contract defaults. Ideally, one would use forward freight agreements that are cleared, thus eliminating counterparty risk. However, this paper opted to use TC rates due to the time-series data dating back much further than futures.

6. Conclusion

This paper developed two underlying valuation methods to estimate the intrinsic value of a dry bulk vessel: 1) cyclically adjusted earnings inspired by Campbell and Shiller 10-year average / median approach 2) *newbuild equivalent* approach inspired by Tobin's replacement cost idea. The results from the two models indicate that there is a lack of evidence to support the existence of a systematic and predictable mispricing in the dry bulk sector across the whole spectrum of valuation methods and vessel classes. However, for the Panamax class using the cyclically adjusted earnings methods does indicate cyclicality. On the other hand, neither Handymax nor Capesize exhibited comparably clearly cyclicality in valuation. Therefore, the proposition of irrational investment behavior is rejected for the overall dry bulk sector.

The ultimate test for an intrinsic valuation model is its ability to predict subsequent investment returns. The results suggest that entry valuation is a strong predictor of average expected returns with varying degrees of accuracy across all bulker categories. In addition, the overall returns from ownership of second-hand vessels have been very positive and exceeded IRRs for newbuildings. This suggests second-hand vessels are subject to a discount in comparison to newbuildings especially prior to year 2000. What is more, the ranking of obtained returns is from smaller to larger bulker classes, with Handymax obtaining the largest average returns over the sample and Capesize the lowest.

The findings from this paper imply that starting valuation is an important predictor of long-term returns. Investors in the shipping sector should incorporate intrinsic value tools into their investment decision-making process as this can potentially deliver significantly higher returns on investment over the business cycle. In addition, having a reliable tool for long-term valuation reduces the short-term biases and provides a different perspective to gauge the potential return on investment.

The author admits there are multiple avenues of improvement from the methods presented and this area of research deserves more attention from both academics and shipping professionals going forward. This thesis provides an introductory glance into the insights to be gained from intrinsic valuation and its ability to provide superior returns to its followers.

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8. Appendix

I. Regression table: Age effect on TC rate

Age effect on obtained TC rate

	(1) Handymax	(2) Panamax	(3) Capesize
market_proxy	0.963***	0.986***	0.922***
	(102.13)	(245.91)	(81.14)
age	24.14	206.1***	295.5
	(0.47)	(7.10)	(1.80)
age^2	-7.873**	-22.19***	-49.64***
	(-2.68)	(-13.81)	(-5.22)
age_interaction_dummy	-280.4***	-243.3***	-440.6**
	(-3.32)	(-7.32)	(-2.96)
dwt_interaction_dummy	0.0377***	0.0388***	0.0252***
	(5.89)	(14.33)	(3.68)
age^2_interaction_dummy	3.551	5.057***	10.91**
	(0.80)	(4.78)	(2.86)
_cons	698.3**	-50.41	1706.6***
	(3.21)	(-0.42)	(3.37)
R^2	0.961	0.976	0.964
N	1824	5388	1406

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

II. Table: TC rate discount according to vessel age

Discount to reference rate:			
Vessel age	**Panamax**	**Handymax**	**Capesize**
0	0%	0%	0%
1	0%	0%	0%
2	0%	0%	0%
3	0%	0%	0%
4	0%	0%	0%
5	0%	0%	0%
6	0%	0%	0%
7	0%	-1%	-2%
8	0%	-2%	-4%
9	0%	-3%	-6%
10	-1%	-4%	-9%
11	-3%	-4%	-12%
12	-4%	-6%	-16%
13	-6%	-7%	-21%
14	-9%	-8%	-25%
15	-11%	-9%	-30%
16	-14%	-11%	-36%
17	-18%	-12%	-42%
18	-21%	-14%	-49%
19	-25%	-16%	-56%
20	-29%	-17%	-63%
21	-33%	-19%	-71%
22	-37%	-21%	-79%
23	-42%	-24%	
24	-47%	-26%	
25	-52%	-28%	