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Can vessel values in dry bulk be predicted?

A study on the relationship between government bond yields and vessel valuations

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Abstract

Seaborne freight of dry bulk commodities is an important gauge on the global economy. How dry bulk shipping markets move is dependent on demand and hence economic growth, further import and export volumes and commodity prices. The US and China are among the most active importers and exporters of dry bulk commodities globally, in addition to being good representatives of global economic growth. This paper investigates the interaction between dry bulk vessel valuations and economic growth with the purpose of establishing a leading indicator on vessel values, here represented by the 18-month change in US and Chinese 10-year government bond yields. The findings in this paper cast a fascinating light on the effects changes in government bond yields has on vessel values through cycles and vessel classes. The inverse relationship is stronger for the bigger vessels, albeit explaining less of the value fluctuations than its smaller peers, indicating the presence of additional influential factors. Hence, this paper provides a plethora of insight for decision-makers on whether to buy or sell dry bulk vessels within a 12-18 month time period.

1. Introduction

Keeping the global economy going requires a stable flow of input factors such as labour, technology, capital, energy, and raw materials. While labour, may be sourced where they are consumed and technology and capital transported free of cost, energy sources and raw materials are due to geological conditions, scarcity, and economies of scale often extracted en masse in bulk and transported the seaway far from their origin to be processed and consumed.

As the growth of the global economy leads to growth in demand for the input factors, it is implied that the demand for transportation of input factors follows the trend of the global economy. While this simplified analysis may be true, finding the demand impact on different freight classes is more complicated than the overstated implication. Changes in trade patterns will also impact the demand for transportation, and different raw materials have different elasticity to the global Gross Domestic Product (GDP) and a mix of leading interest rates.

At first glance, shipping seem to be an industry facing almost perfect competition, which thus would imply the absence of profits – albeit this is not the case. Shipping is cyclical and both the earnings potential and the asset values see great variance. The aim of this research is to learn more about the predictability of asset values in shipping, and to investigate whether interest rates through government bond yields may give valuable insight to future values of dry bulk ships.

1.1 Introduction to research question

Initial research suggests there is a relationship between the aggregate changes in US and Chinese 10-year government bond yields and the vessel valuations within dry bulk shipping. By comparing the 18-month change in government bond yields with the year-over-year change in vessel values, there is signs of an emergence of a variable with predictive force. Any changes in bond yields are largely reflected the overall economy, but the effect of the change in yields on the economy is not fully apparent until after some time has passed. Hence, by pushing forward the change in government bond yields 18 months in order to let the effects materialise, there seems to be a striking correlation between the yields and the vessel values.

The aim of this paper is to provide an answer to the following:

1. Is it possible to predict future movements in vessel values based on the 18-month aggregated change in US and Chinese 10-year government bond yields?

Vessels of varied sizes trades on different routes carrying different cargoes. This leads to some decoupling across vessel types, which makes it imperative to believe that the different vessels have separate responses to the changes in government bond yields. Hence, a regression of the aggregated change in government bond yields is done separately on the four most common vessel types rather than against a more general second-hand value index. The vessel types addressed are Capesize, Panamax, Supramax and Handysize. Moreover, addressing the effects of other variables on asset values is another important part of the research conducted in this paper, as vessel valuations represents a dynamic picture affected by many distinct factors.

1.2 Why Shipping?

All industries are affected by cyclicality and macroeconomic changes and the state of the economy matters in valuation of all kinds of companies. However, for some companies it is easier, or more accurate, to predict the tides in the next years or decades. Most of the valuation methods widely applied in finance are applicable for a wide range of industries and cash generating assets. For instance, a discounted cashflow analysis has wide use, outside of the shipping space. An important reason for shipping being the industry of choice for this research is the commoditized product they offer, with a high variance in pricing and its sensitivity to macroeconomics and supply/demand dynamics in general. Vessel valuations are transparent, availability of both vessel values and ship rates are good, and new information is available in a timely manner. In addition, vessel values are basis real transactions in the market, being second hand or newbuilds. Therefore, analysis of movements through cycles and sensitivity to external factors is doable with a prominent level of granularity and accuracy.

1.3 Limitations to Dry Bulk

The global shipping industry has a wide selection of segments for carrying different cargoes. Table 1 below displays the categories of freight and what type of vessels that carry each category of cargo. Ship types in each category differ in both the exact freight it carries and size. Size also decides what routes a ship is capable of sailing, and what ports it may enter. There is a wide range of ship types, so this thesis is limited to the dry bulk segments and how

they are impacted by the distinct factors, such as interest rates, freight rates, fleet growth, and prices of the commodities the vessels carry. There is an acknowledgement that indeed all segments have a high elasticity to the state of the global economy. Dry Bulk represent a large part of the total seaborne shipping volumes, and has a high number of active vessels, providing sharp granularity in supply and demand responses (Stopford, 2009).

Table 1: Overview of vessel types and their cargoes

Freight Type	**Ship Type**
Dry Bulk Cargo	Bulk Carrier, Handysize, Handymax, Supramax, Panamax, Capesize
Container Cargo	Container Ship, Feeder, Panamax, Post-Panamax, New Panamax, Ultra Large Container Vessel (ULCV)
Liquid Bulk Cargo	Oil Tanker, Product Tanker, Chemical Tanker, LNG carrier, LPG carrier.
General Cargo	General Cargo Ship, Multi-purpose Vessel (MPV), Heavy Lift Vessel, RoRo (Roll-on/Roll-off)
Refrigerated Cargo	Reefer Ship, Reefer Container (carried by container ships)
Vehicles	RoRo (Roll-on/Roll-off), Pure Car Carrier (PCC), Pure Car and Truck Carrier (PCTC), Vehicle Carrier
Project Cargo	Heavy Lift Vessel, Multi-purpose Vessel (MPV), Semi-submersible Heavy-lift Ship, Open Deck Carrier

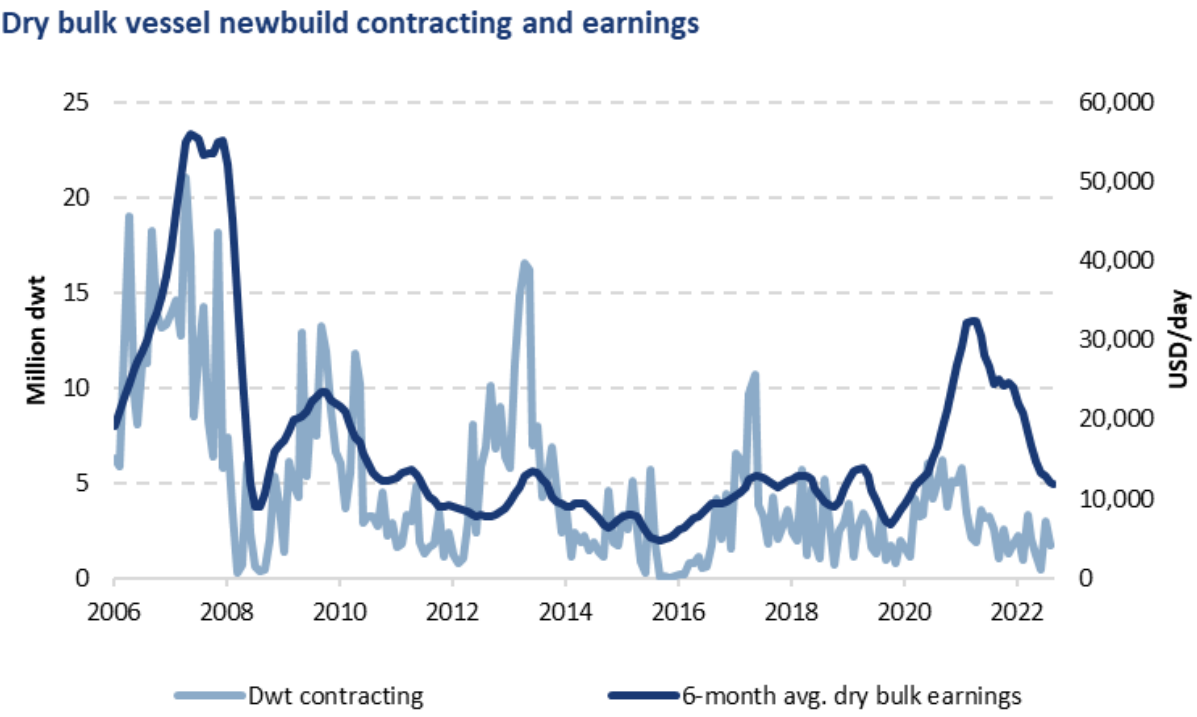
Source: (Stopford, 2009)

Table 1 above gives an overview of the main global freight types and the corresponding ship types that typically carries them. In general, specialised vessels are used for carrying each freight and exist in different sizes. Some ships can also swing between different cargoes and

do so based on freight rates for different cargoes. An example here is the case of Klaveness Combination Carriers, which are constructed for both Dry Bulk and Clean Tanker freight, capable of transporting cargo both directions of a trade route, or to go all in on the segment with best current earnings potential (Klaveness Combination Carriers, 2023).

In shipping, the ship owner is often referred to as his own worst enemy. I.e., when earnings are good, owners rush to shipyards to secure slots for newbuildings. This is highlighted by newbuilding contracting which seemingly follows freight rates.

Figure 1: Freight Rates and Contracting



Source: Fearnleys, Clarksons SIN

The lead time for a newbuilding has historically been around 2 years, meaning that new vessels is delivered two years after the order has been placed. Excluding exceptional ordering activity pre the financial crisis, fleet growth has been 4.7% p.a. on average (fleet wide).

Figure 2: Fleet Growth

Source: Clarksons SIN

1.4 Freight Rates

The current earnings potential of a shipping company is strictly determined by the current freight rates for the ships it has under management. While the freight rate for each individual charter a ship sails normally are agreed upon in an over-the-counter deal between the charterer and the ship owner, often facilitated by a ship broker as an intermediary, indices are composed for the normalized rates within ship segments and sailing routes. Concerning the dry bulk segment, the leading index is the Baltic Dry Index, which is a spot market index (Baltic Exchange, 2023). Apart from trading freight over the counter, closing charters through forward freight agreements (FFA) are also common. This is a forward contract to hedge the freight cost, used for both buyers and sellers of freight (Baltic Exchange, 2023).

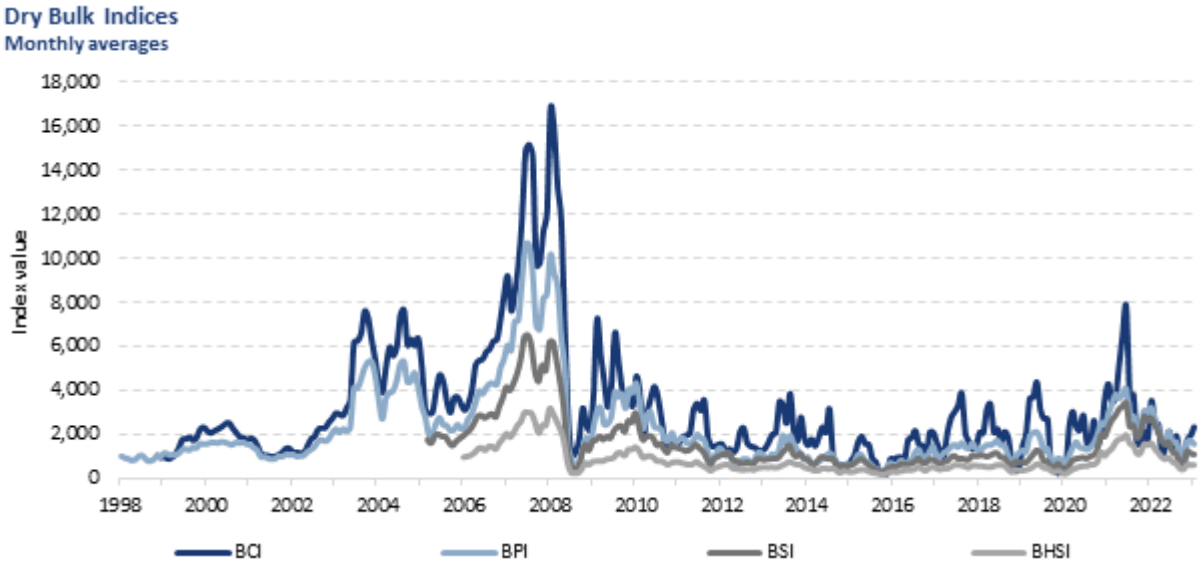
In dry bulk, earnings are mainly split into four categories of vessels: Capesize, Panamax, Supramax/Ultramax and Handysize earnings (Baltic Exchange, 2023). Earnings are more often than not denoted in USD per day, or USD per tonne (Baltic Exchange, 2023). Moreover, Baltic Exchange (2023) has developed freight rate indices which measure the strength in current freight rates across trading routes. The BCI (Baltic Capesize Index) shows average

earnings for the Capesize type vessels. Similarly, the BPI (Baltic Panamax Index), BSI (Baltic Supramax Index), and BHSI (Baltic Handysize Index) illustrate the earnings for the three other vessel classes. Lastly, the Baltic Dry Index (BDI) measure the volume weighted strength of earnings across segments.

The FFAs are derivatives on the underlying physical shipping markets and are usually traded as either futures or options (Baltic Exchange, 2023). It is most commonly used in dry bulk and tanker markets, but volumes in LNG and LPG shipping have recently increased as well. The FFAs is traded on the forward curve ranging from one month up until six years and are purely financial contracts with specified expiration dates (Baltic Exchange, 2023).

During the uptick to the financial crisis, dry bulk shipping earnings rose substantially on the back of strong Chinese iron ore import growth (Bimco, 2021). With this earnings backdrop, shipowners made haste to secure yard slots for newbuild deliveries in order to expand their fleets (Clarksons SIN, 2023). The logic is “that if everyone else is ordering and expanding, why shouldn’t I?”. Consequently, newbuilds hit the water left, right and centre during 2008-2010. Coupled with the worst financial crisis seen in decades in 2008/09, the overcapacity in dry bulk freight markets became massive. As Figure 3 and Appendix I shows, earnings in the dry bulk space remained largely muted for many years.

[1]Figure 3: Dry Bulk Indices, Monthly Averages



Source: Baltic Exchange (2023)

The figure above shows the indices for the main Dry Bulk segments from the Baltic Exchange in the period 1998 – 2023. The four segments represented on the chart is the Baltic Capesize Index (BCI) Baltic Panamax Index (BPI) Baltic Supramax Index (BSI) and the Baltic Handysize Index (BHSI). The chart shows the cyclical nature of Dry Bulk shipping, which faces an almost perfect competition, but with a delayed supply response due to the lead time of contracting a new build ship from a yard, taking about 2-3 years. Scrapping of old values happen, normally at 20 – 30 years of age (Psaraftis & Cariou, 2014). After a weak decade in the 2010s, the indices have seen an uptick the last three years.

1.5 Commodity Basket

Another factor to consider regarding freight rates is the value of the cargo, i.e., commodity prices. Before the financial crisis, there was a formidable rally in prices of iron ore, coal, grains, and soybeans on the back of a tight supply-demand balance (Bloomberg, 2023). When prices rise, the timing importance of timing of cargo deliveries increases. Hence, both the value of the cargo and timing of deliveries was partaking in the upwards push of freight rates.

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But, as a common phrase in Economics states, “The best cure for high prices is high prices” and both Dry Bulk carried commodity prices and freight rates saw a decade of low values following the China driven super cycle of 2007 (Bandyopadhyay & Rajib, 2023).

Figure 4: Commodity Basket

Source: Bloomberg NEF, Fearnleys

The figure above shows how an equal weighted commodity basket of the core Dry Bulk freights Grains, Iron Ore and Thermal coal has been quoted through the time period. The shipping component of the total cargo value is quite small; hence the freight price has limited impact on demand (Stopford, 2009). In other words, the high value of the cargo translates into an extremely high willingness to pay for shipping, as it represents only a small portion of the total cost. The effect is rather vice versa, i.e., high commodity prices may reduce demand for tonnage. The supply chain effects stemming from the COVID 19 pandemic is very visible on the chart.

1.6 Earnings Potential Drive Value for Shipping Companies

1.6.1 What is Valuation?

In finance, valuation relates to the analytical process of determining what an asset or a company is worth. Valuation may be conducted in different manners and gives a review of what the asset valued may be traded for (Damodaran, 2009). In this paper, valuation has relevance as the research concerns what a dry bulk vessel is worth. Dry bulk vessels represent the lion's share of the balance sheet of companies operating in dry bulk shipping, and their value is therefore of great importance to investors and other stakeholders of the shipping industry.

However, valuations on a single asset differ with the assumptions the analyst puts into their calculations. This is why a market exists, as each transaction has a buyer who expects to earn money from an investment, and a seller who finds the time being right to take profits. The following chapters will cover different valuation approaches and evaluate their applicability for valuing ships and shipping companies.

1.6.2 Newbuilding Parity and Required Rate

In shipping specifically, ship owners and analysts operate with a term called newbuilding parity. This term is meant to explain what day rate that is required in order to defend the price one pays for a newbuilding by using a required rate of return (Fearnleys, 2023). As such, if you pay USD 60m for a Capesize today, you will need c. USD 27,000/day for the entire useful life of the vessel using a discount rate of 10% (Fearnleys, 2023). This day rate is then often seen in comparison to historical averages as a metric in taking the temperature of current vessel valuations. However, in extraordinarily strong markets, longer-term charters at strong rates may return substantial parts of a vessel's purchase price in short time periods. Hence, vessel valuations must be seen in this context as well.

Currently, newbuilding prices range between USD 63 million for a Capesize, to USD 30 million for a Handysize. The most common input factor in constructing new ships is steel and labour. Hence, development in wages and steel and iron ore prices are key factors when considering the history of the newbuilding price (Stopford, 2009).

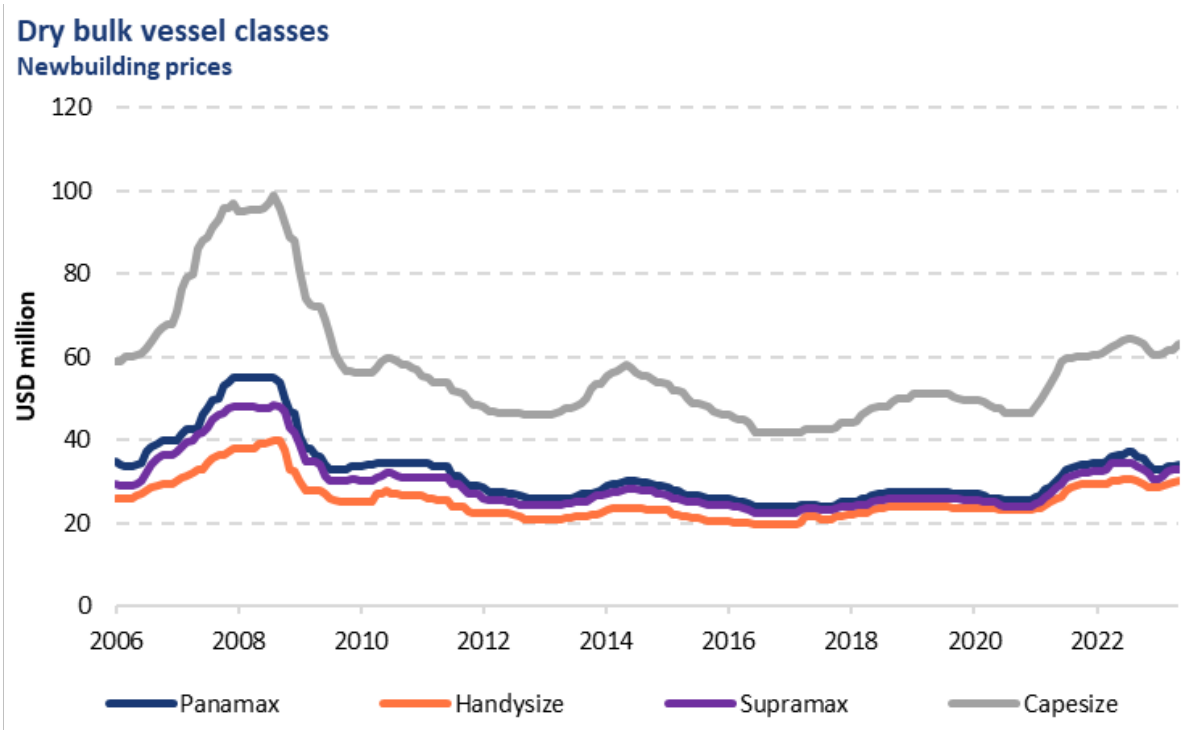
Furthermore, when the newbuilding parity rate is calculated, the assumed salvage value is taken into consideration. Historically speaking, a rate of USD 400 per light displacement tonne have been realised when selling vessels to demolition (Clarksons, 2023). Light displacement tonnage refers to the actual weight of the vessel with empty cargo holds (Fearnleys, 2023). Historical demolition values for dry bulk vessels are illustrated in Table 1.

Table 2: Current Demolition Values

USD millions	Capesize	Panamax	Supramax	Handysize
Scrap value	12.88	6.27	5.18	3.60

Source: Clarksons SIN

Figure 5: Historical Newbuilding Prices



Source: Fearnleys, Clarksons SIN

Of course, this logic extends to second hand tonnage. Assuming a 25-year useful life, a purchase of a 10-year-old vessel means the owner envisions operating the vessel for a further 15 years. Basis the calculation outlined above; one finds the required average day rate for the remaining 15 years that is required in order to defend the purchase price.

1.6.3 Net Asset Value

The net asset value of a company is simply the value of all its assets less the value of the liabilities (Damodaran, 2012). This is a valuation approach which is applicable when a company holds tangible assets which may be sold or bought in the market, close to the expected value. A shipping company is a good example here, as its net asset value (NAV) simplified can be the market value of its ships added cash and equivalents, less gross debt. The asset side of the balance sheet is often referred to as Gross Asset Value (GAV). NAV is also common as a valuation method for other companies holding marketable assets on their balance sheet, for instance investment companies or real estate investments (Damodaran, 2012).

NAV can be conducted from a mark-to-market metric basis determining the value of each vessel in a portfolio. Further, the value is adjusted by factors such as, for instance, the time charter portfolio (source). Eventually, NAV may also be derived from the financial statements and the book value of assets, which is less dynamic and more like the Price-to-Book ratio which measures historic cost (source). In a simplified manner, NAV can be expressed as this:

$$NAV = GAV + Time\ Charter\ Portfolio - Net\ Interest\ Bearing\ Debt$$

One of the reasons NAV makes sense as a valuation method is that in a liquid market, the portfolio of a company may be replicated by acquiring similar assets. An anecdote is that if a shipping company is traded in the stock market at two times the NAV, an investor should buy similar vessels in the market instead and in that sense do arbitrage. Whilst the NAV is a very dynamic measure, it is less volatile than the later valuation methods this paper cover. The interesting valuation takeaway from calculating the net asset value is to see where the equity is valued in relation to the NAV. The formula utilized for this purpose is the price/NAV formula which divides the price of the share with the NAV per share. Figure 6 displays the trading range of Dry Bulk shipping companies' P/NAV for the time period 2015 – 2023. The average was 0.85 whilst the stocks only traded outside the 1.2 - 0.6 range briefly for short time periods, displaying how net asset value "anchors" the equity values (Fearnleys, 2023).

Another topic worth discussing regarding the asset value of a shipping company is the valuation of the floating vessels themselves. A simplified approach is to do this on a mark-to-market basis by looking at recent transactions of vessels of similar size, age, and class, then adjusting the value of a portfolio of vessels based on current transaction prices, or new-build quotes. This is possible due to the commoditized design of large commercial ships which often

follow the same design within each segment and generation. Then again, one may adjust the mark-to-market valuation subject to characteristics such as being fitted with a scrubber or not, or the fuel type (Fearnleys, 2023). The alternative solution is to perform a thorough valuation of the fleet of a company, valuing ship by ship with individual third party quotes, as often is the solution when a transaction is on the table. Nevertheless, thanks to the standardised design, mark-to-market valuations are common among brokers and equity research firms (Fearnleys, 2023).

Figure 6: Historical P/NAV Development

Source: Fearnleys

1.6.4 Price/Earnings

The Price earnings multiple is a widely used valuation method among analysts and investors. The input variables here are the market price of the equity, and the net income of the company. It gives a snapshot of how many years like the current year are needed to break-even on one's investment in the equity (Damodaran, 2012). However, especially in cyclical industries, defining what is a "good" or a "bad" P/E multiple is challenging, as the Earnings part of the equation fluctuates greatly over time, and so does the Price part as well. Nevertheless, PE works well for comparative analysis. By comparing the current ratio to historical figures, or to peers, one may gain greater insights in how the market values the equity. However, the P/E

is not applicable for this study, despite its popularity among investors and equity analysts. The reason it is not applicable is that the Price part of the equation relates to the market value of equity, which differs from the market value of the vessels the company may own.

1.6.5 Free Cash Flow Yield

Like the P/E metric, the Free Cash Flow yield measures the earning power of an asset in relation to its market price. The major difference between PE and FCF yield is that Free cashflow gives a precise measure of how much the balance sheet of a company increased for a given year (before dividends, and when P/NAV = 1) whilst the net income tells the earnings rate before changes in working capital, net of capital expenditures and with depreciation and amortization lowering the actual cash inflow before capex (Damodaran, 2012). A trait of the FCF yield is its direct answer to the question: “For each dollar invested, how many cents are earned this year?”. The free cash flow yield does not consider whether the free cash flow is retained in the company or paid out as dividends. This is a trait that is well fitted for comparison over time and between companies because corporate governance is a layer on top of the fundamental valuation. For that matter, the dividend discount model is another valuation model one may use, but this model is not assessed to be a good metric for cyclical industries, as the cyclical nature makes dividends more lumpy and less predictable over time.

1.7 Cyclical and Commodity Industries

The great volatility in earnings for cyclical and commodity companies derives mostly from macroeconomic or industry specific events rather than firm-specific events. As the reader can see in examples provided in the text, macroeconomic factors change fast. The price for a commodity is set by supply and demand, and a minor change on either side might cause a dramatic change in the market balance and hence the new market price. For shipping, a supply side response can take years, as ordering and building new vessels take 2-3 years, depending on orderbooks and yard availability (Stopford, 2009).

2. Litterature Review

This research concerns shipping and different segments within dry bulk, which academically is a narrow segment of the wider logistics & transportation industries. The research on the topic will be limited to vessel valuation and to what extent changes in government bond yields, are a leading indicator of future asset values, and how earnings, commodity prices and Fleet growth affect the same asset values. The academic literature covering the topic of this master thesis is limited, which increases the motivation to cover the topic. There is some literature related to the relationship between GDP and BDI regarding BDI leading GDP growth. Moreover, there exist some literature on establishing leading indicators on freight rates. Hence, this research paper is intended to supplement existing literature and provide further nuances on the ever so interesting dynamics within dry bulk shipping.

As a central part of this research is the relation between government bond yields and shipping, reviewing literature on government bonds is also relevant. Therefore, the literature review covers both shipping, with freight rates and ship values and Government bonds, including their relation to global shipping market.

2.1 Shipping

2.1.1 Cyclical Nature of Freight Rates and the Economy

Studies such as those by Beenstock and Vergottis (1989) and Kavussanos (1996) indicate that shipping markets, including dry bulk, have a cyclical nature that is intricately linked to the global economy. During periods of global economic growth, there is increased demand for commodities, leading to higher freight rates. On the other hand, during downturns, the demand for commodities decreases, leading to a decrease in freight rates.

2.1.2 Impact of Economic Activity in Specific Regions

The economic activity of specific countries or regions, particularly China, significantly impacts dry bulk shipping rates (Stopford, 2009). As the world’s largest importer of raw materials like iron ore and coal, which are carried by Dry bulk ships, changes in China's economic policies and growth rates have immediate effects on dry bulk rates.

2.1.3 Role of Global Trade Patterns

Research by Tvedt (1997) and others highlight how changes in global trade patterns, influenced by factors such as trade policies, geopolitics, and technological advancements, can affect freight rates. For instance, trade liberalization often leads to increased shipping demand and higher freight rates. An example here is the inclusion of China to the World Trade Organization.

2.1.4 Supply Factors

While not directly linked to the global economy, the supply of vessels also plays a crucial role in determining freight rates (Koopmans, 1957). Decisions about shipbuilding and scrapping are often based on economic forecasts. Therefore, mismatches between supply and demand can lead to significant volatility in freight rates.

2.1.5 Impact of Global Crisis

Events like the 2008 financial crisis and more recently, the disruptions caused by the COVID-19 pandemic, have demonstrated the sensitivity of shipping rates to global economic shocks (Alderton & Winchester, 2002; Haralambides, 2020). These events are both highly visible in the data and will be discussed in in this paper's findings.

2.2 Valuation Applied for Shipping

Valuation in commodity industries, such as shipping, is a complex and multifaceted process. The shipping industry is subject to high levels of volatility, and this can have a significant impact on company valuations. This literature review presents key sources that discuss valuation methodologies and approaches, market dynamics, and their implications for the shipping industry.

Damodaran (2012) offers a comprehensive overview of valuation techniques, with a focus on discounted cash flow (DCF), relative valuation, and contingent claim valuation. Although not focused on shipping, it provides a foundation for understanding the valuation process in several industries, including commodity industries. Damodaran has also authored a paper called Ups and Downs: Valuing Cyclical and Commodity Companies (2009) where the argument is to normalize earnings when doing equity valuation. Further, this argument can be

applied to valuation of normalizing asset values despite their current earnings potential, which would lead to lower volatility in ship values.

One thing is valuation of shipping companies, their assets, and earnings. Another aspect of the equation is also how freight rates and freight rate derivatives add colour to the picture. Kavussanos & Marcuolis (2005) have explored the use of freight derivatives and its applications for valuation and risk management in shipping (Tsolakis, Cullinane & Alexandridis, 2012). also reviews freight rate forecasting and its implications for valuation in shipping, with suggestions for future research.

This book provides a thorough overview of the shipping industry, including its market dynamics, such as demand and supply, market structure, and freight rates. It also discusses the factors that affect shipping company valuations, such as macroeconomic trends, regulatory changes, and technological advancements. This book is widely referenced in this paper.

2.3 Government bonds

The United States, with its robust and resilient economy, has long been a focus of economic research. U.S. government bond yields, particularly Treasury yields, are often regarded as a global "risk-free" rate (Gürkaynak & Wright, 2012). Research shows that these yields reflect expectations about future U.S. monetary policy and inflation (Ang, Piazzesi, & Wei, 2006). Fluctuations in Treasury yields can impact global financial conditions, influencing the cost and availability of capital worldwide (Rey, 2013).

China, as the world's second-largest economy, has become increasingly significant in global economic research. Chinese government bond yields reflect the perceived health and future prospects of the Chinese economy. Studies suggest that these yields are influenced by various factors, including the country's monetary policy, economic growth, inflation expectations, and global economic conditions (Ma, Xiandong, & Xi, 2019). Changes in Chinese bond yields can have substantial impacts on emerging market economies, which often look to China as a bellwether for economic trends (Prasad, 2017).

Some studies suggest a degree of correlation between the bond yields of the two nations, reflecting their interconnected economies and shared influence on global markets (Belke, Dubova, & Volz, 2017). Other research explores how changes in U.S. bond yields impact

Chinese yields, and vice versa, illuminating the interplay between these two major economies (Chen, 2020). Overall, American, and Chinese government bond yields are vital indicators of these countries' economic conditions and prospects, and they play significant roles in shaping global financial markets. Research has shown that changes in these yields can influence the cost of capital worldwide, affecting investment decisions in capital-intensive industries such as shipping (Rey, 2013). A rise in bond yields increases the cost of financing for ship construction and operation, potentially leading to decreased supply and higher shipping rates (Stopford, 2009).

3. Theoretical Framework

3.1 Segments Within Dry Bulk Shipping

3.1.1 Capesize / Newcastlemax

Capesize vessels are the largest vessels that operate within the bulk carrier segment (Maritime Economics, 2009). The vessels' size span from 100,000 deadweight tonnes (dwt) up until 180,000 dwt and typically transport iron ore and coal and are too large to transit through the Panama Canal. Albeit this vessel class spans from 100,000 dwt in size, there is rarely any new ordering of Capesizes below the 170,000 dwt mark as size has become more important (Clarksons SIN, 2023). Only a few ports in the world can accommodate fully laden Capesizes, which typically sail from the Atlantic around the Cape of Good Hope (Bulk Carrier Guide, 2023). Brazil, China, and Australia thus are important hubs for the Capesize trading through their importance within the iron ore and coal trade.

Recent times has seen the emergence of Newcastlemax class vessels, which name originates from the maximum capacity of depth in the port of Newcastle, Australia (Maritime Page, 2023). These vessels are even bigger than Capesizes with their 200-210,000 dwt and has become increasingly important in the China trade due to its cost-efficiency (Maritime Page, 2023). Newcastlemaxes does not have a separate earnings index and earns a rate basis Capesize indices (2020 Bulkers, 2022).

3.1.2 Panamax / Post-Panamax / Kamsarmax

The Panamax vessels gets their name from the maximum size vessel that is able to transit the Panama Canal (Bulk Carrier Guide, 2023). The Post-Panamax notation refers to the new and bigger Panama Canal locks opened in 2016 (Fan & Gu, 2019). The Panamax vessels range from 60-100,000 dwt and typically carry grains and coal but may also transport small iron ore parcels from predominantly US ports (Stopford, 2009). The avg. size of vessels has trended upwards since 1970, highlighted by the recent introduction of the post-Panamax vessels which increased the cargo capacity of the Panamaxes due to the upgrades in the Panama Canal (Stopford, 2009).

3.1.3 Supramax / Ultramax / Handymax

Handymax dry bulk carriers typically range between 35-50k dwt and is usually equipped with cranes and grabs, fit for on and offloading in ports without the necessary infrastructure (Stopford, 2009). The vessels usually transport iron ore, coal, grains, and other smaller bulk cargoes.

Moving up a notch in size, the Supramax vessels typically carry 50-60,000 dwt of cargo (Stopford, 2009). Albeit being bigger than a Handymax, Supramaxes still enjoy synergies related to its size as it can transit most canals and ports globally (Marine Insight, 2023). Hence, these vessels are the most common type of dry bulk carriers above 10,000 dwt. Moreover, in addition to being flexible in terms of trading patterns, the vessels offer the flexibility of carrying different types of cargoes at once due to its many cargo-holds (Marine Insight, 2023).

Ultramaxes can carry 60-65,000 dwt of cargo and is a further development of the Supramax class of vessels and represent the largest dry bulk vessel segment fitted with self-unloaders (Stopford, 2009; Belships, 2023). Their trade patterns and cargo are typically the same as for Supramaxes, and the Ultramaxes can load and discharge from other vessels, barges, or directly into storage facilities in industrial zones/ports (Belships, 2023).

3.1.4 Handysize

The Handysize dry bulk vessels is medium in size, typically ranging between 10-35,000 dwt (Stopford, 2009). The vessels are usually fitted with self-unloaders such as grabs, and their size allow them to trade through a large number of ports. The cargo they carry often vary in both quantity and variety, serving as a flexible workhorse in trades where parcel size and draft restrictions demand are a limitation.

3.1.5 Further Considerations

The hypothesis is that the different vessel types have a different level of strength in their relationship to interest rates, represented by the R squared and regression coefficient in regressions covered in Chapter 6. The reasoning behind this hypothesis is that whilst the vessels are substitutes and can swing between freights and distances due to supply and demand in different routes, it is imperative that different freights have varying elasticity to the global economic status, in this paper represented by interest rates. Moreover, liquidity in the second-

hand market for the various vessel classes is another factor which affect the volatility of asset values.

Moreover, each vessel class has a history of being built with different cargo carrying capacities, as the long-term trend has been that vessels are becoming bigger. An example of this is the Panamax, initially built at around 75,000 dwt, now being built with a capacity of up to 95,000 dwt (Clarksons, 2023). This also applies to the Capesize type of vessels, with the Newcastlemax now being the state-of-the-art vessel.

The Supramax term further includes vessels known as Ultramax and Handymax. The Handymax is a term used in conjunction with Supramax, whilst Ultramaxes are marginally bigger than its peer Supramax. Due to the size, value, and utility being so similar, the vessels are often spoken of in connection with each other. This applies when talking about both freight rates and vessel values.

3.2 Interest Rates as an Indicator of the Global Economy

For finding out how the different shipping markets respond to the state of the global economy, it is crucial to find a good indicator for the sentiment and state of the global economy. For conducting analysis of significance, the indicator should be responsive and volatile, which disqualifies for example the global quarterly GDP, as the variance is low (The World Bank, 2023).

As a single global interest rate does not exist, one must look at either a national/regional interest rate or a basket of different interest rates. Chinese and American government bond yields are considered great indicators for the state and sentiment of the global economy because of the large size and great influence of these two economies. Together, the U.S. and China account for about 40% of the global GDP, and they are the two major players in international trade and financial markets (The World Bank, 2023). China have been especially and increasingly important for the shipping market on this side of the millennium shift due to high infrastructure spending, which leads to high consumption of raw materials such as coal, iron ore and oil, which all arrive the seaway.

With reference to Table 2 Below: Bond yields on the left Y axis and Global GDP growth on the right axis. Annual prints, GDP growth data after 2021 not yet available from the World

Bank. Same duration as the sample size for finding relation between bond yields and the global economy within the sample for shipping data.

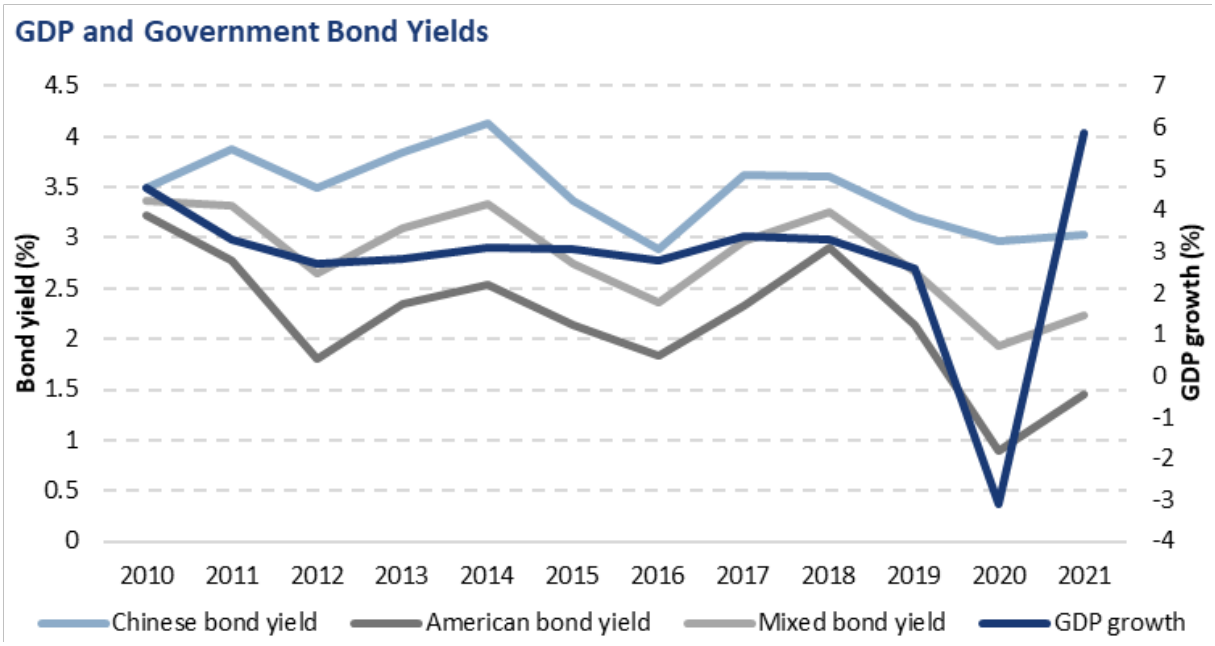
3.3 Dry Bulk Earnings as an Indicator of the Global Economy

For years, the Baltic Dry Index, or dry bulk freight earnings if you will, have continuously been seen as a leading indicator of the global economy due to its macro dependent cargo (Bandyopadhyay & Rajib, 2023). The BDI captures the volume of seaborne trade, demand for industrial commodities and finished manufactured products, and manufacturing activity through its daily freight rate quotes. Hence, the demand for raw materials tend to move in tandem with the BDI, resulting in an increasing BDI during times of economic expansion due to increases in demand for raw materials.

3.4 Government Bond Yields: How are They Affected by the Global GDP?

There is a relation between the global GDP and the government bond yields, which Figure 7 is called “Mixed bond yield” to avoid confusion with the two national bond yields. The correlation coefficient is positive at 0.47. This indicates that the GDP and Interest rate yields tend to drag moderately in the same direction, which also means that as GDP tends to increase, bond yields also tend to increase, and vice versa. However, keep in mind that correlation does not always imply causation. The two variables move in sync, displayed with the data in Appendix II. Even though the variables move together, it does not necessarily mean that a change in one directly causes a change in the other. A correlation coefficient of 0.47 is far from one (1), so it is not a strong relationship, but it indicates a relationship. Nevertheless, the interest rate/government bond yield effect on dry bulk ship values is as interesting despite not having a direct relationship to global GDP growth.

Figure 7: GDP and Government Bond Yields



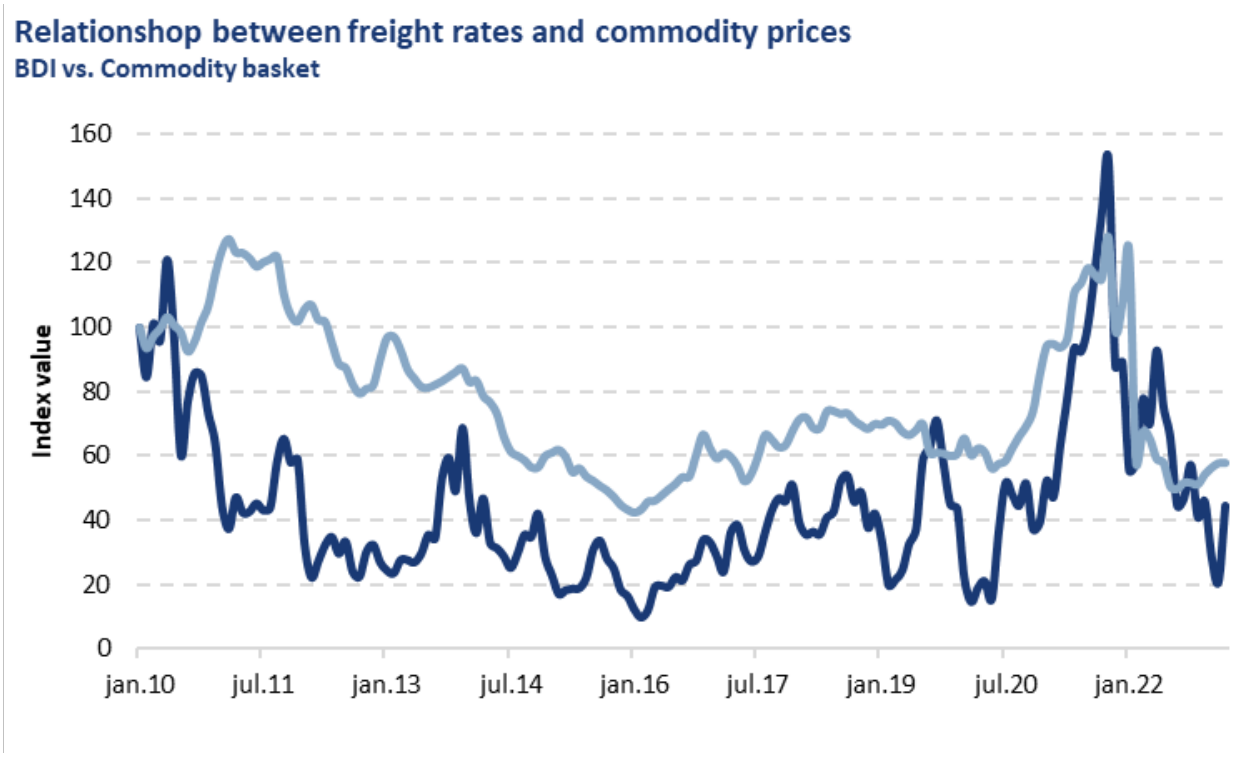
Source: Fearnleys, IMF, Bloomberg NEF

3.5 Commodity Prices: How do they impact Freight Rates?

Dry bulk vessel transport commodities in dry bulk, such as coal, iron ore and diverse grains. The ships are made from steel, a material with iron ore as the main input factor. As the steel in a vessel has an opportunity cost, new build prices are directly affected by iron ore, and this has a spill-over effect to supply of tonnage leading into freight rates (Psaraftis & Cariou, 2014). The more direct link between the two is however that with demand for the commodities rising or falling, the demand for transporting them are also rising (Haralambides, 2020). On the other hand, commodity prices rising may lead to demand destruction and a new equilibrium price

finding place at a lower volume, affecting the demand for freight. This is further examined in chapter 6 with a regression showing the relation between the two in Table 5.

Figure 8: Freight Rates and Commodity Prices



Source: Baltic Exchange, Bloomberg NEF, Fearnleys

3.6 How Government Bond Yields Affect Vessel Values

Knowing that freight rates have the most obvious effect on vessel valuations, and that freight rates are dependent on demand and hence the economic direction, the movements of bond yields give an indication of whether the macroeconomic policy is expansive or contractive. Taking this a step further, looking at the world's two largest importers and exporters of goods, the aggregated change in bond yields in US and China work as great proxies for global dry bulk demand. When leading an expansionary/contractive monetary policy, the effects do not show before after some time. After investigating the government bond yield changes in relation to global GDP growth, it appears to be an 18-month lag on the effect of bond yield fluctuations.

Hence, the relationship between bond yields and vessel valuations seems apparent as long as the link between yields to GDP/commodity demand, to freight rates and, eventually, vessel values remain intact.

4. Data and Methodology

4.1 Data

The data that have utilized for this research stems from various sources, including Clarksons Shipping Intelligence Network (SIN), Fearnleys shipping research, Bloomberg NEF, and Baltic Exchange. The data spans from April 2006 until March 2023 and is based on publicly available data on ship values for 10-year-old vessels in the different classes: Capesize, Panamax, Supramax, and Handysize. Furthermore, this paper has used interest rate data on the change in US and Chinese 10-year government bonds. The data is believed to be accurate, neutral, and objective.

The reasoning for the length of the sample is that at least a whole decade of data is needed to be able to see the response in ship values to different interest rate fluctuations, and to see the value of the global dry bulk fleet reacting over time. A short sample could be exposed to noise from the market microstructure within one or several of the segments.

There are limitations to the duration of the data series due to factors such as price history. This relates to the Chinese bond yields, as price history only goes back to 2006. Moreover, as this paper measures the 18-month change in government bond yields, the duration of the data is cut by another 18 months on the front end.

The basis of this analysis is the aggregate changes in US and Chinese government bond yields the last 18 months. Furthermore, this 18-month change in interest rates has been moved forward 18 months in order to display its leading effect on asset values. These changes are then seen in comparison to the year-over-year changes in the most common vessel classes within dry bulk (Capesize, Panamax, Supramax, Handysize). This relationship is illustrated in Figure 9.

Figure 9: Change in Vessel Values vs. Change in Government Bond Yields

Source: Fearnleys, Bloomberg NEF, Clarksons SIN

In order to better understand the dynamic relationships within dry bulk shipping, this paper have utilized monthly quotes from the Baltic Dry Index. Furthermore, freight rates for each vessel class with data from Fearnleys shipping research is also utilised. These are also monthly data, ensuring that all variables have the same data granularity, and the same duration.

All data in the time series is intact and included, meaning there has been no trimming or winsorizing. Simply put, there were no challenging outliers to the data. Having monthly rather than daily data may have been a benefit, as daily fluctuations may be more randomized and monthly data more trend following.

A basket consisting of USA and China government bonds serves as a more balanced and elastic indicator of the global economy than only a single one of them would do. USA has the biggest economy in the world, with its GDP amounting to 25% of the world total in 2021, while the Chinese economy amounts for 17% of GDP, giving the combined economies a total of more than 40% of the global economy (The World Bank, 2023). Due to Chinas high demand

for raw materials, and therefore also shipping, plus their role in refinery and processing of materials, the choice fell on equally weighting these two government bond yields in the analysis, rather than weighting the two with their respective share of the combined GDP of the two states.

The choice on Government bond duration is the 10-year bond, which is a globally renowned benchmark for "risk-free" rate (Damodaran, 2009). The 10-year government bonds of USA and China are also highly liquid. The 10-year maturity is long enough to provide insight into the market's long-term economic expectations, including growth and inflation, but short enough to be responsive to changes in the economic outlook (Gurkaynak & Wright, 2012).

As shown in Figure 9, the value of dry bulk vessels seems to have a negative correlation with the interest rates represented by "risk free" USA and China 10-year government bond yields. The correlation is further investigated in chapter 6.1. The reference vessel being a 10-year-old Capesize is chosen as it represents a close to median age of the benchmark dry bulk vessel, which depending on market conditions, corporate policy of the owner, and salvage values at the time of considered scrapping varies between 20 – 30 years (Psaraftis & Cariou, 2014).

The index called "Commodity Basket" in this research relates to an index that is composed with the purpose of illustrating the interaction between commodity prices and dry bulk freight rate indices. This is in order to understand whether commodity prices drive demand for dry bulk shipping, and whether one may expect rising earnings for shipping companies from increased prices in the underlying commodities. The data is derived from Bloomberg NEF and the prices are quoted in U.S dollars, which is the same currency as global shipping rates and ship values are quoted in. This removes a potential layer of currency risk, which would impact the results if the variables were quoted in different currencies. The commodity basket consists of historical spot prices for a variety of commodities in USD, before they are indexed to one hundred (100) at the starting point of the data series.

Figure 11 displays data on the average six-month earnings for these four dry bulk vessel segments compared to the asset values. This is also the basis for the regression performed in Chapter 6.3, which pointed to a strong relationship between six-month earnings and asset values. This data is equal weighted between the four asset classes and presents the exact day rate earned (Capesize + Panamax + Supramax + Handysize) / 4. The data is retrieved from Clarksons SIN and Fearnleys.

4.2 Methodology

For researching various value drivers of dry bulk ships, and the effects of government bond yields, relevant freight rates and commodity prices have on vessel values, numerous methodologies have been applied. The main methodology has been linear regressions between the variables listed above conducted in RStudio with R programming on the datasets listed in the Data section of this paper. Other methods utilized include Correlation, Variance analysis and multiple linear regression. When conducting the multiple linear regression, a check for multicollinearity was conducted, described in chapter 7.

5. Leading indicator research

5.1 Government Bond Yields

This paper investigates whether the aggregated change the last 18 months in US and Chinese 10-year bond yields are a leading indicator for future vessel values within dry bulk shipping. The change in yields is moved forward 18 months in order to capture the leading effect it has on vessel values. The above-mentioned change is then compared to the year-over-year change in vessel values for 10-year-old ships.

Hence, the basis of this analysis is the aggregate changes in US and Chinese government bond yields the last 18 months moved forward 18 months in order to display its leading effect on asset values. In other words, the 18-month change on 1 January 2008 is seen in comparison to the year-over-year change in asset values for 10-year-old ships on 1 June 2009. The vessel classes that are examined are Capesize, Panamax, Supramax, and Handysize. This is shown in Figure 9.

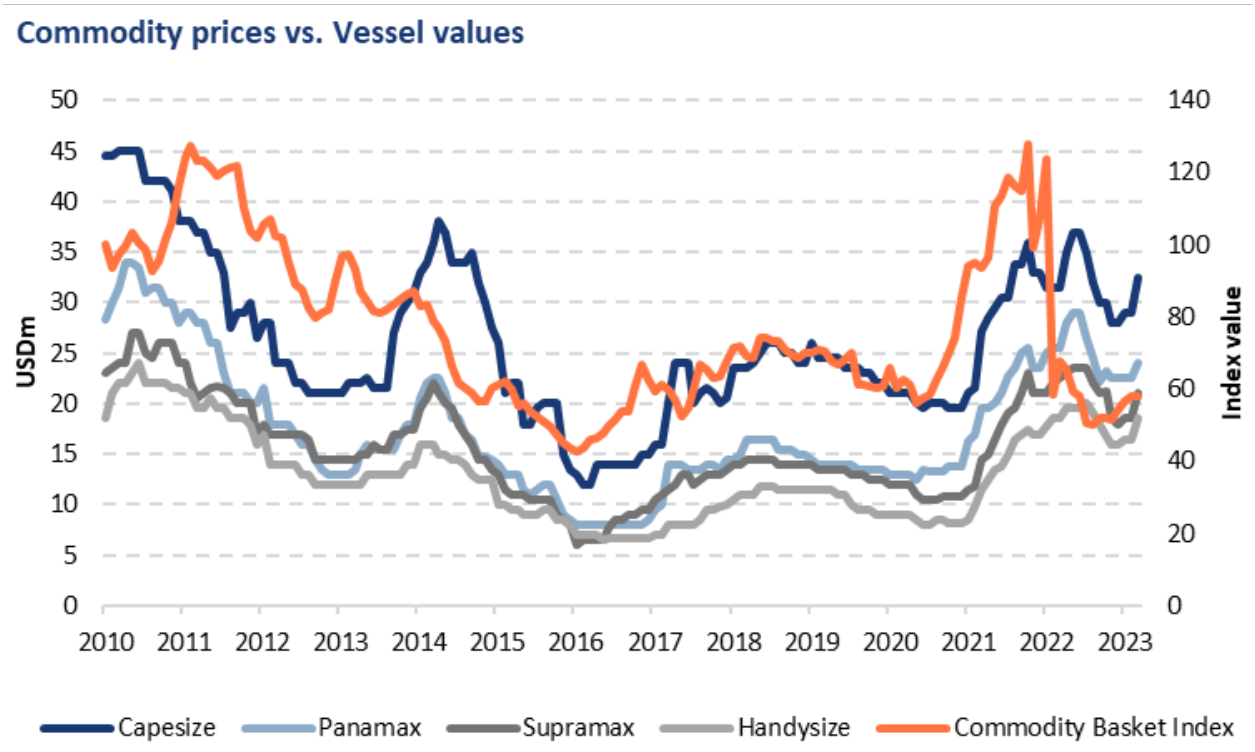
10-year-old vessels are chosen due to representing the midpoint between a brand-new ship and a ship at the end of its life, therefore having “equal” exposure to newbuild prices and salvage values. In regard to bond yields, they are chosen as representatives for the global economy. Even more so, the US and China represents a large share of global seaborne commodity imports and exports. Hence, the changes in yields in the above-mentioned countries will prove as great catalysts for future commodity demand as the bond yields tend to fall in advance of economic growth.

Looking at Figure 9, the relationship between the bond yields and asset values is rather apparent. However, other external factors such as freight rates, new build prices, salvage values, fleet growth, supply and commodity prices obviously influence vessel valuations. It is important to note that all the above-mentioned factors are interlinked. Economic growth tends to lead to higher commodity prices and demand, which in turn affect freight rates and eventually vessel valuations. This paper tries to capture all of these effects by moving the 18-month changes in bond yields 18 months forward. By moving the interest rate changes forward, the whole chain of events impacting vessel valuations through monetary policy and expectations from market participants are allowed time to take effect.

5.2 Commodity Prices

Commodity prices have an effect on both the value of cargo and the steel value of the ship. The logic is that an increased price of iron ore leads to an increased price of steel, eventually trickling up to newbuild prices and hence also the newbuild parity rate. In addition, this dynamic also applies to the amount of money you receive by selling the vessel to demolition (Fearnleys, 2023). Correspondingly, a higher commodity price leads to a greater cargo value, which in turn may lead to greater willingness to pay from the cargo owner's side, i.e., higher freight rates. In order to better understand the dynamics of the vessel valuations, a commodity basket is seen up against the movements of the asset prices. Moreover, higher commodity prices increase the demolition value of the ship, corresponding to higher residual value for the ship owners. Hence, commodity prices may affect vessel values. The commodity basket consists of iron ore, thermal coal, soybean, wheat, and corn.

Figure 10: Relationship Between Commodity Prices and Vessel Values

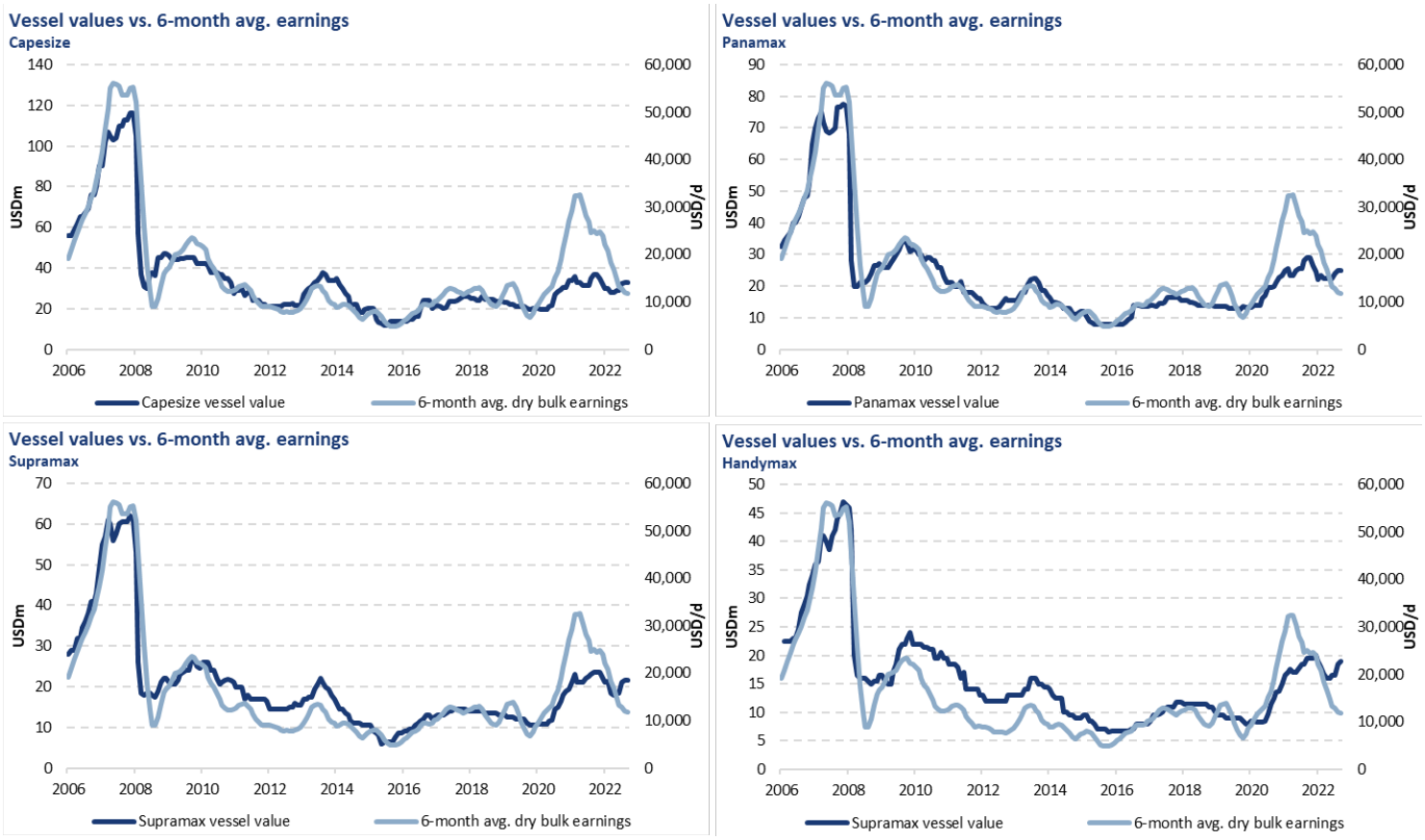


Source: Fearnleys, Bloomberg NEF, Clarksons SIN

5.3 Freight Rates

How much a ship owner earns by operating a ship obviously affects the valuation of said vessel. By looking at Baltic indices such as the Baltic Dry Index, one gets an interpretation of current earnings levels. Instead of looking at freight rates directly, this paper focuses on the indices from the Baltic Exchange. The reason for this is that freight rates reflect earnings on specific shipping routes, whereas the indices give a volume-weighted average of current earnings (indexed). The indices for all segments of dry bulk are paid attention to, therein Capesize, Panamax, Supramax and Handysize.

Figure 11: Vessel Values vs. 6 months Trailing Average Earnings



Source: Fearnleys, Clarksons SIN

5.4 Correlation Matrix

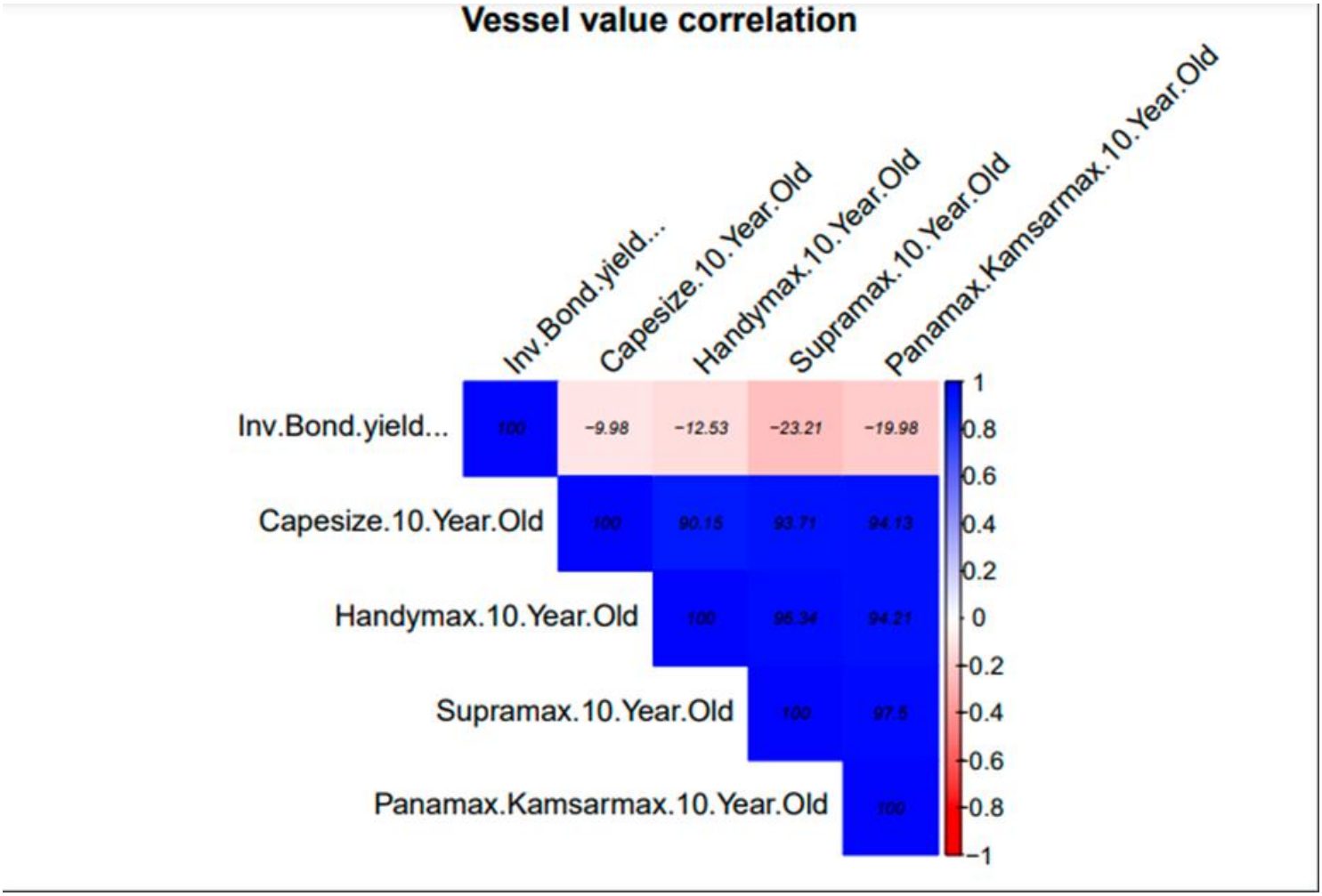
The graphic below shows the correlation values between the four different vessel classes within Dry Bulk shipping. For the period analysed, an interesting observation is that Capesize vessels are the least correlated to government bond yields, while the value of a 10-year-old

Supramax has the highest correlation to the inverse government bond yield in China and USA. The correlation value is -0.23, which is a moderate correlation.

The corelation between different vessel sizes is also notable. Supramax and Panamax values have the strongest correlation of 0.975 which is significantly high. Nevertheless, no surprises here as the different ships are almost perfect substitutes. The lowest correlation is between Capesize and Handysize values, at a level of 0.90, still significant, but also expected to have the lowest correlation as these ships have the lowest substitutionary effect due to the difference in size and specs.

Further, a linear regression analysis will tell us more about the relationship, therefore testing a linear regression between the value of a 10-year-old Capesize and the government bond yield changes was the next step to better understand what moves asset value for shipping companies. The results of that are presented in Chapter 6.

Figure 12: Correlation Matrix, Government Bond Yields and Vessel Values



6. Results

6.1 Regression Between Change in Vessel Values and Change in Government Bond Yields

Table 3: Regression Between Change in Vessel Values and Change in Bond Yields

Change in ship values vs. Change in Government bonds

	Dependent variable:			
	Change.Handysize Handysize	Change.Supramax Supramax	Change.Panamax Panamax	Change.Capesize Capesize
	(1)	(2)	(3)	(4)
Intercept	-0.17***	-0.18***	-0.17***	-0.15***
	(0.02)	(0.02)	(0.02)	(0.02)
Bond Yield Change	-0.04*	-0.04**	-0.04*	-0.05**
	(0.02)	(0.02)	(0.02)	(0.02)
Observations	170	170	170	170
R^2	0.42	0.46	0.42	0.33
Adjusted R^2	0.42	0.45	0.41	0.33
Residual Std. Error (df = 168)	0.28	0.28	0.29	0.29
F Statistic (df = 1; 168)	122.69***	141.43**	119.52***	83.70***
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 3 shows the results of the regression. The change in 10-year-old vessel values is the dependent variable, and the change in government bond yields is the independent variable. The following paragraphs address the findings of the regression analysis.

6.1.1 Interpretation of Regression

In general, the results suggest a positive relationship between the change in the Government Bond yields and the change in values of Dry Bulk ships. The bond yields are expressed in absolute numbers; hence a one (1) unit increase in the bond yield change is equivalent to 1% on a percentage basis. In other words, a 1% aggregated increase in US and Chinese bond yields leads to a 5% year-over-year decrease in Capesize asset values 18 months later. The relationship is equally strong for the other vessel classes, meaning that the 18-month change in US and Chinese 10-year government bond yields have a strong predictive value for what happens to asset values 18 months later.

Notably, the relationship is strongest for Supramaxes and Panamaxes for the time series, and weakest for Capesize and Handysize. However, these relationships do not necessarily imply causation, and there may be other factors at play. The R-squared values suggest that while the Government Bond yield can explain some of the variability in these changes, there are also a substantial proportion of the variability that is yet to be explained by other variables not included in these models.

The given output presents the results of a linear regression analysis between the dependent variables of each individual vessel segment, and the annual change in USA and China government bond yields, leading with 18 months being the independent variable. Following is the interpretation of the results.

Capesize Change: The intercept of –0.15 shows that when the change in government bond yields is zero, the value of the dependent variable is equal to –0.15. This value is statistically significant on the 1% level. The coefficient for the Government Bond variable is -0.05 and is statistically significant at the 5% level. This implies that a one-unit increase in the Government Bond yield leads to an estimated decrease of 0.05 units in the Capesize Change. The R-squared of 0.36 indicates that approximately 36% of the variance in Capesize Change can be explained by the Government Bond yield, which is natural given the number of internal and external factors affecting the value of a vessel, government bond yield does not solely set capesize ship values. The value of the F-statistic assesses the overall significance of the model, and a value of 83.7 at a 1% confidence interval indicates that the model is significant.

Panamax Change: The intercept of –0.17 means that when the change in government bond yields is zero, the value of the dependent variable is equal to –0.17. This value is statistically significant on the 1% level. The coefficient for the Government Bond variable is –0.04 and is statistically significant at the 10% level. This implies that a one-unit increase in the Government Bond yield is associated with an estimated decrease of 0.04 units in the Panamax Change. The R-squared value of 0.42 indicates that approximately 42% of the variance in Panamax Change can be explained by the Government Bond yield, which is higher than that of Capesize. The value of the F-statistic assesses the overall significance of the model, and a value of 119.53 at a 1% confidence interval indicates significance.

Supramax Change: The intercept of –0.18 tells that when the government bond yields change is zero, the value of the dependent variable is equal to –0.18. This value is statistically significant on the 5% level. The coefficient for the Government Bond variable is -0.04 and is statistically significant at the 5% level. This suggests that a one-unit increase in the Government Bond yield leads to an estimated decrease of 0.04 units in the Supramax Change. The R-squared value of 0.46 indicates that close to half of the variance in Supramax Change can be explained by the Government Bond yield, which indicates that bond yields are important for valuing Supramaxes, and that Supramax is the segment which is most sensitive to government bond yield changes in the sample. The value of the F-statistic assesses the overall significance of the model, and a value of 141.44 at a 1% confidence interval indicates significance.

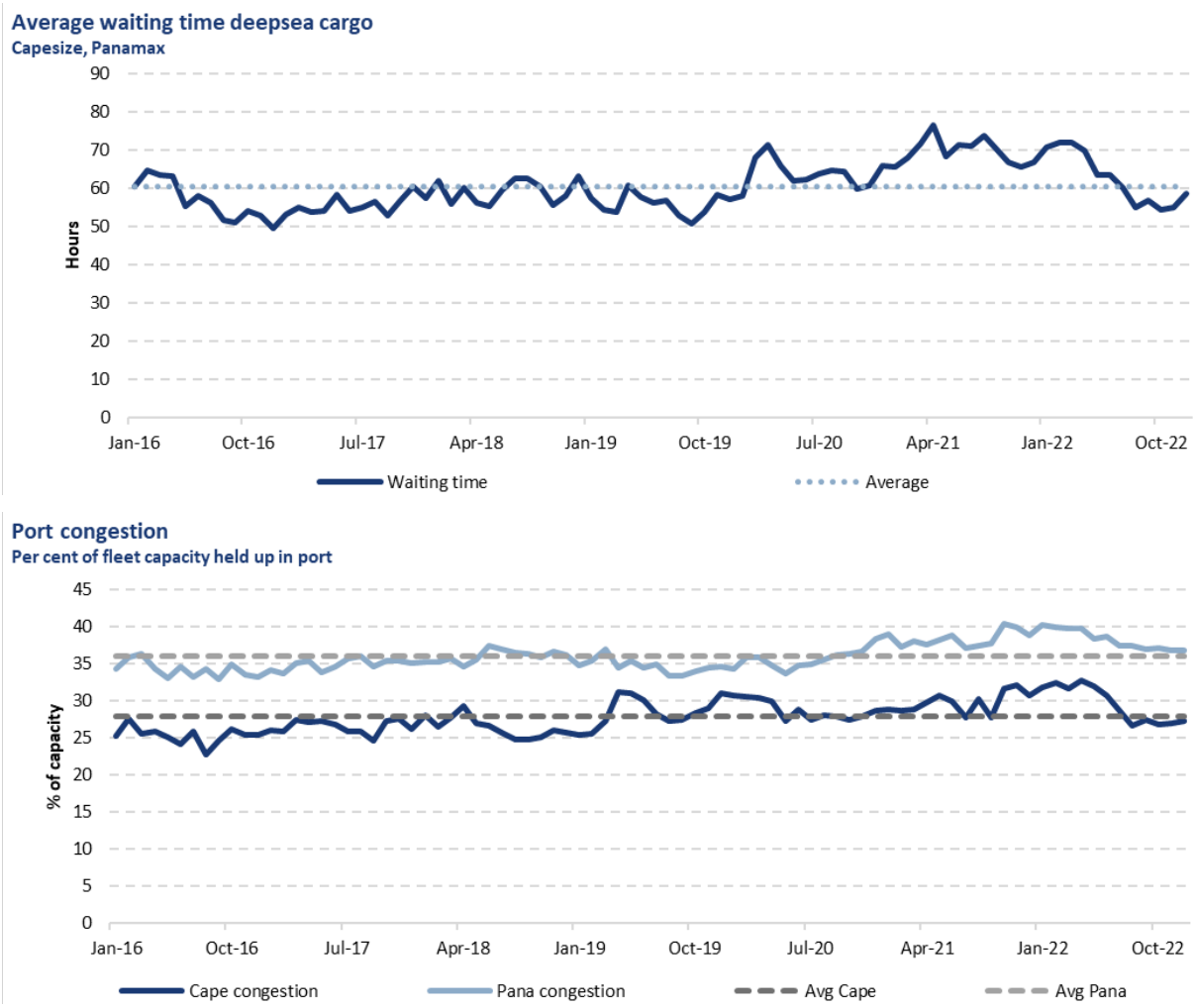
Handysize Change: The intercept of –0.17 means that when the change in government bond yields is zero, the value of the dependent variable is equal to –0.17. The coefficient for the Government Bond variable is 0.08 and is statistically significant at the 1% level. This implies that a one-unit increase in the Government Bond yield is associated with an estimated increase of 0.08 units in the Handymax Change. The R-squared value of 0.26 indicates that approximately 26% of the variance in Handymax Change can be explained by the Government Bond yield. This is the lowest R-squared value of the four dry bulk sizes. The value of the F-statistic assesses the total significance of the model, and a value of 141.44 at a 1% confidence interval indicates that the model has significance.

6.1.2 Controlling for Decoupling of Correlation due to Extraordinary Events

Another key factor to consider is the increased congestion in ports during 2021-2022, which reduced the availability of tonnage simply due to an above average number of vessels being held up at ports. The data series below clearly shows how congestion of deep-sea cargo was above average in 2021-22 both in terms of hours at port and % of capacity held up in ports.

The congestion in 2021 occurred as a result of a mix of stricter policies related to Covid-19, shortages of labour, China/Australia trade war (Chinese ban on import of Australian coal), and ramifications due to the blockage of the Suez Canal (Fearnleys, 2023). Hence, the mixture of factors occurring at the same time was so extraordinary that a replay in the near future seems unrealistic from an objective point of view.

Figure 13: Congestion of Deepsea Cargo



Source: Clarksons SIN

Hence, there may have been a decoupling of the above-mentioned correlation for these years due to extraordinary events leading to shortfall of tonnage resulting in higher freight rates and increased willingness to pay for tonnage. Doing the regression up until January 2021 yields the following results:

Table 4:Regression Between Change in Vessel Values and Change in Bond Yields. Controlled for Port Congestion.

October 2007 - December 2020

	Dependent variable:			
	Change.Capesize Capesize	Change.Panamax Panamax	Change.Supramax Supramax	Change.Handysize Handysize
	(1)	(2)	(3)	(4)
Intercept	-0.15***	-0.18***	-0.18***	-0.17***
	(0.02)	(0.02)	(0.02)	(0.02)
Bond Yield Change	-0.05**	-0.04*	-0.05**	-0.05*
	(0.02)	(0.02)	(0.02)	(0.02)
Observations	159	159	159	159
R	0.34	0.42	0.46	0.43
Adjusted R	0.33	0.41	0.46	0.43
Residual Std. Error (df = 168)	0.30	0.30	0.28	0.29
F Statistic (df = 1; 168)	79.63***	112.05***	135.12***	18.71***
Note:				*p<0.1; **p<0.05; ***p<0.01

The regression up until the time the start of the port congestion issues yields marginally different results. Hence, there is no statistical grounds for claims that it has a meaningful effect on the regression presented in Table 3. There are thus other factors that explain the lower R-squared of Capesize vessels.

6.2 Relationship Between Commodity Prices and Freight Rates

To better understand the relation between prices of the commodities carried by Dry Bulk Ships and the price they are paid for carrying it, a linear regression between the aforementioned "Commodity Basket" (CB) and the Baltic Dry Index (BDI) is conducted. The BDI served as the dependent variable and the CB as the independent variable. Table 5 display the findings.

The resulting equation from the model was BDI = 0.59625 * CB - 0.68204. This suggests that, for each one (1) unit increase in the CB, an increase of 0.59625 units in the BDI is to be expected, ceteris paribus.

The t-statistic for the CB was 7.806, and the associated p-value was significantly less than 0.001, indicating that this basket of dry bulk commodities is a statistically significant predictor of the Baltic Dry Index.

Figure 10 shows the fluctuations of Freight rates for Dry Bulk represented by the Baltic Dry Index and commodity prices represented by the Commodity Basket (Coal, Iron Ore, Soybeans, Wheat, and Corn) for the sample period. The correlation between the two was calculated to be 0.528 on monthly granularity. This indicates a moderate, but not a direct correlation between the price of what is carried and the cost of carrying it.

A regression between the two with the Commodity Basket as the independent variable reveals that the Baltic Dry Index moves in positive correlation with commodity prices. In figure both are indexed to start at a value of 100 in 2010 and run until March 2023, same sample as for the regression in Table 5. The regression states that with Commodity prices at 0, Baltic Dry would have negative value, hence the Intercept of -0.68. It is logical to infer that market participants will not pay for freight if commodities are valueless, but this a non-realistic scenario, and the intercept only then hypothetical.

Table 5: Regression Between Commodities and Baltic Dry Index

Commodity baskets impact on Baltic Dry Index	
	Dependent variable:
	Baltic.Dry.Index
	Baltic Dry Index
Commodity Basket	0.60^{***}
	(0.08)
Intercept	-0.68
	(6.11)
Observations	159
R^2	0.28
Adjusted R^2	0.28
Residual Std. Error	21.59 (df = 157)
F Statistic	60.94^{***} (df = 1; 157)
Note:	*p<0.1; **p<0.05; ***p<0.01

Most importantly, the regression shows that a on1 unit increase in the commodities will lead to 0.6 increase in the dry bulk earnings, and that this is statistically significant at the 1% level. As the adjusted R squared equals to 0.28, the fluctuations in BDI also stem from a variety of

other sources than the price of the commodities they carry, which accounts for about 28% of the pricing action according to the regression.

6.3 Relationship between Freight Rates and Vessel Values

Table 6: Regression Between 6-month Average Freight Rates and Vessel Values

Earnings effect on ship values 2007 - 2021

	Dependent variable:			
	Capesize.vessel.value	Supramax.vessel.value	Panamax.vessel.value	Handysize.vessel.value
	Capesize	Supramax	Panamax	Handysize
	(1)	(2)	(3)	(4)
Intercept	0.002***	0.001***	0.001***	0.001***
	(0.0001)	(0.0000)	(0.0000)	(0.0000)
Dry Bulk Earnings	8.07***	5.46***	4.29***	5.81***
	(1.20)	(0.60)	(0.73)	(0.50)
Observations	200	200	200	200
R^2	0.81	0.83	0.84	0.77
Adjusted R^2	0.80	0.83	0.84	0.77
Residual Std. Error (df = 198)	10.22	5.12	6.22	4.24
F Statistic (df = 1; 198)	819.40***	948.14***	1,074.31***	673.16***
Note:				*p<0.1; **p<0.05; ***p<0.01

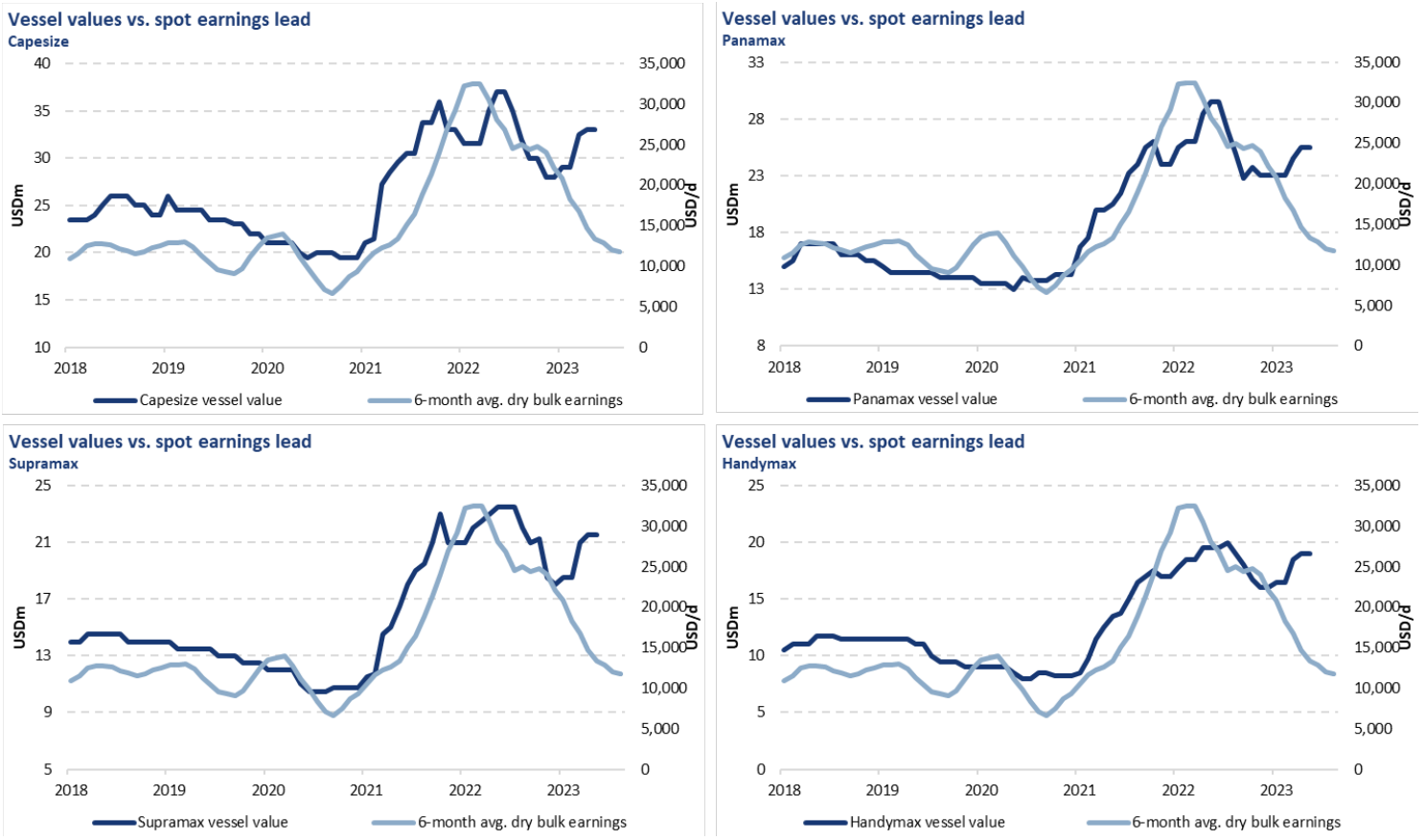
The freight rates and vessel values (across sizes) have a strong relationship in terms of R-squared, which for all classes comes in at, or above, 0.77. This means that more than 77% of the variance in asset values is explained by the movements in freight rates. Broadly speaking, the correlation coefficient also states that there is a strong, statistically significant coefficient on a 1% level. Interpreting the results, asset values would be close to zero in a theoretical, but not realistic, scenario where 6-months average dry bulk earnings are USD 0/day, which is natural considering the vessels are losing money at that point. However, this theoretical scenario does not consider the vessel's demolition values, which is a considerable size worth multiple million dollars. It neither considers the forward curve, which is expected to be positive in a scenario where earnings are zero (0) for a 6 month period, as this earnings rate is expected to lead to excessive scrapping of vessels.

The regression coefficients are all statistically significant on a 1% level, ranging between 4.29 to 8.07. The regression is basis earnings in thousands and vessel values in millions.

Effectively, this means that vessel values will move USD 4,290-8,070 per USD 1/day change in rates. E.g., if freight rates increase by USD 1,000/day, vessel values increase by USD 4.29-8.07 million across the different sizes.

Applying the results in a practical manner, 6-month average dry bulk earnings can be moved 3 months forward with the purpose of showing its leading relationship. With reference to Table 6, the model tells us that asset values will come down for all asset classes the coming 3 months, as illustrated in Figure 14.

Figure 14: Vessel Values and Spot Earnings Leading Indicator



Source: Fearnleys, Clarksons SIN

Table 7: Multiple Linear Regression. Fleet Growth added as Independent Variable

Ship values vs. Fleet Growth and 6-month avg Dry Bulk earnings

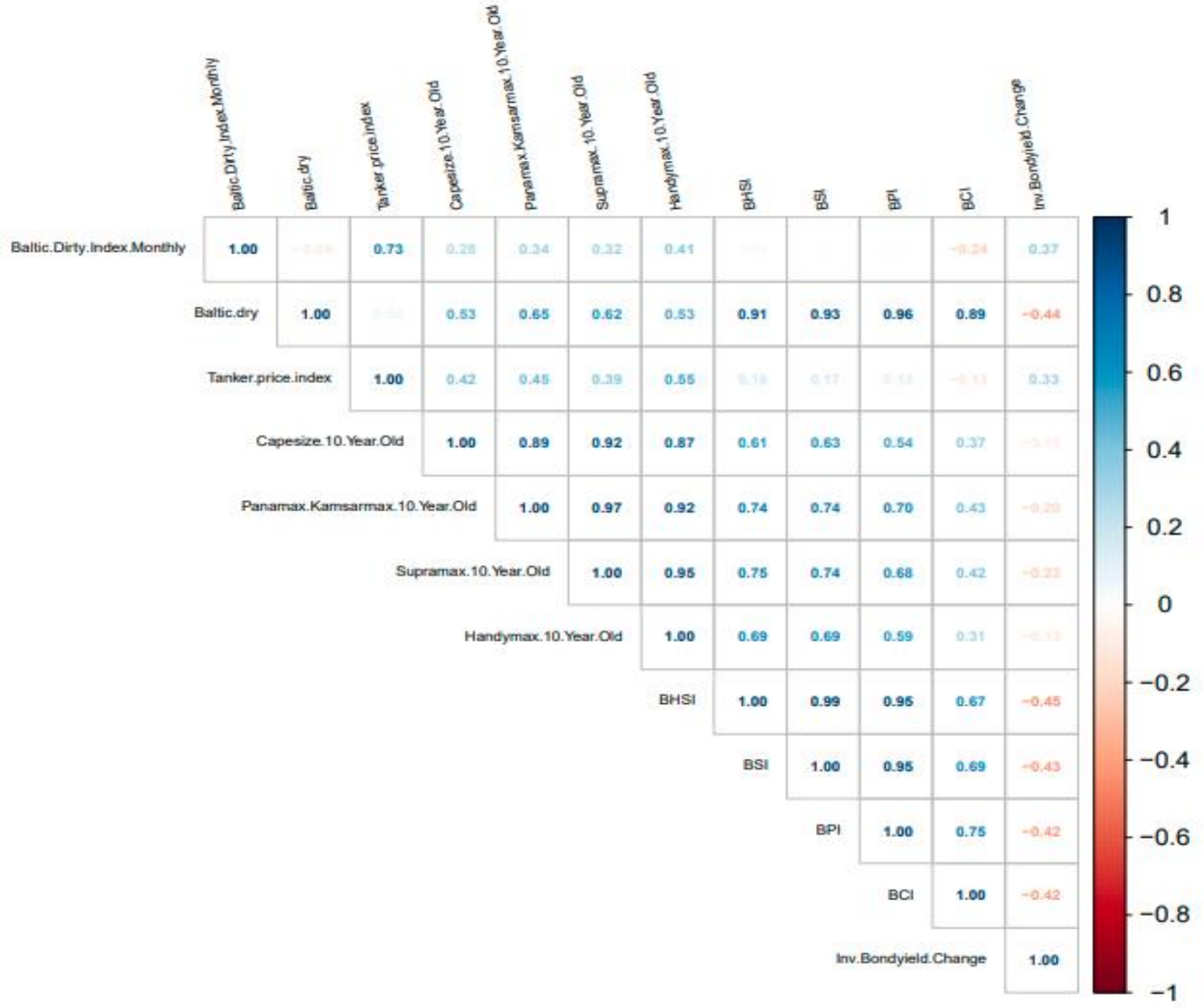
	Dependent variable:			
	Change.Handysize Handysize	Change.Supramax Supramax	Change.Panamax Panamax	Change.Capesize Capesize
	(1)	(2)	(3)	(4)
Intercept	45.26***	39.97***	48.72***	49.43***
	(4.86)	(6.92)	(8.89)	(14.66)
Fleet Growth	0.001***	0.001***	0.001***	0.002***
	(0.0000)	(0.0001)	(0.0000)	(0.0000)
6 month avg Dry Bulk earnings	2.03***	1.82***	2.42**	2.73*
	(0.47)	(0.66)	(0.85)	(1.40)
Observations	200	200	200	200
R^2	0.89	0.88	0.88	0.85
Adjusted R^2	0.88	0.88	0.84	0.84
Residual Std. Error (df = 197)	3.02	4.30	5.52	9.11
F Statistic (df = 2; 197)	759.27***	712.95***	707.34***	541.11***
Note:				*p<0.1; **p<0.05; ***p<0.01

Adding Fleet Growth as a variable and running the regression again as a multiple linear regression, the R squared increases to 0.85 – 0.89 and the impact of the six-month average earnings seems reduced as the fleet growth also impact vessel value, which backs up that supply and demand matters for vessel values, as (Koopmans, 1957) argues.

The results of the regression further states that fleet growth and asset values have a positive relationship, which is contradictory to the economic logic of an increase in supply leading to a softening of asset values and freight rates, all else equal. Overall, the relationships between the different vessel classes and fleet growth and freight rates are positive in a statistically significant matter and hold a significant predicative force.

6.4 Correlation Matrix

Figure 15: Full Correlation Matrix



The above correlation matrix displays the correlation between many dataseries from 2010 - 2023, namely the Inverted bond yield change, the different rates and ship values of Drybulk classes, and an earnings and a price index for tankers. The main takeaways from this matrix are that tanking freight rates and vessel values are positively correlated with the bond yield change whilst Dry bulk is negatively correlated with government bond yields rate of change. Rates correlate stronger than ship values with the government bond yield, this may be because rates are a leading indicator for ship values, and more volatile. This paper have researched this

as well, with a regression between the Capesize 10 year old and 6-month average dry bulk earnings, in chapter 6.3, proving a strong relationship.

The purpose of the correlation matrix above is to briefly investigate if the findings for Dry Bulk also is applicable for dirty bulk, the ship segment carrying crude oil and refined oil products in tankers (Stopford, 2009).

The correlation matrix indicates little to none correlation between dry bulk earnings and dirty tanker earnings. Regarding ship values, the tanker price index correlates 0.39 - 0.55 with the different dry bulk segments indicating a moderate relationship. However, the relation it has to government bond yield changes is positive 0.33, opposed to the weak negative correlations of the dry bulk vessels to bond yield changes. This may be due to the leading indicator baltic dirty index proves a positive 0.37 correlation whilst the Baltic dry index has negative –0.44 correlation to the inverse bond yield change. The data for baltic dirty and tanker price index stems from (Clarksons SIN, 2023). The takeaway from the correlation is that the results from dry bulk in this paper is not applicable for dirty bulk, and separate research has to be done to understand how interest rates are a leading indicator for tanker values.

7. Robustness

The commodity basket consists of Iron Ore, Thermic Coal, and Grains, with Grains being a mix of wheat, corn, and soybeans. For simplicity, the basket is equal weighted. This will not represent the actual price of the average cost carried for the global dry bulk fleet, but hopefully it works as an indicator and moves in the right direction. The sample for the "CB vs BDI" regression is somewhat limited due to data availability. Still, it is a long sample of 159 consecutive months and the results found here expected to hold with some differences for longer or shorter samples.

The paper presents regression analyses performed on different length, in chapter 6.1 the regression is until most recent date, whilst 6.1.2 has 11 months earlier cut-off to adjust for the extraordinary events leading to port congestion at the end of the researched period. This works as a sensitivity analysis and shows that different samples affect the result of our research. However, markets are dynamic, and one cannot conclude that the future will see similar relationships between government bond yields and dry bulk vessel values.

For the multiple linear regression performed in Table 7 it was important to check whether the result was impacted by multicollinearity. This was done with a variance inflation factor (VIF) test and the findings were that for a multiple linear regression with Fleet Growth and Dry Bulk Earnings as the independent variables, the impact of multicollinearity is negligible, at a VIF of 1.009, and does not affect the significance of the results.

Table 8: Multicollinearity for Fleet Growth and Dry Bulk Earnings

Statistic	N	Mean	St. Dev.	Min	Max
Handymax	2	1.009	0.000	1.009	1.009
Supramax	2	1.009	0.000	1.009	1.009
Panamax	2	1.009	0.000	1.009	1.009
Capesize	2	1.009	0.000	1.009	1.009

8. Discussion

8.1 Is it Possible to Predict Future Movements in Vessel Values Based on the 18-month Aggregated Change in US and Chinese 10-year Government Bond Yields?

Firstly, the second-hand market for dry bulk vessels is highly liquid and competitive. Vessels are being sold on a weekly basis through a large number of market participants. If a well-known and widely regarded predictor was in place, every market participant of some size would utilise it, which may lead to implications on volatility. In addition, one must assume that market participants have investigated this relationship previously, albeit there is limited academic research on the topic.

The regression outputs and correlation coefficient are complicated by sudden movements in yields and asset prices originating in other factors such as sudden recessions, demand shocks, rate spikes, and newbuild deliveries. Hence, in order to fully understand the movements in asset prices one must consider the earnings of vessels and the magnitude of the continuous supply of tonnage. Large amounts of deliveries during short time periods effectively produce supply shocks that are not necessarily easily absorbed. Thus, the predictive force of the aggregated change in US and Chinese 10-year government bond yields may be mitigated by the event of a sudden flood of newbuilding deliveries. The same logic may be applied to the mentioned recessions, demand shocks, and rate spikes.

The evidence of predictive value varies by vessel type. This may be explained by the differences in cargo they carry and the routes of which they travel. Owners of Panamax and Supramax ships may expect the value of their assets to be less sensitive to fluctuations in interest rates, compared to Capesize and Handysize owners. This has implications for corporate governance and strategy in shipping companies, as it presents one of the options to mitigate interest rate risks.

Therefore, the R-squared, which measures how much of the variance in the dependent variable that can be explained by the independent variable, on the regression between the government bond yields and vessel values does not exceed 50%. However, this does not explicitly mean that the aggregate changes in government bond yields have no predictive power: In fact, a 1% change in yields does indicate an outsized inverse effect on asset values of all types. Hence, it

is important to consider multiple factors when assessing the results of the analysis and not rely on black and white representations of reality.

9. Conclusion

9.1 Summary of the Research and its Findings

The research in this paper has investigated whether it is possible to predict future movements in asset values by establishing a set of statistically significant leading indicators. By investigating the changes for the past 18-months in US and Chinese 10-year government bonds, it is established that the changes in bond yields have a strong leading relationship to asset values by inverse metric. Furthermore, it is found that freight rates explain movements in vessel values as well. Albeit freight rates in itself are hard to predict, the establishment of freight rates as leading indicators allows for the use of historical earnings for the purpose of predicting future vessel values.

This paper has found that by moving the changes in bond yields 18 months forward it is possible to predict future vessel values, i.e., changes in yields between 01.01.2010-01.07.2011 predicting year-over year changes in asset values as of 01.01.2013.

In addition, this paper found a short-term leading indicator by utilising freight rates, where 6-month average earnings are moved forward 3 months to predict future vessel values, i.e., 6-month average earnings per 01.07.2011 predicting up and downward movements in asset values as of 01.10.2011.

9.1.1 Conclusion on Government Bond Yield Regression

This research paper has analysed whether changes in bond yields of the world's two largest economies can predict future developments in asset values within dry bulk shipping. The results from the analysis reveal that even though there is a statistically significant relationship between changes in bond yields and changes in asset values, it does not fully explain future developments in asset values. This correlation coefficient was strongest for Capesizes, which is in line with the initial hypothesis. The movements in bond yields explain 33% of the variation in vessel values, which leaves a substantial portion of the variation unexplained. However, by doing the regression up until 2021, the results show a stronger relationship. This may be partly explained by an increase in congestion and port issues during 2021-2022 which decoupled the vessel class from macro and overall demand, as these issues practically reduced the total supply of vessels being available for trade due to waiting times etc. This paper does

not cover this specific topic and its implications for vessel values; hence it is not investigated further.

The intercept and correlation coefficient are all statistically significant, warranting a 4% year-over-year change in values for every 1% 18-month aggregated change in bond yields. The intercept states that when there is no movement in bond yields, the movement in vessel values are negative. Such scenario, however, is very unlikely and thus only works as a theoretical example of the bond yield's effect on vessel valuations.

In conclusion, 18-month changes in US and Chinese 10-year government bond yields explain future movements in asset values and works as a variable with statistically significant inverse predictive power. The changes in bond yields are a leading indicator on vessel valuations. By moving said changes in yields 18 months forward, it is possible to predict future movements vessel valuations, meaning that vessel values should come down over the coming months.

Finally, it is important to emphasise that the predictability is short term, and that interest rates are hard to predict. The implication of the research would thus be that it may be used as a leading indicator towards whether to buy or sell a vessel today, knowing what the leading indicator states will happen to vessel values one year from today.

9.1.2 Conclusion on Supportive Regressions

In order to obtain a nuanced picture of movements in vessel values, supportive regressions were done. Regressing asset values together with 6-month average freight rates, a strong correlation is proven. Vessel values and freight rates move closely together, with freight rates explaining more than 83% of all movements in asset values for all vessel sizes. The correlation coefficient further states that a USD 1,000/day movement in freight rates warrants a USD 2.79-5.60 million move in vessel values depending on size. However, predicting 6-month freight rates is a tough job and the task of thousands of analysts globally already. Hence, the strong relationship between freight rates and vessel values must be utilised in another way. Elsewise one ends up being dependent on predicting freight rates in order to predict vessel values.

In conclusion, by moving the 6-month average freight rates 3 months forward, one is able to use historical information with the purpose of predicting future vessel values. Alike the

conclusion from the analysis on the 18-month changes in US and Chinese 10-year bond yields, this leading indicator predicts a fall in asset values the coming period.

As a supplement to the regression between freight rates and asset values, a regression between the Baltic Dry Index, fleet growth and the commodity basket is undertaken with the purpose of better understanding freight rates. The analysis reveals a statistically significant positive relationship between the Baltic Dry Index, fleet growth and the Commodity Basket (CB). However, the CB and fleet growth explains only parts of the variance in the BDI, suggesting the potential influence of other factors, for example the government bond yields which is also have researched. Concluding, freight rates remain influenced by several other external factors, e.g., available vessels in certain basins a given time, vessels unavailable due to dry docks, differences in earnings across trading routes, and more. Hence, the study of freight rates and its leading indicators are a topic for a research paper in itself.

9.2 Limitations

Whilst the study offers valuable insights into how interest rate fluctuations in China and USA affects ship values, the accuracy and predictive power of the study is somewhat limited due to R squared scores ranging from 0.33 - 0.46, which is displayed in Table 3.

Further, the research also has limitations due to factors as sample duration and lacking coverage of factors impacting the value of ships, such as supply/demand. Firstly, the duration of the sample is limited to a 17-year period which is on the lower end of the needed duration to capture cyclicality in global economy and its effects on microeconomic markets in shipping.

Besides the duration, the other addressable limitation to highlight is the limited significance of main results, with overall lower adjusted R squared values than expected, and lower than the limit of which one can declare the relations to be strong.

Further limitations also exist, but the accuracy and fact-fullness of the study is believed to be into the best knowledge of the researchers.

In future research on the topic, adding more parameters for the state of the global economy could add extra value to the results, in addition to looking at samples with a longer duration. The useful life of a dry bulk ship is about 25 years, and the annual fleet growth is on average

4.7%. This means that the supply side of dry bulk shipping is softly reset over time and the longer the sample, the more robust the findings will be.

10. Appendix

I. Historical data. Baltic Indices, yearly averages.

Year	BDI	BCI	BPI	BSI	BHSI
1998	895.7		894.6		
1999	1,063.0	1,247.2	1,064.9		
2000	1,607.8	2,187.1	1,540.2		
2001	1,216.6	1,472.8	1,248.3		
2002	1,137.5	1,394.4	1,130.0		
2003	2,617.4	3,662.6	2,544.0		
2004	4,510.2	6,011.2	4,383.0		
2005	3,371.2	4,602.9	3,128.1	1,869.2	
2006	3,179.7	4,288.8	3,020.8	2,248.5	1,261.2
2007	7,070.3	9,924.0	7,032.0	4,537.9	2,219.4
2008	6,390.3	9,363.4	6,089.8	3,973.3	2,006.2
2009	2,616.5	4,171.5	2,405.4	1,658.1	788.4
2010	2,758.0	3,479.7	3,114.9	2,147.6	1,124.2
2011	1,548.7	2,236.6	1,748.7	1,377.2	717.8
2012	920.4	1,573.3	963.1	904.0	516.5
2013	1,205.9	2,110.3	1,186.6	982.6	561.9
2014	1,105.3	1,967.4	964.1	939.0	523.6
2015	718.2	1,028.9	696.3	666.2	365.5
2016	673.1	1,031.9	695.7	596.4	360.1
2017	1,145.2	2,082.4	1,217.4	844.3	522.5
2018	1,352.6	2,103.6	1,452.9	1,030.6	596.9
2019	1,352.8	2,261.3	1,386.7	880.2	490.9
2020	1,066.2	1,806.3	1,102.6	744.4	444.6
2021	2,943.4	4,019.3	2,988.7	2,433.6	1,427.9
2022	1,933.8	1,950.6	2,304.0	2,013.9	1,185.4
2023	1,134.2	1,330.7	1,364.7	982.7	567.6

Source: Baltic Exchange (2023)

II. GDP and Government Bond Yields

%	GDP growth	Chinese bond yield	American bond yield	Mixed bond yield
2010	4.5408	3.5	3.22	3.36
2011	3.3103	3.87	2.78	3.325
2012	2.7092	3.49	1.8	2.645
2013	2.8079	3.84	2.35	3.095
2014	3.0901	4.13	2.54	3.335
2015	3.0786	3.36	2.14	2.75
2016	2.802	2.89	1.84	2.365
2017	3.385	3.62	2.33	2.975
2018	3.2855	3.61	2.91	3.26
2019	2.5913	3.2	2.14	2.67
2020	-3.1154	2.96	0.89	1.925
2021	5.8698	3.03	1.45	2.24

Source: Bloomberg NEF, IMF

The correlation value for the “Mixed bond yield” and the GDP growth, which is the global GDP growth rate is at 0.47 at an annual granularity.

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