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Bulk carrier economics: the impact of design

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The objective of this thesis was to find how design impacts a bulk carrier's earnings and costs. Foreship BlueTech Ltd. was interested in finding out how they could improve their design in order to increase the earnings of shipowners.

This thesis was done by conducting a literature review. Furthermore, in order to gain a deeper understanding, specialists were interviewed, and the large database of RS Platou, a leading ship broking company, was used to gain market information of the industry.

In order to find out how design impacts bulk carrier economics, all costs and means of earnings were identified. The costs include capital costs, operating costs and voyage costs. A shipowner can earn money by time chartering, voyage chartering or by chartering only the vessel. The actual earnings depend on the costs and the vessel's ability to carry cargo.

The study showed that, of the identified costs, design has the biggest impact on voyage and capital costs. Voyage costs can be lowered by improving fuel consumption. By creating a lighter, easy to manufacture design, the capital costs can be lowered. Maintenance related costs are also affected by the design. If the bulk carrier is used for over 10 years, the cost of maintenance increases significantly. Earnings are largely defined by the costs; the lower the costs, the higher the earnings. The design has a big impact on a bulk carriers earning capacity. By maximizing hold volume and the ability to carry cargo, the bulk carrier's earning capacity rises.

As a result of the study, it is recommended that Foreship BlueTech Ltd. should focus on creating designs that maximize hold capacity and the ability to carry cargo with minimum fuel consumption. These are largely determined in the design phase, and it is very hard to make improvements later on. It was also found that depending on the intended operating life of the vessel, the design should focus on different aspects to lower the costs.

Keywords	bulk carrier, shipowner, shipping, ship design

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Tekijä Otsikko Sivumäärä Aika	Mikko Hakulinen Suunnittelun vaikutus kuivarahtilaivan kuluihin ja ansioihin 50 sivua + 3 liitettä 19.01.2015
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Lopputyön tavoitteena oli tutkia kuinka designilla voidaan vaikuttaa kuivarahtilaivan tuottamiin kuluihin ja tuloihin. Foreship BlueTech Oy oli kiinnostunut kehittämään heidän laivakonseptiaan parantaakseen asiakkaidensa ansioita.

Työssä käytetty tutkimusmenetelmä oli kirjallisuustutkimus. Siinä tehtyjä löydöksiä täydennettiin haastattelemalla alan asiantuntijoita. Markkina-analyyseissä käytettiin RS Platoun, johtavan maailmanlaajuisen laivavälittäjän, laajaa tietokantaa.

Ennen suunnittelun vaikutuksen tutkimista, kaikki kulut sekä ansaintatavat tunnistettiin ja määriteltiin. Kulut voitiin jakaa pääomakustannuksiin, käyttökustannuksiin sekä matkakustannuksiin. Laivanvarustamon yleisimmät ansaintatavat ovat aikarahtaus, matkarahtaus sekä rahtaus ilman miehistöä. Laivan todelliset tulot riippuivat paljolti kuluista sekä aluksen lastinkantokyvystä.

Määritetyistä kuluista suurin vaikutus suunnittelulla oli matka- sekä pääomakustannuksiin. Matkakustannuksia voitiin alentaa parantamalla laivan polttoainetaloudellisuutta. Pääomakustannuksiin pystyttiin vaikuttamaan suunnittelemalla kevyempi, helposti rakennettava laiva. Käyttökustannuksista huoltokuluihin pystyttiin myös vaikuttamaan ennaltaehkäisevällä suunnittelulla. Etenkin jos laivan käyttöikä ylitti 10 vuotta, jonka jälkeen huoltokulut nousivat merkittävästi, pystyttiin suunnittelulla vaikuttamaan huoltokuluihin. Kulut määrittivät pitkälti kuivarahtilaivan tulot; mitä pienemmät kulut, sitä suuremmat tulot. Työssä todettiin että suunnittelulla on suuri merkitys kuivarahtilaivan ansaintakykyyn. Maksimoimalla ruumatilavuus ja lastinkantokyky, laivan ansaintakyky kasvoi.

Työn tuloksena voidaan sanoa että Foreship BlueTech Oy:n tulisi keskittyä laivakonsepteissaan maksimoimaan ruumatilavuus sekä lastinkantokyky, minimoiden polttoainekulutus. Nämä asiat määritetään suunnitteluvaiheessa ja niihin on vaikea tehdä parannuksia myöhemmin. Todettiin myös että laivan suunniteltu elinikä sekä käyttötarkoitus osaltaan määrittävät mihin asioihin suunnittelussa tulisi keskittyä.

Avainsanat	kuivarahtilaiva, varustamo, merikuljetus, laivansuunnittelu

Contents

Abbreviations

BDI	Baltic Dry Index
BV	Bureau Veritas
CSR	Common Structural Rules
DNV	Det Norske Veritas
DWT	Dead Weight Ton, Dead Weight Tonnage
FEM	Finite Element Model
FOC	Fuel Oil Consumption
GDP	Gross Domestic Product
HVAC	Heating, Ventilation and Air Conditioning
IFO	Intermediate Fuel Oil
ILO	International Labor Organization
IMO	International Maritime Organization
ISO	International Organization for Standardization
ITF	International Transport Workers' Federation
LOA	Length Overall
OECD	Organization for Economic Cooperation and Development
PCNT	Panama Canal Net Ton
RANS-CFD	Reynolds-averaged Navier–Stokes - Computational Fluid Dynamics. Ways of calculating and optimizing hydrodynamic abilities of a hull.
SCNT	Suez Canal Net Ton
SDARI	Ship Design and Research Institute
SDR	Special Drawing Rights
SOLAS	Safety of Life at Sea

1 Introduction

In this thesis I examine bulk carrier economics and how a bulk carrier's costs and earnings can be affected by design. This study is done for Foreship BlueTech Ltd., a Finnish ship designing company.

The acquisition of a bulk carrier starts as a need; a shipowner determines that it requires a specific type of vessel to satisfy this need. The next stage is to choose a design that fulfils it. The design has an impact on a vessel's economics through its life span, and therefore it is crucial for shipowners to choose an optimal design for their need.

Foreship BlueTech Ltd. is interested in better understanding of the costs and earnings of a bulk carrier, in order to better respond to the needs of their clients. In order to provide the customers with the best possible design, the company is interested in knowing what can be done to improve the earning capacity and to lower the costs of a bulk carrier.

In the first part of this study I present the company and the market in which Foreship BlueTech Ltd. is operating. Shipping and shipbuilding are specific lines of business and in order to properly understand the motives, and later on the results, a thorough overview is given. In the latter part I determine what the costs and earnings are to the end-users, either for shipowners or charterers. Once these elements are specified and quantified, I will try to find out which of these can be affected in the design, and finally I propose some potential improvements.

1.1 Presentation of the company

Foreship BlueTech Ltd., referred to as BlueTech from now on, is a fairly new company since it was established in January of 2013. The company started as a project in Foreship Ltd. Foreship, founded in 2002, is a Finnish company specialized in ship designs and engineering. It is an independent company owned by its employees with a personnel of over 60 naval architects, marine & structural engineers and interior & HVAC (Heating, Ventilation and Air Conditioning) designers. (Foreship 2013) In order to fully concentrate on the design and development of efficient and eco-friendly cargo ship standard designs, the decision was made to create an independent company. Foreship remains the major owner of BlueTech along with the current employees. Currently there are eight employees with different areas of expertise.

BlueTech has developed an efficient CSR (Common Structural Rules) bulk carrier series, called Bluetech. The series is based on state-of-the-art hydrodynamics, including optimization with RANS-CFD (Reynolds-averaged Navier–Stokes - Computational Fluid Dynamics), and the latest engine technology, providing world-class fuel economy figures. The daily consumption is 30% below average current designs. (Foreship BlueTech 2014) Also, BlueTech has created a series of ships, currently four different Handysize that are highly competitive when it comes to fuel efficiency (see appendix 1 for bulk carrier size chart). Model tests have been conducted which validate the RANS-CFD calculations, the current hull design is effective and with modern engines the Bluetech ship series is very competitive in a tightly contested market.

The business idea of the company is the design and development of efficient and eco-friendly standard cargo ship designs. BlueTech is aiming at a refined design, which will then be licensed and used by numerous shipowners. Each ship-owner has its own specific needs and desires according to which the design can and will be modified, but the hull form and main design and technical features stay the same from ship to ship. Bulk carriers are fairly inexpensive and low-tech ships (Minchev & Schmidt & Schnack 2013) and are also referred to as standard ships.

BlueTech is a small but highly competitive company with a team of employees that are very motivated and eager to create the best possible design. The employees have a long experience in the key areas of ship designing, and they have established themselves as well known known actors in the engineering industry. The close relationship with Foreship allows BlueTech to be flexible in its actions and provides additional expertise.

1.1.1 RS Platou

Partly because of BlueTech's size but also for the added value, the company has chosen to work with a broker that takes care of the worldwide marketing of the ships. RS Platou, a leading international broking company founded in 1936 (Platou 2014), has the exclusivity to represent BlueTech designs. With their long experience and wide knowledge of the industry they contribute to making BlueTech successful.

RS Platou's current business areas are ship broking, offshore broking, investment banking, economic research, project finance and real estate (Platou 2 2014). Their expertise in ship broking is what is most important for BlueTech, but the other activities contribute to making RS Platou an important partner with experience and a large network. RS Platou's role is to find clients for BlueTech, and to provide the company with useful information of the market and future trends. They also give advice concerning the design as they have long relationships with shipowners.

1.1.2 Competition

BlueTech has identified four main competitors to its Bluetech series. Seahorse is a design by Grontmij, Europe's fourth largest engineering consultancy company with a turnover of approximately 1.5 billion USD. (Grontmij 2014) In addition, Bestway, the company responsible for the Emerald 39 design, is China's largest and strongest professional enterprise group in marine and offshore engineering. (Bestway 2014) Finally, the Green Dolphin is a joint creation of DNV and SDARI and B-Delta is designed by Delta Marin, a formerly Finnish company that has recently been purchased by the Chinese AVIC group.

Table 1. Comparison of the BlueTech ships and competitors. Copied from BlueTech 2014

Handy/handymax bulk carriers	LOA	Speed	A FOC*	B dwt*		C Cargo hold		A/B FOC/dwt		A/C FOC/Hold volume	
	[m]	[kn]	[t/d]	[t]	Δ	[m3]	Δ	[t/dwt]	Δ	[t/m3]	Δ
BLUETECH 41	180	14	17.8	36000	7.8 %	53000	5.0 %	4.94	-6.7 %	3.36	-4.2 %
BLUETECH 42	185	14	18.2	36900	10.5 %	58000	14.9 %	4.93	-6.9 %	3.14	-10.5 %
SEAHORSE 375	180	14	21	34900	4.5 %	46700	-7.5 %	6.02	13.5 %	4.50	28.3 %
EMERALD 39	179.9	14	18.4	33400	0.0 %	47500	-5.9 %	5.51	4.0 %	3.87	10.5 %
B-DELTA37	180	14	17.9	35000	4.8 %	50000	-1.0 %	5.11	-3.5 %	3.58	2.1 %
GREEN DOLPHIN	180	14	17.7	33400	ref	50500	ref	5.30	ref	3.50	ref

*)at design draft, ISO conditions without engine tolerances

Table 1 shows how the BlueTech designs stack up against the top competitors. All have roughly the same length, 180 m, as well the design speed of 14 kn. In this table the Green Dolphin is the reference vessel to which others are compared. The green highlighting means that the figure is better than in Green Dolphin's case, and vice versa when the highlighting is red.

When looking at the FOC (fuel oil consumption), BlueTech 41's 17.8 tons per day is equivalent to the best current design, Green Dolphin. However from then on it is clear that the BlueTech design has advantages over competitors. It is able to carry up to 10.5% more DWT (tonnage) than others, its cargo hold capacity is up to 14.9% bigger, and when looking at these figures compared to the FOC, it can be said that the BlueTech design is the most fuel-efficient on the market at the moment.

It is important to emphasize that these competitors are not to be neglected. All these other designs are of big design companies that are well-known in the industry, and they have sold numerous ships already. The shipbuilding industry is traditionally one that appreciates earlier references very much, and in this area the competitors have a clear edge over BlueTech.

To conclude, BlueTech is a young company with an excellent and proven product. The market is ready and calling for an efficient design such as Bluetech, but there is fierce competition and the company's biggest competitors are established and renowned parties in the industry. That said, with the collaboration with the mother company Foreship and RS Platou, a leading brokering company, BlueTech is well placed in order to be successful in the near future.

1.2 Presentation of the market

When looking at the market where BlueTech is operating we must take a step back in order to see overall. What we are really dealing with is the shipping industry, and it is necessary to take a look at it to understand in what kind of environment BlueTech is working.

Shipping is undoubtedly one of the world's most international industries (Stopford 1997). It is also a great actor in the world economy (Corbett & Winbrake 2008). Gobalization has created a trend that raw products are collected or produced at a certain place and refined elsewhere, usually for cost savings. Here bulk carriers play an important role since they mostly carry large quantities of unrefined raw materials such as grain, coal and iron ore (Stopford, 1997). As over 90% of global trade is carried by sea, (IMO 2012) it is easy to understand the importance of shipping. It makes it also easier to understand why shipping is closely linked to the world economy; there is a direct link between the growth in GDP (Gross Domestic Product) of a country and the growth in exports and imports (Corbett & Winbrake 2008), in other words shipping.

1.2.1 Actors

In the case of BlueTech there are three possible end users. The main group of clients is the shipowners. Most of the ships are ordered by shipowners who then charter their ships in various ways for charterers, the second group of clients. The operator, or charterer, is either the producer of a certain commodity, or a third party that buys the good and then ships it forward. The operators can, depending on the commodity and the destinations, choose from different chartering methods the ones that suit their needs in the best way. The third potential type of client is a speculator. Speculators try to read the market, predict price changes and buy a bulk carrier at a low price, and then sell it once the ship is built, hopefully with a profit.

1.2.2 Bulk carrier markets

Bulk cargos are commodities such as crude oil, grain, iron ore, coal or chemicals (Stopford 1997). In this study I focus on dry bulk cargo, not on liquids such as oil. There are different ways of classifying what is "bulk" but when referring to bulk carriers they are mainly the products that are being transported in large quantities and in a non-packed form and that have a homogenous physical appearance.

As mentioned in the section 1.2, the bulk carrier market is very dependent on the world economy and as for the world economy, the recovery has been quite slow after the 2008 financial crisis (Platou Report 2014; UNCTAD 2013). The driving force in the last few years has been China, and in 2013 its dry bulk imports increased by 12 percent and now account for more than 40 percent of the world's dry bulk commodities in deep sea trade (Platou Report 2014).

BULK CARRIER FLEET BY SIZE
Mill dwt

Start	Handysize	Handymax/ Supramax	Panamax/ Kamsarmax	Post Panamax	Capesize	Total
2004	68.3	67.6	64.3	4.5	94.2	299.2
2005	69.6	71.2	69.7	5.0	101.6	317.4
2006	70.8	76.4	75.9	5.7	110.5	339.3
2007	71.4	81.0	82.6	7.2	120.2	362.4
2008	73.4	86.0	87.5	9.0	130.6	386.5
2009	74.7	92.1	92.4	10.7	143.5	413.4
2010	74.3	100.5	96.4	14.4	169.3	454.9
2011	79.8	117.9	104.3	22.6	207.8	532.5
2012	83.8	134.6	116.3	34.8	242.5	612.0
2013	86.8	145.8	132.8	44.4	268.4	678.3
2014	**86.5**	**153.8**	**146.6**	**48.3**	**280.9**	**716.0**

Table 2. Bulk carrier fleet by size in millions DWT. Table copied from Platou Report 2014.

Table 2 shows the changes in fleet sizes over the past 10 years. It can be seen that the bulk carrier capacity in 2014 is 716 million DWT, or roughly 40% of the world's merchant fleet. (UNCTAD 2013) This corresponds to 9 965 bulk carriers, of which 5 942 are Handysize or Handymax vessels (see appendix 1 for bulk carrier size chart). (Platou weekly 2014) There has been a tremendous increase in the world's bulk carrier fleet, +139% in DWT in the past 10 years. This is partly explained by the fact that ship sizes have been increasing in the past few years, but also because of the number of ships.

1.2.3 Freight and ship prices

It is important to understand is that the bulk carrier market functions by the rules of demand and supply. The freight prices vary depending on the market situation of the transported good, and on the number of ships available.

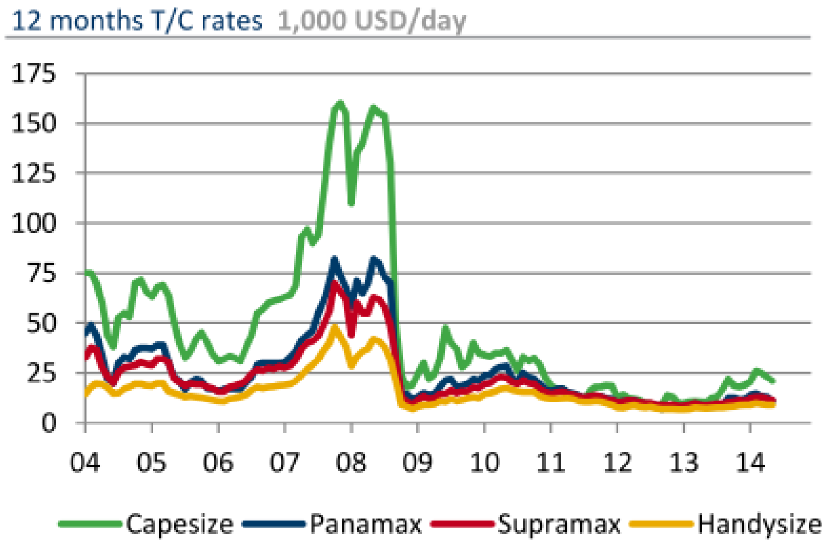

Figure 1. Time charter rates 1000 USD per day. Copied from Platou Monthly 2014

Figure 1 indicates the development of freight rates over the past 10 years. Freight rates represent the price a shipowner can have for chartering his ship, in this case in time charter. In 2007-2008 shipowners were paid up to USD 160 000 a day for chartering a Capesize vessel. In 2014 the same ship can be chartered for USD 25 000 per day. The time just before the financial crisis was exceptional and those kinds of freights are not to be expected in the near future, but the freight prices are low at the moment (Platou Monthly 2014).

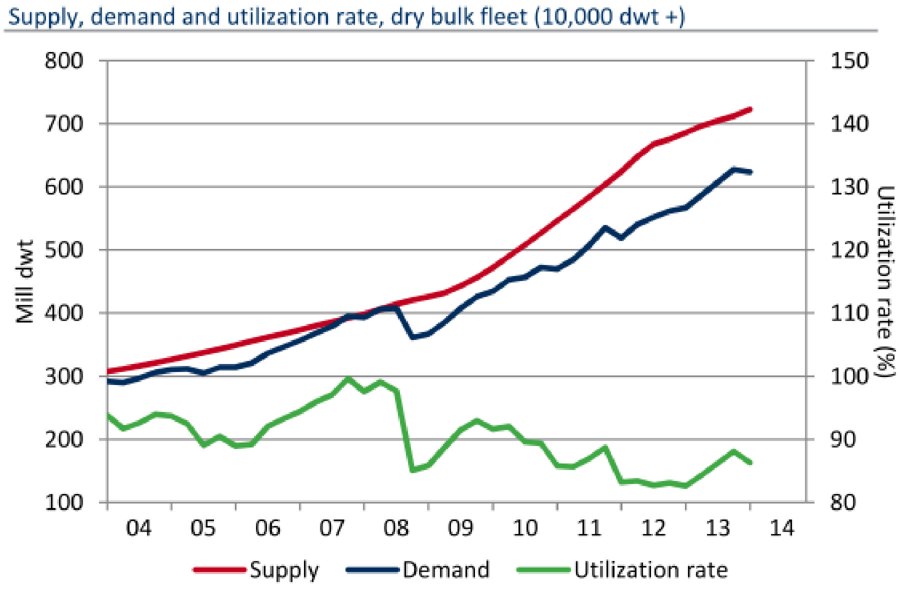

Figure 2. Supply, demand and utilization rate of bulk carriers. Copied from Platou Monthly 2014.

Figure 2 further illustrates the supply and the demand of bulk carriers. In 2008, just before the economic system overheated, the utilization rate of bulk carriers was 100% and ship-owners ordered new ships in order to satisfy the demand. This was problematic because it takes 18-36 months from order to a complete ship, and by the time the ships were delivered the world economy had collapsed. The effects can to some extent be seen still in 2014. In 2008 the order book of bulk carriers was equivalent to almost 80% of the actual fleet (UNCTAD 2013), which meant that in the coming years there were many ships but the market did not have a demand for them. The problem still exists today. There is a large imbalance between supply and demand, which causes freight prices to stay down. (Hellenic Shipping News 2013)

Figure 3 illustrates this same issue and it also shows how shipowners tried to solve this unbalanced situation between supply and demand. In 2011-2013 over 70 million DWT worth of ship were scrapped. Of course bulk carriers are not eternal; they have an operating life of some 15-20 years, but these kinds of removal figures can be explained by the fact that shipowners needed to reduce the supply, in order to achieve better freight rates. This is also a consequence of the fact that at lower freight rates some ships that have high operating and voyage costs are no longer profitable and thus the owner is forced to either do modifications to make the ship more fuel-efficient, or to scrap the ship.

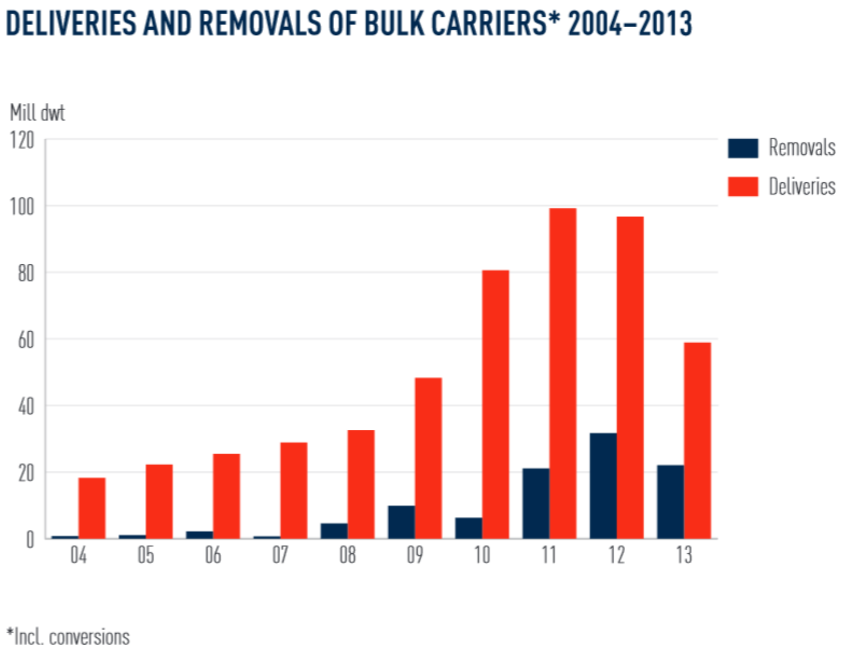

Figure 3. Deliveries and removals of bulk carriers 2004-2013. Copied from Platou Report 2014.

Another aspect that is important to point out is the development of ship prices. Again, there is a strong correlation between the world economy and the prices. It is generally argued that the price is mainly based on supply and demand, steel, labor and equipment prices and exchange rates naturally have an effect as well, but only supply and demand explain the volatile prices.

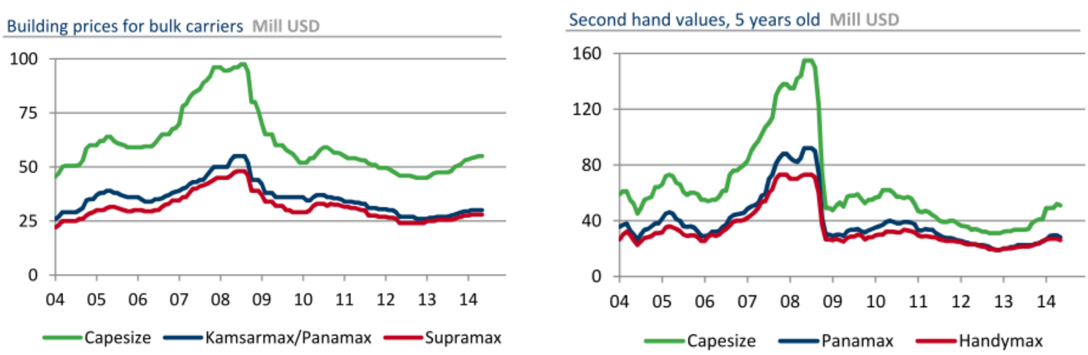

Figure 4. Building prices for bulk carriers, 2004-2014. Copied from Platou monthly 2014.

Figure 4 demonstrates the development of bulk carrier prices over the last 10 years. It can be seen that the curve behaves much in the same way as in the freight price chart, only with lower peaks. When owners order a ship, they will estimate the need for a specific type of bulk carrier and make their decisions depending on what the market looks like and what kind of earnings they foresee in the future. There is again the problem of time to delivery, which makes estimating difficult and leads to situations where a 5-year-old ship that is available immediately is more expensive than a brand new that is delivered in two years (Platou Monthly 2014). These are the types of situations speculators are interested in.

Another important market indicator is the BDI (Baltic Dry Index) which shows the average price to ship raw materials on different routes and by ship size (De Monie et al, 2008). It is also considered a leading indicator of economic activity, since it represents the flux of raw products. When the BDI is high, more raw materials will be shipped and this usually means that there will be more production.

The bulk carrier market is an intriguing market and it can be approached from different angles. To fully understand and describe how it functions would require a study of its own. For the sake of this project it is important to understand that it is a highly volatile market that is influenced largely by the world economy. Bulk carriers are a cornerstone of the world economy as they carry approximately 40% of the world trade in DWT. The bulk carrier fleet has been growing in the past years and according to experts, although the rate of the growth has slowed, the increase will be of 6% in 2014 (Platou monthly 2014).

2 Presentation of the study

There are a few reasons why this study is of importance at the moment. First it allows BlueTech to receive additional information about the industry and about the ships. This information is useful in design, but also in sales and marketing. In order to design the best possible vessel, it is necessary to seek different ways of improvement. Knowledge about bulk carrier economics will also have an impact on the sales; this study aims to provide useful information which could be used in justifying some technical choices or other aspects of the design. As mentioned in the chapter 1, BlueTech is a young company and not all aspects of the industry are well known.

Personally I was very interested in the project for many reasons. First I find the industry very interesting and I am eager to better understand how it functions and how the ships operate. My current job in the company is to assist in the design elements mostly by updating and creating AutoCAD drawings. I am also responsible for the FEM (Finite Element Model) calculations with the use of BV Veristar software. This study allows me to better understand what happens after the design phase, and it also potentially helps me move towards a more commercial role in the company.

Although this study is made especially to serve BlueTech's needs, the findings could be beneficial for someone interested in shipowners or bulk carriers in general.

2.1 The relevancy of the study

There are a few good reasons why this study is important at the moment. The bulk carrier market is tightly contested and ships are facing stricter rules and regulations. As mentioned above, BlueTech's business idea is the design and development of efficient and eco-friendly cargo ship standard designs. In the past ships were designed only by engineers and designers. A more modern approach is to involve the end user in the design, in this case the shipowner (Younis 2003). It may seem trivial, but this did not happen until 2008 when Grontmij, a Danish company, teamed up with charterers and operators to create the Seahorse 35. The focus was on economical and efficient cargo handling, low maintenance costs and operational costs among others (Minchev & Schmidt & Schnack 2013). BlueTech in its current situation has to take these aspects in to account in the design, since competitors are doing so as well.

The next phase would be to offer clients something they did not even know that they wanted, or that it existed. That kind of proactive approach is common in modern industry, but in the traditional standard ship industry it has not yet become popular. That is also a good reason for investigating bulk carrier economics and how they impact the end user. There is potential to find something new that has not yet been tried.

BlueTech has determined four design targets: most fuel-efficient in its own class, low cost, highest earning capacity in its own class and robustness. (BlueTech 2014) Table 1 showed that at the moment the first target is attained, BlueTech's design is the most efficient when looking at fuel oil consumption. Low cost can be attained by cutting the weight down as much as possible as the steel weight is a major factor in the building costs. Also a simple design that is easy to build reduces the costs. However the actual cost of the ship is to some extent out of BlueTech's hands. As explained in section 1.2.2, the prices are very volatile and depend greatly on the market situation. Still, the goal is to create a design that is low cost compared to the competitors' designs. A ship's earning capacity is very closely linked to the ship's efficiency, and according to table 1, with a Bluetech ship a shipowner is able to transport up to 10% more volume than the best competitor compared to the consumption. Robustness is almost self-evident. It is evident that a ship that faces immense stresses and forces must be designed and built to last the toughest of weathers and loads. In the pursuit of lightness and efficiency it is important to say that all calculations and design features are made according to the classification societies and CSR and SOLAS (Safety of Life at Sea) rules.

In order to have and maintain success, it is vital to push the design further and also to find new ways of improving the design. In this case the study focuses on BlueTech's customers and tries to determine the elements that can be affected in the design, and to find out what can be improved. As Foreship BlueTech Ltd. is a rather new company, it is important for the company to know, in as much detail as possible, how their clients work and what can be done in order to make their job more profitable.

In the past 20 years there have been a few major events that have had an impact on bulk carrier designs. In the 1990s there was an alarming number of shipwrecks and especially many bulk carriers were lost at sea. This led to the creation and tightening of various rules and regulations set by IMO (International Maritime Organization) and regulated by various classification societies such as DNV (Det Norske Veritas), Lloyd's and Bureau Veritas. Another event that changed the way bulk carriers are designed is closely linked to the 2008 financial crisis.

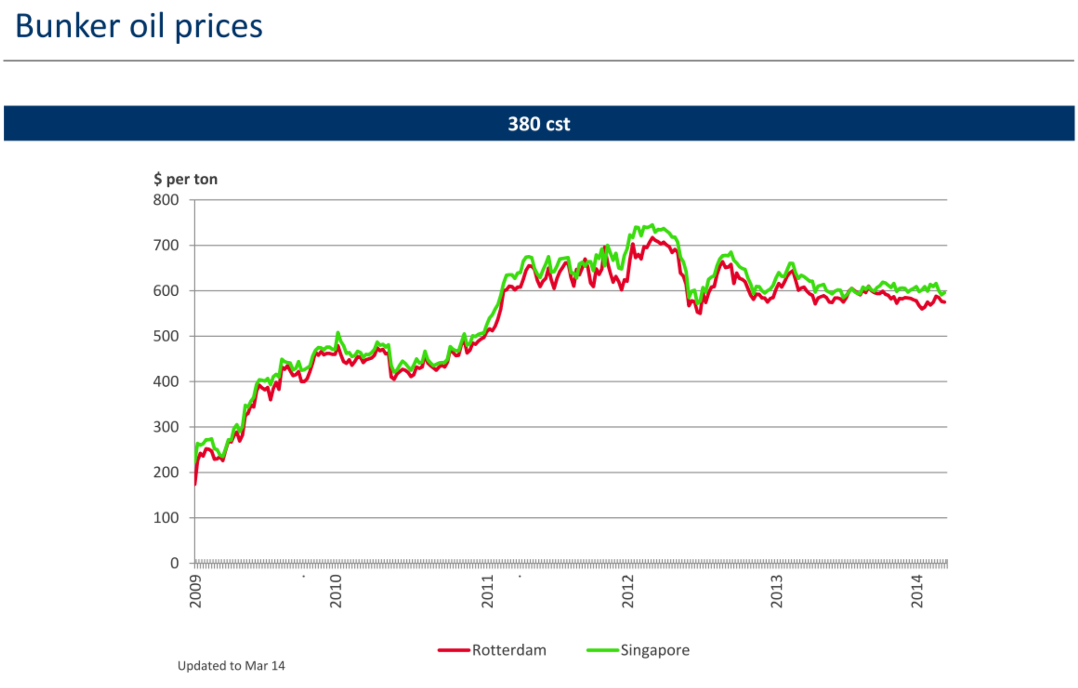

Figure 5. Bunker oil prices 2009-2014. Copied from Platou monthly 2014.

Figure 5 shows how the price of bunker oil has changed after the crisis of 2008. It can be seen that the price has practically tripled in the past five years; this has an enormous impact on bulk carriers' voyage costs. This is one major reason why this study is relevant. Before the year 2008 bulk carriers were considered simple, fairly low-cost ships and not too much attention was paid to their efficiency since they were profitable ships and fuel cost was not an issue (See appendix 2). Nowadays it is harder to make profitable ships and every possibility for improvement must be examined.

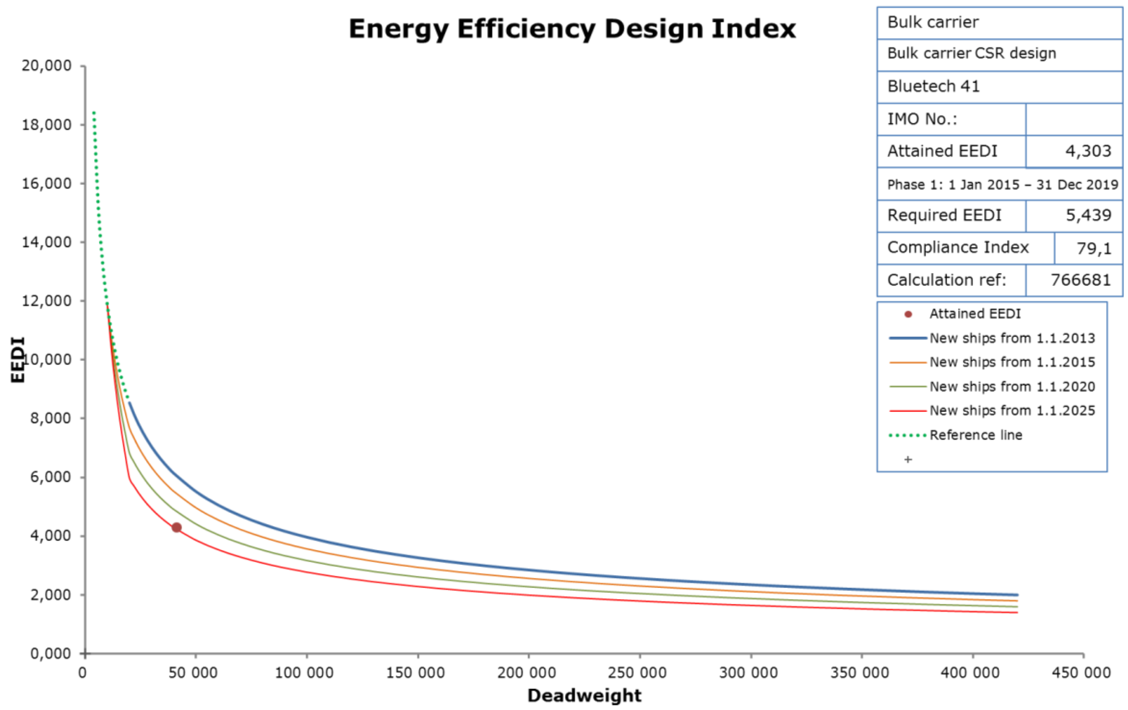

Figure 6. EEDI limits and timetables (BlueTech 2014)

Another factor that is pushing engineers and designers in finding more efficient ways of transporting goods is the EEDI. The Energy Efficiency Design Index is created by IMO, and ships built after 2013 have to attain a certain level of energy efficiency in order to be allowed to sail (Hughes 2012). Figure 6 shows the limits per year and where the BlueTech design is at the moment. As can be seen, the current design is well in the limits for the first three stages. However BlueTech is always looking to attain an even better EEDI and to reduce its CO2 emissions. By doing so it is probable that a shipowner's earning capacity will be increased, since a more efficient ship is usually capable of achieving higher earnings.

This study is relevant because BlueTech is interested in better understanding clients' needs. Finding out what the elements are that impact a bulk carrier's costs and earnings, and how they can be affected by the design, will provide valuable information that will help in designing better ships.

2.2 Research problem and objectives

The research problems of this thesis can be roughly divided in to two: first the problems related to the costs of a bulk carrier, and second I will be studying the earnings, not only for the shipowner but also for the operator that buys the service from the shipowner. The objective is to define these, find a correlation between the costs and their impact on the earning capacity and to find out ways in which BlueTech can affect these in its designs.

A bulk carrier causes three types of costs for a shipowner: capital costs, operating costs and voyage costs (Drewry 2004; Stopford 1997). In order to fully understand the bulk carrier economics it is needed to define those three aspects.

Cost related research problems are the following:

- **What are the costs that can be affected by the design?**
- **How can BlueTech affect them in their design?**

Before finding the solutions to these problems, the study aims to answer the following questions:

- What are the elements that create costs?
- What is the repartition of the costs between capital, operating and voyage costs?
- What is the correlation between the costs?
- What is their impact on a ship's earning capacity?

Other research problems are related to the earnings. Shipowners have three ways of chartering their ships: bareboat, time and voyage charter. (Drewry 2004; Stopford 1997) These are to be defined in order to understand from what consists a bulk carrier’s earning capacity. It is also necessary to consider the operators, the clients of the shipowners, earnings. This will help in understanding the overall and it will give information about the ship’s earning capacity from a different standpoint.

Earning related research problems are the following:

- **What is the value of a DWT or m3 for a) a shipowner b) a charterer?**
- **What design changes can be done to increase earning capacity?**

To access these problems, the following questions are to be solved:

- What are the differences between the different charter options?
- How are they impacted by the ships earning capacity?
- What is a bulk carrier's earning capacity?
- Means of earnings for shipowners vs. operators?

These problems together give us the complete research problem and objective: **What are the costs and earnings related to a bulk carrier, and how can they be affected in the design?**

By answering these questions BlueTech is able to create better vessels and to be competitive in a tightly competitive market. This information will also help the sales, as they will be able to give better arguments on why our design is better than that of others, and also in justifying some technical arrangements.

Additional objectives of this study are to gain more knowledge of the industry in general, and to find potential new ways of designing and to see what may be done in the future.

3 Methodology of the study

In order to execute a professional thesis, emphasis has been put into carefully and critically finding sources of information. The search can be divided into two parts; firstly a thorough literature search was conducted in order find out all the existing information of the subject. Furthermore, specialists were interviewed and the large knowledge of the BlueTech employees was also utilized.

3.1 Literature review

When conducting the literature search I noticed that there was a very limited number of books written of bulk carriers, it made me wonder the reasons for this. As presented in the section 1.2.2, shipping has a major impact on the world economy and vice versa, and since bulk carriers account for 40% of the world's shipping volume, they are important. One part of the explanation can be in the ownership of bulk carriers. Quite a few nations have national bulk carrier fleets, China for example (UNCTAD 2013), and I could imagine that they do not share their knowledge easily and that in the course of the years they have found their way to be effective. In Greece, which has one of the world's largest bulk carrier fleets, shipping companies are often family-run companies and there the knowledge and expertise is passed on to future generations.

However there are books written about the shipping industry and bulk carriers. Martin Stopford is a highly recognized author and economist that has written a book called Maritime economics. The 3rd edition of the book was published in 2009 and it along with the later editions provided excellent information for this study. A more bulk carrier oriented book is Captain J Isbester's Bulk Carrier Practice (1993). It can be considered the bulk carrier "bible" since there are not many books specialized in bulk carriers. In more technical matters Schneekluth and Bertram's Ship Design for Efficiency & Economy (1998) offered accurate information even though the book is quite old. These three books have been of great assistance but given the fact that they are a bit aged, theories and facts presented in these books were checked and newer information was used if it was found reliable.

I had the privilege of using the large knowledge of RS Platou during this process. Throughout the project I received weekly and monthly statistics about the market situation, and they provided me with valuable information. Concerning statistics, only reliable and renowned sources were used. Clarkson's is one of the world's oldest shipping broker companies and its statistics and articles have been useful during this study. UNCTAD and OECD reports provided information especially of the markets and the relation between the world economy and shipping economy. IMO was also an important source for information.

In addition to these sources, prior studies regarding the same field were read and analyzed. These were done with precaution as the credibility of the studies is not always a certainty; the selected studies were carried out by credible actors and thus can be considered reliable. These were studies conducted by Harvard and Princeton Economy students, MIT technology PhDs or by recognized organizations such as the Ship Structure Committee. Some specialist consultant reports were also used, such as Drewry's Ship Management (2004). Using such sources can be problematic as a specialist consultant is often trying to sell its services, but there is reliable and interesting information as well.

Internal documents were also used in order to complete the information. BlueTech employees had information which was very useful and necessary to complete the study.

3.2 Interviews

In order to gain a deeper understanding and to receive expert opinions, some interviews were conducted. I had the opportunity to have a discussion with Mr. Jean Labescat, Technology General Manager of Setaf-Saget, a French shipping company. He has a long firsthand experience and his opinions were highly valuable for this project.

In more technical matters BlueTech employees were consulted. BlueTech's broker RS Platou was also of assistance during the course of the project.

4 Bulk Carrier-related costs

The economics of a ship consists of the costs and the earnings. There is naturally a strong relation between these two, and before investigating the earnings it is important to understand the costs and how they are divided.

Type	Bareboat	Time charter	Voyage charter*
Master	Appointed and directed by a charter	Appointed by the owner, directed by a charter	Appointed and directed by the owner
Revenue	Depends on hire rate and duration	Depends on hire rate and duration	Depends on the quantity of cargo and rate
• Costs (paid by the owner)	• Capital (depreciation, interests) • Brokerage Operating costs	• Capital (depreciation, interests) • Brokerage • Crew costs • Stores • Maintenance & repairs • Insurance • Administration Voyage costs	• Capital (depreciation, interests) • Brokerage • Crew costs • Stores • Maintenance & repairs • Insurance • Administration • Port charges • Light dues • Stewadoring charges • Cleaning holds • Cargo claims • Bunker fuel • Canal fees

Figure 7. Bulk carrier costs and their repartition. Copied from Stopford 2009.

Figure 7 demonstrates the repartition of bulk carrier related costs. As can be seen, the costs can be divided into three parts: capital costs, operating costs and voyage costs. The choices and modifications done in the design affect all these three and in order to understand how, it is important to clarify, determine and specify each of these.

These costs however, are not easy to define as shipowners often keep them a secret. Capital costs and voyage costs are fairly easy to specify as ship and bunker costs are public information. The operating costs are much harder to determine and accurate up to date information is not easily available. There are a few reasons for this. Low operating costs provide a key competitive edge (Hadjiyiannis 2010) and shipowners do not wish to give this away. Another reason could be that shipowners do not wish their clients to know the operating costs because it would reveal their margins, and that would give an edge to the charterer in the freight price negotiations. Low operating costs can also be considered a compromise in quality or safety (Hadjiyiannis 2010), which is another reason why it can be hard to find accurate information.

4.1 Capital costs

A bulk carrier's capital costs are calculated by taking into account the ships price, the costs of the loan; in essence the interests, and the depreciation. The periodic maintenance is also often taken in to account in the capital costs. (Stopford 1997)

As discussed in section 1.2.3 the bulk carrier prices are highly volatile and vary over time. They can however be broken down into smaller pieces in order to understand what the elements are that create the price, and which of those are affected by the choices made in the design.

4.1.1 The ship

A bulk carrier's actual price consists of numerous factors, mainly the supply and demand and yard availability, for instance. An elaborated model is presented in Jiang (2010)'s study of bulk carrier prices in China. For the sake of this thesis these factors are dismissed and they are considered multipliers, which they are in essence. The actual physical parts are the ones that BlueTech has control over, and those are the parts that I will focus on.

Physical elements that make the building price of a bulk carrier are mainly the steel that is needed to build the ship, the workforce that builds it, the main engine along with auxiliary engines and the propulsion line. Hatches and cranes are also quite expensive. Other costs come from equipping the ship. Navigation and communication equipment and the interior design also have a cost, if not significant (Internal interviews 2014).

An estimate is used to evaluate the steel price of the ship. It is rather simple but sufficient for the sake of this thesis. The price of 1 kg of constructed steel is roughly USD 1 in the Chinese shipyards (Internal interviews 2014). Using this formula it can be calculated that a ship with a steel weight of around 7 300 tons will cost 7 300 x USD 1 = USD 7 300 000. For a ship of that size the engines will have a cost of USD 3-3.5 million, depending on the power of the main and auxiliary engines. The price of the engine is proportional to the power, so the less power is needed, the less they will cost.

The power need is determined by the ship's lightweight and the DWT it carries. There are also some regulations and requirements that secure the ship's sailing capacity in rough weather as well. Hull design also has a big impact. A hull that creates minimal hydrodynamic resistance does not require as much power as a ship that has a poorly designed hull.

Other features are also important in the formation of the price, but the ship's design and machinery choices are the most important parts that can be affected in BlueTech's actions. The easiest way to reduce the capital costs from a designer's standpoint is to make the ship lighter as there is a straight impact on the price. Engines are chosen and optimized for the design and also have a big impact on the price. These two often go together and changes in one can affect the other.

4.1.2 Interests

Current bulk carrier prices vary from some USD 25 million for a Handysize to over USD 60 million for a Capesize vessel. Few shipowners pay such sums in cash and thus loans are needed to finance these projects. The OECD (Organisation for Economic Cooperation and Development) has recommended credit terms which are widely used in the world, typically an 8% interest and 70% of the loaned sum repaid in 7 years (Younis

2003). So when speaking of the actual price with the cost of the loan, the formula is as follows.

Final price = Cash price + Interests, or Cash price + n × Instalment

Loan =Cash price – Down payment

CRF (Capital Recovery Factor) $= \frac{r \times (1+r)^n}{(1+r)^n - 1}$

Instalment = CRF x Loan

Final price = Cash price + Interests, or Cash price + n × Instalment

4.1.3 Depreciation

Bulk carriers are not eternal. They have a life span of 15-20, some Capesize vessels up to 25-30 years. However the maintenance costs tend to increase over time and some shipowners have a strategy to sell their ships after 10 years of use.

Regardless of the shipowner's strategy, when talking about depreciation, a ship is given a life of 20 years. Some companies use their own methods, Star Bulk Carriers calculates their depreciation with a 25-year life span (Wikinvest 2009) but normally the calculations are made using 20 years and 350 operational days. These figures are true when talking about new ships. If an owner was to buy a 10 year old ship, the ship would have only 10 operational years remaining.

At the end of the 20 years a ship is often scrapped. In some cases it will continue to serve but for the sake of accountancy it is assumed that the ship will then be destroyed. Scrap metal has a value that gives an estimate of the salvation value of the ship. Currently it is around USD 415 per lightweight ton (Platou monthly 2014). This figure is multiplied by the lightweight of the ship. Lightweight is not only the steel weight of the ship, but everything that comes with the ship, cranes, hatches and interiors for instance.

The depreciation can be calculated in different ways. One way is the straight line depreciation method where the capital is divided into equal parts according to the expected life span of the ship. Another one that can be used is the free depreciation method where the costs are written off as quickly as possible, in other words as much per year as the ship makes profit. (Younis, 2003)

$$\text{ADE (Annual Depreciation Expense)} = \frac{\text{Cost of the ship} - \text{End value}}{\text{Ship's life span in years}}$$

$$\text{DDE (Daily Depreciation Expense)} = \frac{\text{ADE}}{\text{Operational days per year}}$$

End value = Lightweight × Price of scrap metal

4.2 Operating costs

From figure 7 it can be seen that the operating costs consist of crew costs, stores, maintenance & repairs, insurance and administration costs. As mentioned in section 4, these are costs that are secret and hidden. They can also be presented in a different manner and sometimes the information is given for the operating costs as a whole, which makes the analysis difficult. The shipping companies have their reasons to keep operating costs hidden, since they are the costs they have the most control of. Accurate and up to date costs are very hard to find for these reasons, but sufficient data is available in order to define the operating costs and to determine which of them has the biggest impact.

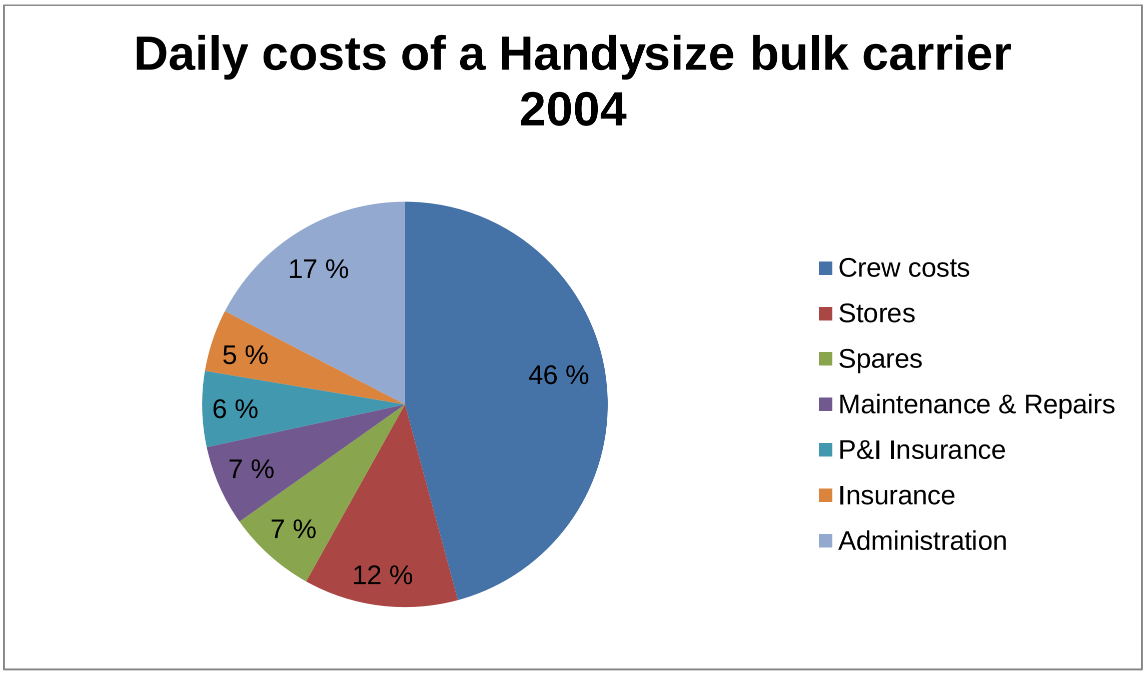

Figure 8. Operating costs 2004. Data adapted from OpCost 2004 database (Pocuca 2004)

Figure 8 shows how operating costs are divided between different areas. The data is collected from 89 Handysize ships by the Moore Stephens OpCost database. Since the actual figures date back 10 years, the costs are maybe not real today, but we can assume that the repartitions are the same today. Crew costs cover the biggest part of the operating costs, 46%. Administration costs are the second biggest expenditure at 17% followed by stores costs that account for 12% of the operating costs. Spares and maintenance & repairs can be linked together as they often are, and together they represent 14% of the daily operating costs. Insurances combined account for 11% at roughly equal shares.

Table 3. Daily operating costs of Capesize bulk carriers. Copied from Hadjiyiannis 2010.

End 2009 Prices	5 years	10 years	15 years	20 years	25 years
Crew Cost	$2,183	$2,203	$2,412	$2,503	$2,564
Stores & Consumables	$395	$602	$712	$889	$986
Maintenance & Spares	$152	$198	$286	$531	$547
Insurance	$686	$798	$912	$989	$1,113
General Costs	$756	$813	$864	$924	$1,034
Total	**$4,172**	**$4,614**	**$5,186**	**$5,836**	**$6,244**

Table 3 shows the daily operating costs of Capesize bulk carriers. As the table 3 shows, operating costs are a very important expense for shipowners and thus it is necessary to examine the expenses one by one, and to see the areas that can be affected by the design.

4.2.1 Crew costs

Crew costs cover the biggest part of the operating costs and reducing them would have the biggest impact. Crew costs consist of direct costs such as wages, training and travel costs, and indirect costs such as the recruitment, medical tests, social dues, crew insurances and sick pay. (Drewry 2004). Shipowners have reacted to the high costs by seeking cheaper workforce from cheaper countries.

Country	Master	Chief engineer	Chief officer	2nd Officer
UK	9 000 – 13 000	9 000 – 13 000	7 000 – 10 000	5 500 – 7 000
Italy	7 000 – 9 000	6 500 – 8 500	6 000 – 8 000	4 500 – 6 000
Croatia	4 900 – 5 500	4 800 – 5 400	3 400 – 3 800	2 150 – 2 350
Poland	4 600 – 8 000	4 400 – 7 000	3 470 – 5 000	2 750 – 4 000
Romania	3 800 – 4 120	3 600 – 3 910	2 880 – 3 180	2 060 - 2 340
Ukraine	3 500 – 5 000	3 300 – 5000	2 560 – 3 700	1 850 – 2 400
India	4 300 – 6 000	4 000 – 5 700	3 200 – 4 200	2 000 – 2 400
Philippines	3 700 – 6 000	3 300 – 4 800	2 300 – 3 700	1 950 – 2 600

Table 4. Crew wages by nationality in USD. Data adapted from Drewry 2006.

Table 4 shows a price range of monthly salaries in different countries, and it can be seen that there are significant differences. The data is eight years old so the figures have probably risen, but the fact remains the same.

Some shipowners register their ships in Flags of Conveniences (Drewry 2004; ITF 2014), in essence countries that are not as strict about regulations and wages (ITF 2012). ITF (International Transport Workers' Federation) regulates the wages and protects the seafarers' working conditions as unions usually do (ITF, 2012). ILO (International Labor Organization) is operating under the United Nations and it has set rules and regulations regarding wages and other measures that are to be respected by shipowners. The high labor costs have however caused shipowners to be forced to seek cheaper workforce, and thus Indian and Philippine crews are common today.

Rank	Note	Basic	Consolidated Allowances	Bonus (officers)	Provident Fund[b]	Totals[c] 2007	1993	% ch
Master	India	1,967	3,933	300	35	6,235	3,644	171%
Chief officer[a]		1,294	3,206	200	35	4,735	3,025	157%
2nd officer		1,077	1,773	—	35	2,885	2,338	123%
3rd officer		1,030	1,320	—	35	2,385	1,650	145%
Radio officer		radio officer no longer required in 2007					1,650	0%
Chief engineer		1,760	3,990	300	35	6,085	3,575	170%
1st asst engr	2nd eng.	1,294	3,206	200	35	4,735	3,025	157%
2nd asst engr	3rd eng.	1,077	1,773	—	35	2,885	2,338	123%
Bosun	Philippines	670	649	—	182	1,501	1,521	99%
5AB		558	542	—	171	6,353	6,479	98%
3 oiler		558	542	—	171	3,812	3,888	98%
Cook/std	chief cook	670	649	—	182	1,501	1,596	94%
Std	2nd cook	558	542	—	171	1,271	1,296	98%
Messman		426	378	—	158	962	1,071	90%
Total crew number modern ship: 20						45,344	37,094	122%
Additional crew for 10-year-old ship								
3rd asst engr	India	1,030	1,320	—	35	2,385	1,650	145%
Electrician	Elec. off.	1,077	1,823	—	35	2,935	2,338	126%
AB	Philippines	558	542	—	171	1,271	1,296	98%
1 oiler		558	542	—	171	1,271	1,296	98%
Total crew number 10-year-old ship: 24						53,205	43,673	122%
Additional crew for 20-year-old ship								
2 ordinary seamen	Philippines	426	378	—	158	1,925	2,142	90%
1 oiler		558	542	—	171	1,271	1,071	119%
1 messman		426	378	—	158	962	1,071	90%
Total crew number 20-year-old ship: 28						57,362	47,956	120%
		Annual crew cost for 20-year-old ship				688,344	575,475	120%

Figure 9. Example of crew costs per month in USD in 2007 and 1993 (Stopford 2009)

Figure 9 indicates the development of crew wages by position, and how they have changed in 14 years. The total costs have increased of 22% but when taking the inflation into account, the increase is insignificant. What is interesting to notice is the increase of workforce over time. A new ship requires 20 crew members but as the ship ages, the daily maintenance need increases and thus the need for additional seafarers. In this case the increase of wages for a 10-year-old ship is USD 7 861 per month, or 17%. A 20-year-old ship requires yet another four crew members and the increase compared to a new ship is USD 12 018 per month or 26.5%. This explains for some part why some shipowners have chosen the strategy of selling the bulk carriers after 10 years of use. In a survey conducted by Hadjiyiannis (2010) it can be seen how the crew costs per day increase as the ship gets older. Table 3 shows numbers that are perhaps not 100% accurate, but their development and relations can be considered reliable.

The crew costs are a big issue for shipowners also because qualified workers are hard to find. According to IMO (IMO 2012) in 2010 the demand for officers and ratings where bigger than the actual supply and this situation continues and causes concerns as the world fleet keeps growing.

The crew costs are hardly an area that can be directly influenced by current design choices. They are however the biggest contributor to operating costs and something could possibly be done. Indirectly, the seafarers' working conditions could be augmented and activities such as loading, unloading and hold cleaning could be made easier. This would possibly result in better efficiency and fewer days of sick leave. A big impact could be done by making the ship more maintenance free or prolonging the need for maintenance. At the moment a bulk carrier needs four additional crew members after 10 years of service. If this time could be pushed up to 15, the cost savings using the numbers of figure 9 would be 471 660 USD over the five years, given that the wages remain the same. This would also have a positive impact on other operating costs.

4.2.2 Stores

Stores in this case can be divided in to four main groups: marine and deck stores, engine room stores, steward's store and the lubricants (Drewry 2004) which account for about 40% of the costs (Pocuca 2006). Stores are fairly uncostly products that are however necessary for the ship to keep on operating in a safe and efficient manner. Stock management is the key. Isbister (1993) reminds that every time a spare part is used, one should remember to order a new one. I would consider a more preventive approach. Since the spares and lubes are not very expensive, at least compared to the consequences if the ship cannot sail, I would consider a solid stock with some reserve of the most needed parts and a sufficient number of other spares.

Understandably shipowners seek to find all possible ways to reduce costs, but risking the movement of the vessel for a pot of lubricant worth USD 100 is not rational.

In the design phase however the number of lubricants that are needed could be affected. New machines need less lubricants and this can be taken into consideration when choosing machinery. Another part that can be affected is number of paints needed to repaint parts where the coating has suffered. An area that is particularly vulnerable is the tank top. When emptying the hold, the grab will damage the paint (Isbister 1993). If this problem could be solved, the amount of money spent on paints would decrease.

Table 3 shows the development of the operating costs, and we can see that the increase in the stores between a 5-year-old ship and a 10-year-old is basically 50%. The cause of the increase is most definitely the increased need for lubrication and paints. Perhaps by the choices of machinery and materials this could be avoided or prolonged.

The rest of the stores are not easily affected by the design. Ropes, wires, tools, safety equipment and cleaning equipment (Drewry 2004) are necessary and they do not make up for a big share of the costs.

4.2.3 Maintenance, repairs and spares

When talking about maintenance and repairs, the spares are often included. Figure 8 shows that the two combined account for 14% of the operating costs, with a fifty-fifty repartition. Here maintenance and repairs are mainly the small maintenance jobs that are carried out mainly by the crew, although specialist “flying squads” can be used as well. (Drewry 2004)

Table 3 shows how maintenance and repair-related costs augment over time, as do all operating costs in general. As a ship gets older, the need for maintenance increases, which is rather logical. A note has to be made regarding table 3. As the findings were drawn from a survey, I cannot be sure that there has been monitoring of the repair and maintenance costs of a ship over time. In fact it is quite certain that part of the raises in costs are due to the fact that the ships are of a later design. New engines, for instance, are easier and cheaper to maintain and repair, so they would have an impact on the increasing of costs over time. However it is logical that the need for maintenance augments over time and the figures can be considered relevant.

Prevention is very important. Even during the first years of service a ship needs to be regularly maintained and repairs should be done quickly, as they can create bigger problems in the future. Maintenance is something that has to be done on a daily basis and monitoring it is important. (Isbister 1993)

There are a few factors that impact a ship's maintenance & repair costs. The classification society has a major impact on the maintenance schedule. Class surveys are held periodically and in order for the ship to sail, it has to be within the regulations of the classification society. (Drewry 2004) The shipowner's strategy also affects maintenance costs. If the owner has a strategy of selling the ship after 10 years, as seen before, he can choose to do the bare minimum and expect the problems to begin only after the ship is sold. If on the other hand the strategy is to operate the bulk carrier for a longer time the shipowner should pay attention to maintenance from the beginning. A third determining factor is the choice of manufacturers. Different engines and equipment have different needs for maintenance and they determine what needs to be done and how often.

There are roughly two types of repair costs; routine maintenance costs and costs that are due to a breakdown (Stopford 1997). Paintwork and machinery maintenance are examples of routine maintenance. These can vary considerably according to the choices of machinery and shipowner strategy. Breakdowns can to some extent be prevented. The choice of machinery has an impact. The cheapest option is not necessarily the cheapest in the long run. Build quality is also a big factor in breakdowns. Labescat (2014) underlined that good design is the key, but alone it is not sufficient. Strong emphasis has to be put in the supervision of the construction and quality control. Not all breakdowns can be prevented. Accidents occur and those cause repair costs.

Spares are added to the maintenance and repair costs as there is a direct link between them. The less there are repairs and maintenance, the less need there is for spares. Spares can cause big problems. Their price is one issue, but the availability is another. Bulk carriers sail all over the world and one never knows where a breakdown occurs. If a ship has to stay in port and wait for a spare part to be shipped from halfway across the world, the spare part's price will become meaningless as the bulk carrier loses a significant amount of money by not being able to sail.

The impact of the design is important when looking at maintenance and repairs. The choice of machinery has a big impact on the costs and maintenance and repairs have to be taken into consideration in the design stage. There will always be a need for maintenance and it can never be completely eliminated, but it can be emphasized in order to lower the need for maintenance. Another aspect that should be considered when designing is the ease of maintenance work. Places that are known to be prone for repairs can be made easily accessible which will decrease the time spent on repairs and maintenance.

One specific area that causes problems is the tank top in the holds. (Labescat, 2014; Stopford 1997) When the grab is used to empty the holds, it will cause damage to the coating that protects the steel from corrosion. Some owners have opted not to paint the surface at all since the paint does not hold. (Labescat, 2014) This is a problem because some transported goods increase the corrosion. The repair is also tricky as wet paint is not tolerated in the holds when the ship is loaded. (Stopford 1997) This is true especially when transporting food products, in this case mainly grain. In the worst case scenario the ship will not move until the paint is dried and the operator can be sure that his products are not contaminated by wet paint.

4.2.4 Insurances

The insurances are also an important part of a ship's operating costs. From figure 8 we can see the two types of insurances and their share of the total costs. P&I (Protection and Indemnity) insurance accounts for 6 % and other insurance costs, most notably hull and machinery insurance, for 5%. There are however tremendous differences in the insurance costs and they depend on a number of factors. Isbister (1993) argues that insurance costs vary anywhere from 15% to 40%. It can be stated that these prices have come down since there have been improvements in the safety measures, and stricter rules and regulations oblige designers to make better ships. On the other hand piracy is a concerning issue that has been raising in the past years (IMO 2 2012) and is one factor that certainly has its impact on insurance prices.

It is also important to note that rarely is a single ship insured. Normally the insurance is taken for the whole fleet (Drewry 2004), which makes estimating the insurance prices difficult. Big contributors to the price of the insurance are the owner's prior record, and the value of the ship or ships (Isbister 1993).

There are no list prices for insurances so it is not simple to define what defines the H&M (hull and machinery) insurance price. This insurance covers, as the name suggests, the physical aspects of the ship. Again, the owner's prior insurance history, along with the price of the ship are the determinants of the hull and machinery insurance costs. It would however seem logical that the design and the build quality also impact the prices. If the owner is capable of convincing the insurance provider that the ship is safer than another, it should have a positive impact on the price.

Protection and Indemnity insurance covers the death or injury of crew members, passengers and third parties. Pilferage and damage of the cargo along with collision damage and pollution are also insured by P&I clubs. (Isbister 1993) These clubs are operated and financed by shipowners. Another option is to buy the insurance from standard insurance providers (Drewry 2004).

The area where the ship sails also has an impact on the prices and on the additional insurances needed. A war risk ads to the prices and different areas have their own war additions. The risk of terrorism as well as piracy raises the insurance prices (Drewry 2004).

There was not much information to be found on bulk carrier insurances. Since there are no list prices it is very hard to estimate to what extent the insurance costs can be affected in the design. It would however seem reasonable that a safer ship gives the shipowner an edge in the negotiations of H&M insurances. One remark that can be made from table 3 is that the insurance costs increase as the ship gets older, but the percentage remains more or less the same. If however a major reason is the value of the ship, it would seem logical for the H&M costs to decrease over time as a ships value at 20 years old is nowhere near a new ship's value. It must be understood that the H&M-related problems increase in the same way as the ships value decreases, or even more quickly as the insurance costs increase over time.

4.2.5 Administration

Administration or general costs complete the operating costs. Figure 8 shows that in Handysize bulk carriers of different ages and companies the administration costs account for 17% of the operating costs. The results from table 3 are much alike also management costs seem to increase over time but the percentage remains the same.

The general costs consist of all other costs a shipowner has, and they are then divided between the ships he possesses. Smaller companies with only a few ships tend to have smaller administration costs than big shipowners that have large fleets. (Stopford 1997)

Examples of costs that are considered as general costs are the following: banking, insurance, accounting, taxes, legal services and broker or agent-related costs. Also the company's office and staff-related costs are a part of these (Drewry 2004). Larger companies often have heavy organizations which cause the general costs to be higher than in smaller, simpler companies.

It is hard to see how these costs can be influenced in the design. Communication can cause costs, and when equipping a ship, proper communication instruments have to be installed. Data collection can also become easier in this way, which can also decrease administration costs.

4.3 Voyage costs

One last area is yet to be described regarding costs that a bulk carrier creates, that is the voyage costs. They are also the costs that are most directly influenced by the actions of a designer and thus the part they have most control of. In the section 1 the changes in the market and the constantly raising fuel prices were explained, and these are the main reasons why shipowners place so much emphasis on more efficient designs. This trend has been continuing for approximately five years now (Labescat 2014) and there is no returning to the old ways of designing ships. If anything the requirements for efficient design will become even tighter due to the EEDI limits and other regulations.

$$\text{Voyage costs} = \frac{\text{FOC} \times \text{Fuel Cost} + \text{Port charges} + \text{Canal charges}}{\text{number of days}}$$

The voyage costs compose mainly of the ship's fuel costs. Other costs that are calculated are canal charges and port charges which include tugs, pilotage and cargo handling. (Isbister 1993) These are all direct costs that result from operating a bulk carrier, and the time spent in the harbor is also an important factor in voyage costs. During that time the ship has port-related costs, and it is not earning any money either. However the capital and operating costs are running.

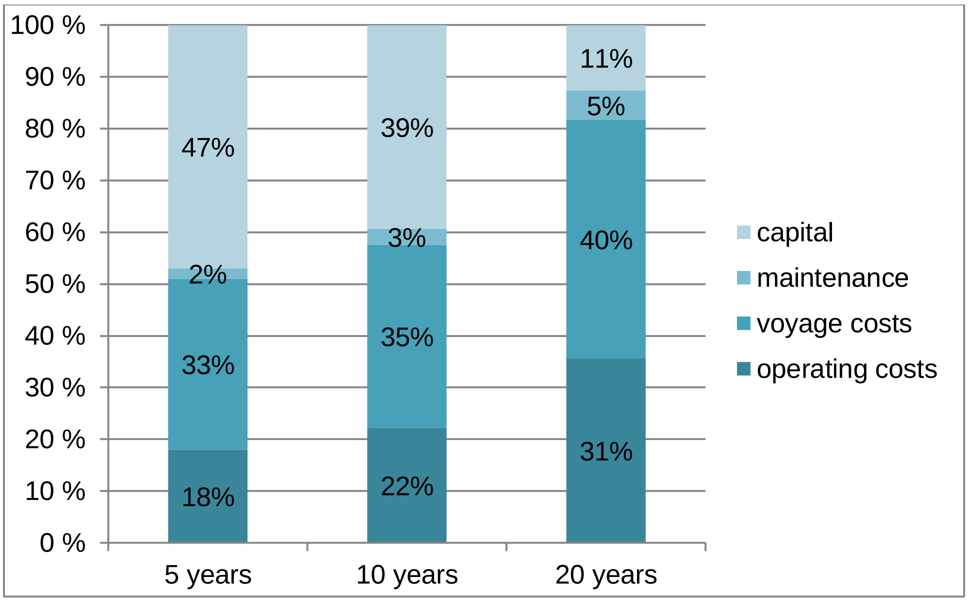

Figure 10. Repartition of the costs over time. Data adapted from Stopford 2009.

Figure 10 shows the average repartition of bulk carriers' costs over time. It can be seen that the voyage costs constitute a big part of the costs, and sometimes even the majority since bulk carrier prices vary considerably. Fuel consumption is the largest part of voyage costs and since it is also the only one that can be affected by the design, it can be considered the most important factor.

4.3.1 Fuel costs

Fuel is needed to power a ship's main and auxiliary engines. A ship's FOC is normally indicated in tons per day at a specific speed. A ship also has a different consumption when it is in port, a bulk carrier's electricity is provided by the engines, either by the main or by auxiliary engines. In port electricity is needed to power all standard activities (communication, computers and other), but also to operate the cranes that are used to load and unload the cargo. Not all bulk carriers are geared, but most modern Handysize ships are as it gives the advantage to take charge of the loading and thus makes them less dependable on port operations. Larger bulk carriers, Capesize for instance, are more rarely geared as the loading is more efficient with bigger cranes and due to the size of the vessel they can only operate at docks that are well equipped. (Stopford 1997)

The most efficient way to reduce fuel costs is to reduce speed. From the second formula we can see the impact of speed on FOC. As an example we can take the BlueTech 42. Table 1 shows that the ship has a FOC of 18.2 tons per day at a design speed of 14 kn. At a current price of USD 613 per ton of IFO180 (Intermediate Fuel Oil, maximum viscosity 180) (Bunkerworld 2014) the daily design fuel costs of BlueTech 42 are 18.2 x USD 613 = USD 11 156. Using the formula (Stopford 1997) we can calculate:

$$\text{Actual fuel consumption} = \text{Design consumption t/d}\left(\frac{\text{Actual Speed}}{\text{Design speed}}\right)^{a}$$

When the design consumption and design speed are known, the actual speed is the desired speed. The value of a varies depending on the engine type; it is about three for diesel engines and two for steam turbines. (Stopford 1997) In this case we can do the calculations with an exponent of 3 to illustrate the impact of speed on consumption.

$$\text{Actual fuel consumption} = 18.2\ \text{t/d}\left(\frac{11\text{kn}}{14\text{kn}}\right)^{3}$$

By reducing the speed to 11 kn, the daily consumption reduces to **8.8** tons per day or USD 5394. In US dollars this difference is equal to USD 5762. In order to demonstrate the importance of fuel efficiency, we can repeat the calculations with 2004 prices. In 2004 the price for IFO in Rotterdam was 150 USD/ton (Pocuca 2004). The Bluetech 42's daily fuel costs at 14 kn would have been 18.2 t/d x USD150 = USD 2730, or 1320 USD with a reduced speed of 11 kn.

The design speed has also an impact on the size of the engines. Earlier it was said that the price of the engine corresponded to the amount of power, and it is much the same way with the consumption. Bulk carriers are often designed to operate at a speed of 14kn. However very rarely if ever, they attain that speed. That means that the amount of power is often overrated, which causes not only increased capital costs but also higher FOC. On the other hand this gives the shipowner added flexibility as the ship is capable of operating at a higher speed, which could be useful if the freight prices were to go up, or fuel prices down.

The design features that affect the fuel consumption were for the most part explained in the chapter 1. As explained, BlueTech has the most fuel-efficient design mostly due to hydrodynamic hull that is CFD-optimized, rudder and propeller optimizations, light weight and a modern more efficient main engine.

The choosing of machinery has a big impact on consumption. Fuel efficiency is the defining element and this is why only the most advanced engines are to be used. As explained in the section 4.1.1, the engine price follows the amount of power. Knowing this, the design speed for which the engines are optimized could be reassessed. An industry standard is to design a bulk carrier for a speed of 14 kn. However when asked about the actual operating speeds, a captain said that they never sail at 14kn (Internal interview 2014). A ship could be optimized to operate at a speed of 11kn as calculated in the example, and in this case the FOC would be even lower than in this estimate, as the hull and engine would be optimized to 11kn. This would also have an impact on the ship’s cost as the power requirements would be lower and thus the price as well.

4.3.2 Other voyage-related costs

Port charges cover the services needed by a bulk carrier when it comes to port, during the time at port and finally when leaving the port. These are, for instance, docking charges, pilotage, towage and cargo handling. (Stopford 1997) The costs of these charges depend on the port and are defined by the transported good and its amount, or the tonnage of the ship. (Port of Rotterdam 2012) There are ways to get discounts of the port charges; an association called Green Award certifies extra clean and extra safe ships with a certificate that provides the owner of the ship with discounts on port charges. (Green Award 2009) In order to acquire the certificate, there are a number of requirements regarding safety and environment, and in addition the certificate has a cost. There are perhaps some benefits but it is up to the owner to decide and calculate if it has a positive impact on the ship’s earnings.

Canal costs concern mainly the ships that have to pass through either the Suez or Panama canals. They have different ways of calculating the costs, the Suez canal has a particular formula of calculating the charges. The formula uses SCNT (Suez Canal Net

Ton) and SDR (Special Drawing Rights), two measures that are not commonly used (Stopford 1997). There are however calculators on the Internet that provide this information in advance; Leth Agencies (2014) is a canal transit specialized company that provides this kind of service.

The Panama Canal charges are calculated with the PCNT (Panama Canal Net Ton). The calculation is a bit more straightforward but the principle is the same. The Panama Canal net site provides more accurate information about the services and formulas. (Panama Canal 2013)

If fuel costs are put aside, voyage costs can be mainly affected be reducing the time at the port. There are three actions that are time consuming, but inevitable for the operating of the bulk carrier. The ship has to be unloaded when it comes to the port. Once the holds are empty, they need to be cleaned, so that they can once again be loaded with new products. This operation is particularly time-consuming on a bulk carrier. A containership can be unloaded and loaded in 12 hours (Ducruet & Merk 2011) whereas a bulk carrier needs much more time. A large vessel can need up to 120 hours. This raises the direct costs as the ship has to stay at port for a longer time, and indirect as during the time at port the ship does not earn any money for the operator or shipowner. The capital and operating costs however continue to accumulate.

The loading and unloading can be facilitated by large hatch openings that allow the easy use of grabs. The hopper tanks' inclination has an impact on the settling of the cargo and a 45 degree angle allows the material to slide smoothly to the bottom, which reduces the need for manual work (Labescat 2014). Smooth surfaces are also easier for the loading and unloading. It also has a big impact on the time spent for washing the holds. In the design stage it should also be taken into consideration how the washing will be done and the required piping must be designed in advance. (Isbister 1993)

5 Bulk carrier-related earnings

Now that the costs of a bulk carrier are determined, a look at the revenues. In order to understand how different parties earn money, it is necessary to consider the different chartering methods. They define which party is responsible for which costs, and thus will help in understanding what the impact of the design is for the owner and the operator.

5.1 Shipowner and operator

There are mainly two parties that earn money with bulk carriers. The shipowner takes the risk and builds a ship to serve an operator's needs. The operator then, in various chartering methods, uses the ship to transport the commodities. This is important to precise, as the shipowners' earnings also depend on the operators' earnings. The operator is also the first to benefit from a more efficient design, as it can transport more goods at lower cost.

There are numerous operators, as there are commodities, chartering bulk carriers. Most commodities transported with bulk carriers are goods that are fungible, in essence considered the same regardless of the place of origin. Iron ore, coal and grains are commodities that are priced at the market, much in the same way as the freight market. This provides an opportunity to see how an operator functions.

Indexmundi (2014) keeps statistics of iron ore prices, prices that operators get for selling their product. The daily (May, 2014) price of a dry ton of iron ore is USD100.56. According to UBS (Union Bank of Switzerland) estimate, the breakeven point for BHP, an Australian mining company, is 38.5 USD per dry ton. (Sedgman 2014) This means that an operator, in this case BHP, has a margin of 62 USD per ton, of which it has to pay the shipping costs. The iron ore prices are at record high levels and not all operators are as cost effective as BHP. This is to say that shipping is an important part of the costs an operator faces.

5.2 Earnings

Before entering the different chartering methods, a closer look is given at the earnings, and of what they are composed. As specified in section 1.2.2, the freight market is a highly volatile market that is mainly supply and demand driven. Shipping markets are often cyclic and the difference in earnings can be very significant. As seen in figure 1, a Capesize bulk carrier could have cost an operator over 150 000 USD per day in mid-2008, and a year later the same ship would have brought roughly 25 000 USD per day for the shipowner. Regardless of the manner the ship is used and whether the owner is also the operator or in the usual case charters the ship for operators, the costs will have a big impact on the earnings.

The ship's price tends to follow the freight prices, as was in 2008. As the capital costs mainly consist of the ship's price, a bulk carrier that is ordered during a good market situation in terms of freight prices will have higher capital costs during its lifetime. What this means in terms of earnings is that two ships that are exactly the same but built one year apart, can have totally different earning capacities.

Operating costs are quite stable; the market does not have a significant impact on them. Voyage costs have experienced major changes, as explained in chapter 4.3. Oil price has a huge impact on the earnings of a bulk carrier. The last crisis had a big impact on the fuel oil costs, and it was not the first time the oil prices exploded. The 1970s' oil crisis had similar effects and it caused problems to the shipowners. This is means that it has happened before and probably will happen again.

What all this really means, is that shipowners and operators are to some extent at the mercy of the markets. They are not affected exactly in the same way but both parties make better profits when the market is good. From a designer's standpoint, what a good design really offers a customer, is first the ability to maximize the earnings by reducing costs and augmenting hold capacity or tonnage, but also provides with flexibility to cope with harder times and a tougher market. This flexibility obviously gives an edge over competition. Whereas other shipowners are forced to do expensive modifications, scrap their ships earlier than planned or make the decision not to operate a ship because of the increased costs and lowered freight rates, a better design provides the owner with a possibility to continue operating even at smaller margins. This can be the difference between life and death for a shipowner.

A basic formula for calculating a bulk carrier's earnings is as follows:

$$\text{Bulk carrier earning} = \text{Freight price} - \text{Total costs}$$

In reality the freight price depends on what is paid by which party, and the repartition of the costs as well. These are detailed further in the chapter when different charter methods are defined.

The elements are that can be affected by the design are now clarified. The impact of the choices made in the design have different effects on a ship's earning depending on the market situation. Even if these can be hard to quantify, I try to find a way to measure the impact the design has. In order to do this a tool is needed, the following formula helps in quantifying the value of a DWT or a m3 of hold volume:

$$DWT \text{ or } m^3 \text{ value} = \frac{\text{Capital Costs} + \text{Operating Costs} + \text{Voyage Costs}}{DWT\ or\ m^3}$$

In order for a bulk carrier to be profitable, or at least not unprofitable, its revenues need to be at least equal to the costs. If they are higher, the ship is profitable and vice versa. This formula provides a value for a DWT or a m^3 of hold volume using the minimum earnings required for a bulk carrier in order to stay operational = total costs. This is a revenue indicator showing the earnings of a ship type. The figures below are rough estimates for a Handysize vessel.

$$DWT \text{ or } m^3 \text{ daily value} = \frac{3\ 692 + 4\ 000 + 12\ 000}{41\ 000\ DWT\ or\ 58\ 000\ m^3}$$

USD / DWT / day value = 0.48

USD / m^3 / day value = 0.34

The capital costs are calculated with a total price of 30 million USD using straight line depreciation with a life span of 20 years and end value of 4.15 million USD. Operating cost is an estimate based on (Pocuca 2004). The voyage costs consists of the fuel cost calculated for Bluetech 42 earlier, and an estimate of canal and port charges for a Handysize bulk carrier, based on (Zanne & Pocuca 2009). The DWT and hold volume are of Bluetech 42 as well. All figures are per day, as are the results.

The formula provides a revenue indicator for a Handysize vessel, the value of a DWT in USD per day. If then another Handysize vessel would have, say, 2000 DWT less, its earnings would be 2000 DWT x 0.48 DWT / USD / day = 960 USD / day less. This way we know the value of an added DWT and its impact on the earnings. The same pattern can be used for ships of other sizes using the corresponding figures.

5.3 Time charter

Time, or period, chartering means that a bulk carrier is leased by a shipowner for an operator. (Drewry 2004) A time charter agreement is made for a specific ship and for a specified time at a certain rate. The time charter freight rate is defined mainly by the amount of DWT or hold volume and the fuel efficiency of the ship. The hire rate, called Gross Hire is normally expressed in USD per ton DWT. (Stopford 1997) Again the prices are volatile and vary considerably, but it can be said that the cheaper it is in terms of costs per ton for the operator, the more he is willing to pay for the charter.

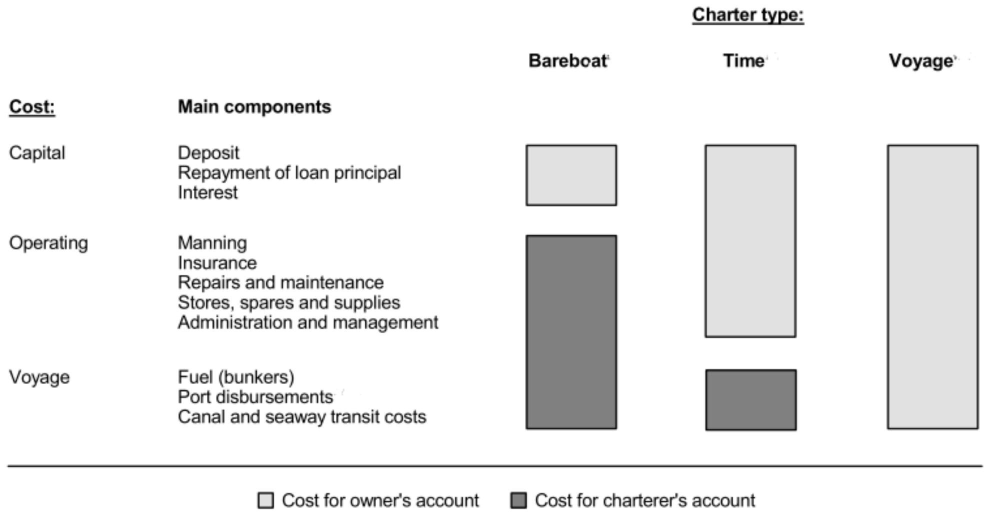

Figure 11. Repartition of costs depending on charter type. Copied from Drewry 2004.

Figure 11 determines what costs belong to which part. It can be seen that in a time charter situation the capital and operating costs are paid by the shipowner and the voyage costs are at the operator’s expense. As the capital and operating costs are rather stable, the risk of the shipowner is reduced as the operator is responsible for the voyage costs that can vary significantly. As the name suggests time charter contracts can be maid for a longer period, providing added security for the owner.

Earnings for the owner:

$$= 12\ \mathrm{month}\frac{\mathrm{T}}{\mathrm{C}}rate\ \times time\ (days) - (C.cost\ \times time + O.cost \times time)$$

From the operator's standpoint this means that his margins are mostly defined by the voyage costs, or fuel costs. Better fuel efficiency provides better profit for the operator and the shipowner is only second in line to benefit from improved fuel efficiency. For an owner the operating costs are very important, especially in a time charter as they are the only costs they have control of. As mentioned in section 4.2, this is one reason why the information is hard to find.

5.4 Voyage charter

Voyage chartering is a riskier business for the shipowner as he is responsible for all costs, except cargo handling costs that can be paid by the operator. The operator pays the owner for one voyage, or sometimes many voyages. The price is normally a price per DWT. (Stopford 1997) Voyage chartering can also be more profitable, given that a shipowner has a fuel efficient ship and other costs are managed well. The daily spot freight rates vary considerably (Platou monthly 2014) and they are hard to predict.

From an owner's standpoint a fuel-efficient design is even more valuable in a voyage charter situation as he is responsible for the fuel costs. Compared to time chartering where the FOC has an impact on the price, in this situation the price is determined mainly by the tonnage and the length of the voyage.

Earnings for the owner:

$$= \text{Spot rate} \times time - (C.cost \times time + O.cost \times time + V.cost \times time)$$

From the operator's standpoint voyage chartering is easy, but it can be expensive as spot prices have higher fluctuations. On the other hand the prices can be much lower for the operator as well.

5.5 Bareboat

In a bareboat charter situation the shipowner, usually a bank of other financial institute, supplies the operator with only the ship. (Stopford 1997) The operator then takes care of the rest and is also responsible for most of the costs. The operating costs and voyage costs are paid by the operator and thus he is the one taking the biggest risk, whereas the owner has only the capital costs to pay.

Bareboat or demise chartering offers the lowest risk for the owner but also the lowest potential earnings. This however is a method that is rarely used with the exception of bank and other financial institutes that do not have the means or expertise to operate the ship themselves. The price of the charter is determined by different qualities of the ship and a fuel and cost efficient bulk carrier should bring a better price.

Earnings for the owner:

$$= \text{rate} \times time - (C.cost \times time)$$

The operator takes care of all other costs and is therefore the party that receives greater use from having a fuel efficient design.

6 Results and recommendations

Earlier I set research problems and objectives regarding costs and earnings, and now I can sum up the results. In the latter part I will make some suggestions for the future and present some potential improvements.

6.1 Results

The elements that create costs are capital, operating and voyage costs. Their influence on the total costs vary over time, but according to figure 10 and other findings it can be said that voyage costs are the most important throughout the life of a bulk carrier. Most emphasis is being placed on reducing fuel costs, and this is also the part that is most easily impacted by the design. Maintenance costs are significant as well. I found that they tend to be an increasing problem as the ship becomes older and needs more maintenance. Capital costs depend on the market situation and they fluctuate considerably. In 2006 the capital costs were more important than nowadays, and the increases of bunker prices have changed the situation, so now the focus is more on the fuel-efficiency. The design however has a big impact on the ship's price and voyage costs have to be controlled as well.

In a more detailed manner, the costs that can be influenced by the design are the ships price, a lighter ship costs less, is more fuel efficient and the weight lost ads to the DWT capacity. Smaller engines reduce costs as the power defines the price of the engine.

Operating costs, reducing the need of manpower by making the ship user-friendlier and decreasing the need of maintenance. Manning causes the biggest part of operating costs, but directly they cannot be influenced in the design. However by making the maintenance easier and less frequent, the need for additional crew as the ship becomes older could possibly be avoided. Other operating costs are more or less linked to the need for maintenance and reducing the need for maintenance would lower the costs.

The most important voyage cost from a designer's point of view is the fuel cost. This is also the cost that is the most easily measurable and comparable as well. Ship designers and engineers have modern tools with which they can optimize the hull and calculate optimal plate thicknesses to maximize fuel-efficiency. Engines are also very important and collaboration with engine suppliers helps in achieving a fuel-efficient design. Various propulsion improvement devices can also be added to the vessel, and those are to be assessed in the design phase.

The earnings of a bulk carrier depend greatly on the costs. The fewer costs a ship creates, the more both the shipowner and the operator earn. The charter method defines the responsibilities and cost repartition between the two parties. When time chartering, the shipowner is responsible for capital and voyage costs, and decreasing these have a direct impact on his earnings. The voyage costs are paid by the operator and his margins depend on those. Voyage costs do however impact the freight price paid by the operator and thus is also as important for the owner. Voyage chartering involves a higher risk for the shipowner as he is responsible for all the costs. High risk means also higher potential rewards, and I suggest that a more cost-efficient bulk carrier is even more valuable when operating on a voyage charter basis. It gives the owner added flexibility and a better chance of making a profit, especially when the market is tight and spot rates at a lower level.

Earnings depend on the market and freight prices vary considerably. It can however be concluded that the cheaper a DWT can be transported, the better the possibility is to earn, both for the owner and the operator. In other words, a bulk carrier's earning capacity can be increased by reducing capital, operating and voyage costs, and by augmenting the hold capacity in terms of volume or DWT.

One issue that occurred in different stages of the study was the importance of the design regarding the strategy and use of the ship. There are some modifications that can be done in order to improve a bulk carrier's design in general, but since everything is linked together, it is crucial to understand what the ship will be used for, and for how long. One universal design does not exist that would meet the needs of all shipowners and operators. A shipowner may prefer a bulk carrier that is easy to maintain and quick to load and unload, whereas another might not mind as long as the hold volume and DWT were maximized. Somewhere in the middle of these two may lay an optimal solution, but in the end it is the shipowner that decides.

The strategy used by the shipowner is equally important when discussing design features. If a shipowner's strategy is to keep ships for 10 years, he will probably be interested in maximizing the profit for the ten years and is not that concerned about the ships condition in the end. A shipowner who plans on using the ships till the end of their life span will probably have a different approach, as he will need to operate twice as long. It was found that operating costs increase significantly after 10 years, and this should be noted in the design phase as well.

Design then has a significant impact on a bulk carrier's economics. It impacts both the shipowner and the operator, depending on the charter terms. Quantifying its importance is not an easy task as both the freight prices and costs vary. Fuel costs can be estimated quite accurately as can the capacity of a bulk carrier. Otherwise without knowing a shipowner's operating expenses this can be a hard.

Type of cost	Effect on the total cost	Effect on the total cost	Effect on the total cost	Effect on the total cost		Impact of the design
	New ship	5y old	10y old	20y old		
Capital costs	High	High	Medium	Low		High
Crew Costs	High	High	High	High		Low
Stores	Low	Low	Medium	Medium		Low
Mainte-nance & Re-pairs	Low	Low	Medium	High		Medium
Insurance	Low	Low	Medium	Medium		Low
Administra-tion	Low	Low	Low	Low		Very Low
Voyage costs	High	High	High	High		High

Figure 12. Effect of different costs vs. impact of the design over time

Figure 12 shows the effect of different costs to total costs of a bulk carrier, and the impact of the design on that specific cost. As specified above, voyage costs, capital costs and crew costs are the most important costs. Of those, the design has the biggest impact on voyage costs and on capital costs.

Over time the effects change, and maintenance becomes more and more important. Even though in table 3 maintenance and spares do not account for a large amount of costs, the actual effect is much bigger. The need for maintenance increases, and the operational days of the vessel are fewer than those of a new ship. This means days on which the vessel is not earning any money to its owner, and these should be seen as costs. Off-hire days are more often and the risks of breakdowns increase for an older vessel.

Figure 12 also confirms what was said before about shipowners' different strategies. When the strategy is to own the vessel for 10 years, the shipowner is most interested in minimizing capital, manning and voyage costs. However if the strategy is to operate the full 20-25 years with the ship, the shipowner might be willing to do some concessions in the ship's price, if in return he gets a vessel that does not need as much maintenance in the later years.

When looking at the impact of the design in earnings, the biggest impact is in reducing costs, and maximizing hold and DWT capacity. The costs set a side, the earning capacity of a bulk carrier is largely defined in the design stage. Even when the ship gets older, it can still carry as much cargo as a new vessel. Another viewpoint is that, if the design does not offer maximal hold and DWT capacity for a new vessel, it will be very hard to increase these at a later stage. This is why a design that provides as much hold volume as possible, and that can carry as many tons of cargo as possible, is a key aspect in the design. This is true regardless of the strategy chosen by the shipowner; a ship that has a higher earning capacity will always be better vessel. A vessel with a higher earning capacity will also be more lucrative regardless of the chartering method.

6.2 Recommendations

As specified in the results, not all design features are interesting to all shipowners as they depend on the strategy and use of the ship. I will however propose some changes that could be done and could have a positive impact on a bulk carrier's earnings. I will also have a look at the future to see if designs can be done differently then.

6.2.1 Tank top issues

A problem that came up repeatedly during this project is the tank top damage. When emptying the hold, the grab does damage to the steel plate. Bulldozers are used to help the operation, which also causes damage to the surface. Some of the commodities have corrosive abilities that increase the problem. Some shipowners have chosen not to paint the surface at all since the coating does not withstand the use of grabs and bulldozers. Others paint it and face the potential problem of wet paint due to maintenance. This will cause problems as grains especially are not to be contaminated with toxic paints, and wet paint could delay the ship, causing additional costs.

Since tank top corrosion is a genuine problem I tried to look at what could be done to prevent it. There are harder paints that help but do not solve the problem. Stainless steel is used in bridges especially in areas where corrosion is high. Cope (2009) suggests that significant saving can be made by replacing regular steel with stainless steel. Now it is necessary to point out that bridges have much longer life spans than bulk carriers, and the higher cost of stainless steel is amortized during the longer life of a bridge. Hadjiyiannis (2009) presents a new anticorrosive steel that has already marine implementations (Nippon Steel 2014). The cost is lower than with stainless steel, but the corrosion is reduced to a fifth of normal steel. (Hadjiyiannis 2009)

By replacing the tank top steel with stainless or anticorrosive steel, a shipowner would save money in costly repairs. Tank top repairs are done when the ship is on a dry dock, and this means that the repairs are costly and the ship is not earning any money as it is not able to operate. The use of anticorrosive steel would also make the ship lighter, as there would be no, or at least less, corrosion additions. This weight reduction would then add to the DWT capacity of the bulk carrier.

Some shipowners and operators use alternative loading when shipping iron ore, which in a Handysize vessel means that only the holds 1, 3 and 5 are in use. This means that the three holds are subject to more use than the other two, and so the corresponding tank tops take more damage. Bulk carriers are often designed for a specific use, and if in the design stage it is known that the ship will be used for iron ore transporting, the option of using anticorrosive or stainless steel should be evaluated.

More accurate calculations and a more technical assessment are needed to evaluate the real impact of this type of change, but there is potential. This is especially true for a shipowner who plans on using the vessel for over 10 years.

6.2.2 Housing spaces

A bulk carrier has cabin decks that are in the house situated in the rear of the ship. Each crew member has his own cabin and there are also common spaces such as the mess. In the current Bluetech design there is enough cabin space to accommodate 24+1 people: 2 captain class cabins, 2 senior officer cabins, 5 junior officer cabins, 15 crew cabins and 1 pilot cabin.

In section 4.2.1 we saw that a new Handysize bulk carrier has, on an average a crew of 20 persons, and after 10 years there will be 4 additional crew members needed. This made me think why should a new bulk carrier have space for 24 or 25 people? In the current Bluetech 42 design the cabin decks' total area is roughly 615 m2. Without taking into consideration the impact that removing 4 crew cabins would have on the common spaces, the cabin decks could be roughly 42m2, or 6.8 % smaller. In simple, the cabin decks could be 6.8 % smaller, lighter and cause less wind resistance. A smaller house would have an impact on the capital costs as the ship would be cheaper to build, but also the voyage cost would decrease due to the smaller wind resistance. The AC uses a significant amount of energy, and by reducing the overall area of the cabin decks the need for AC will decrease.

After 10 years the ship would in this case need to be retrofitted with 4 cabins, and the AC would perhaps need to be updated to respond to the needs of a larger space. Retrofitting or refitting is not anything new to the shipbuilding industry, and adding 4 cabins would cause no problems, especially if it is taken into consideration in the early stages of the design. Bulk carriers are required to undergo periodic maintenances, and after 10 years there is a mandatory dry dock. (Stopford 1997) During this time the 4 cabins could be installed, without any additional time needed. The cost of the retrofitting is probably somewhat higher than if the cabins were installed in the beginning, but other advantages along with the net present value of money make it an interesting possibility.

More accurate and technical study is needed to specify the benefits of retrofitting cabins, but I strongly believe it would have a positive impact on the ships' costs and earnings.

6.2.3 Automated ships in the future

In many industries manual labor is being replaced by machines. If a dangerous task can be done by a machine it will normally be beneficial. Productivity is often the main reason for automatizing, and cost savings area made by saving on salaries.

The same thing may happen to bulk carriers in the future. Working on a bulk carrier is a dangerous job, and as was seen in section 4.2.1, manning costs are the single most important cost in operating costs. Rolls Royce is developing unmanned ships that would be operated from ashore. (Wakefield 2014) This would reduce the need for sailors and they would be replaced by a team in a control center. There are many legislative and technical issues to resolve before this becomes a reality, but it would have a positive effect on the manning costs and potentially increase the safety. It would also mean that ships could be designed in a different manner, as the house would no longer be necessary. This would resolve in a better fuel efficiency due to the smaller wind resistance and an increased earning capacity compared to the current designs.

Another issue that needs to be solved before automated vessel can be a reality is the need of maintenance aboard the ship. If the ships sail unmanned, there will be no one to do minor repairs and maintenance that are normally done during voyages. This would mean different expenses as the ships would need to stay longer periods at port in order to maintain the ship. Another way would be to develop the existing engines and materials to withstand more use and to last longer periods without maintenance.

There are still several questions regarding unmanned vessels but perhaps in the future they will be a reality. From a designer's standpoint it would not change too much, the industry evolves and the designs follows that.

7 Conclusion

This thesis work made for Helsinki Metropolia University of Applied Sciences and Blue-Tech focused on the costs and earnings of bulk carriers. The reason this work was conducted was that the company wanted to gain more information about their clients, and to find ways to improve the design.

The research problems set in the beginning were solved. Different costs were analyzed and the impact of the design was defined, as was for the earnings. Quantifying results was hard since accurate information was not always available, but the significance of the different elements was described.

As a result I can say that design has a big impact on bulk carrier economics. The earning capacity is defined at the design stage, and on this area it is hard to make improvements later. The actual earnings also greatly depend on the chartering agreement between the operator and the shipowner. As for the costs, the design has most impact on voyage costs and capital costs. Maintenance costs can also be affected by the design, especially if the bulk carrier is designed to operate the full 20-25 years.

Another important observation is that it is always the shipowner that defines what is important, and on what the designer should focus on. A fuel-efficient design that has a maximal hold volume and DWT is always the key, but it is the shipowner's strategy and use for which the bulk carrier is intended that ultimately define the bulk carrier design.

I believe that these results are interesting to BlueTech. The findings were not all new information, and in many cases they confirmed what had been found earlier. The purpose of this thesis was also to gain more information about bulk carriers and especially shipowners. This information is important and something that I hope will be of use in Blue-Tech in the future.

The information needed to execute a more specific and accurate analysis of bulk carrier economics is either confidential or expensive. If BlueTech was interested in conducting a more detailed analysis, this study would provide a good basis to build on.

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Appendix 1, Bulk carrier size chart

Table 5. Bulk Carrier size chart, (table copied from Strobel 2010)

Segment	Size range [dwt]		Size	Main dimensions					
	from	up to	typical	L [m]	B [m]	D [m]	T [m]	V [kn]	GT [t]
Mini		10,000	4,250	90.00	15.50	7.10	5.60	12.30	3,037
Handy	25,000	35,000	32,800	**178.00**	27.60	15.10	10.68	14.40	18,100
Laker		37,000	26,737	186.40	**23.76**	14.20	9.70	14.50	18,310
HandyMax	35,000	60,000	52,300	**190.00**	32.26	17.00	12.00	14.50	30,400
Panamax	50,000	85,000	74,000	**225.00**	**32.26**	19.10	14.00	14.50	38,700
CapeSize	100,000	200,000	164,484	290.00	44.00	23.90	17.60	13.50	91,000
VLBC	200,000	259,600	224,200	299.00	50.00	26.65	19.88		113,340

Segment	Size range [dwt]		Size	Main dimensions					
	from	up to	typical	L [m]	B [m]	D [m]	T [m]	V [kn]	GT [t]
Kamsarmax		82,300	82,000	**229.00**	32.26	20.03	14.40		
Dunkirkmax		178,000	175,600	**289.00**	**45.00**	24.10	17.82		88,000
Newcastle-max 1			180,000	284.00	**47.00**	25.40	18.70	13.50	91,000
Newcastle-max 2		211,000	203,000	**299.50**	**50.00**	24.10	17.88		102,500

L= Length

B= Breadth

D= Depth

T= Draft

V= Speed

GT= Gross Tonnage

Table 5 provides a definition for different bulk carrier sizes. The limits are not exact and the vessel sizes tend to get bigger and bigger. The limit between Handysize and Handymax vessels is not distinct, and for instance the Bluetech vessels are referred to as Handysize vessels, although the dimensions are closer to Handymax.

Appendix 2, The development of fuel costs compared to ship costs

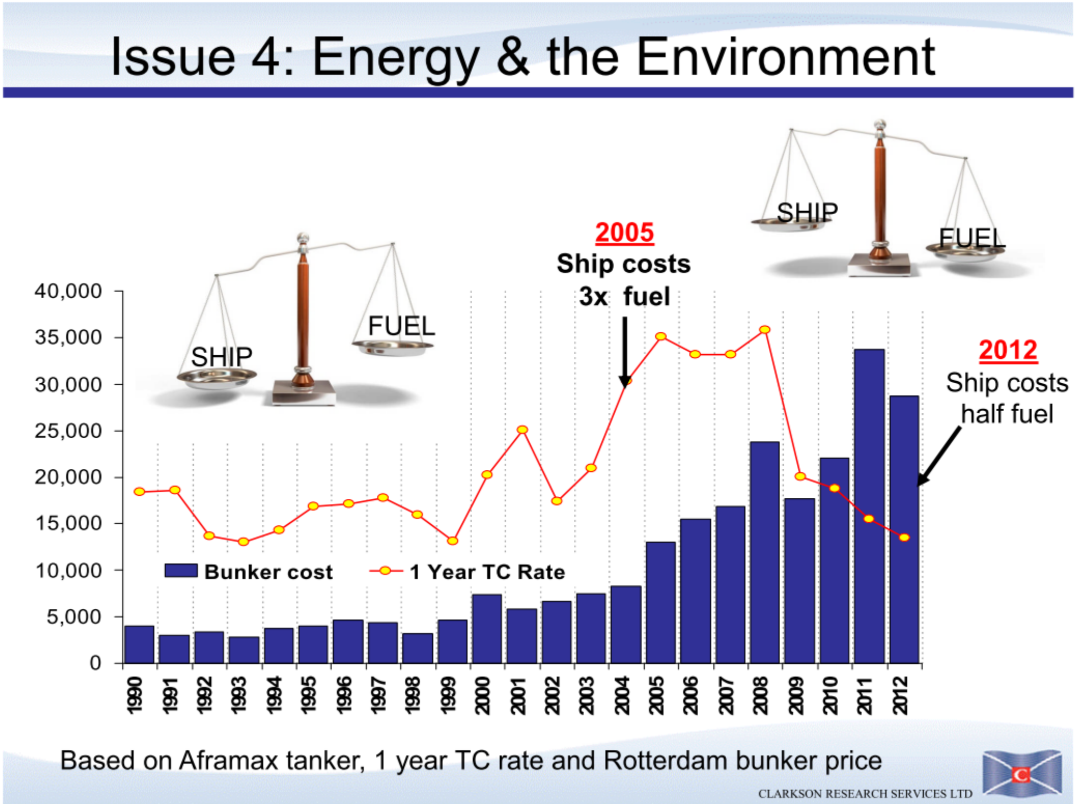

Figure 13. Image copied from Clarkson's.

Figure 13 shows the development of fuel costs vs. time charter rate.

Appendix 3

Interview with Jean Labescat, Technical General Manager of Setaf-Saget, 12.6.2014

Recap of the interview:

The main aspects of the conversation were about the costs created by a bulk carrier. Mr. Labescat pointed out that in the last years the driving force in the market has been the increase of fuel prices, and that a lot of emphasis is put to create cost efficient bulk carriers. This is done by improving the hull and the engine. New slow running engines allow the use of larger propellers which increases fuel efficiency.

When asked about operating costs, Mr. Labescat said that they depend largely on the shipowner's strategy and policies. In order to reduce maintenance costs build quality is very important, and it is something that has to be closely supervised. Attention to detail is also key; every little thing has to be thought and when constructing, the details have to be looked with the shipyard in order to avoid failures and additional costs.

For Setaf-Saget it is a corporate policy to design and build ships that are user-friendly, which also has an impact on operating and voyage costs. Some design features were mentioned: piping is not to be on the weather deck but in the hatch coamings, as a clean deck is better for the shipowner. Another example was the inclination of the hoppers, with 45 degree inclination all cargo (except wet) slides down naturally and helps the unloading.

Another important thing that was mentioned is the fact that when talking about costs, it's always an act of balancing. Improving one thing in order to ease maintenance or cleaning can cause the loss of hold capacity or DWT and this is why the shipowner has to consider every time if it is worth it. One example was single hull vs double hull, a double hulled ship's holds are easier to clean as the surfaces are smooth, but on the other hand a single hulled ship can earn more money due to larger holds. It's up to the shipowner's strategy and calculations to choose, and there is not always one right solution.

I had read from different sources that tank top corrosion is a problem, and Mr.Labescat confirmed this. The grab causes damage to the tank top and breaks the paint coating that protects the steel. He also said that they have decided not to paint the tank top at all since the coating does not stick. Washing of the holds also adds to the corrosion, some products used in the washing process also exacerbate corrosion. This problem is often tackled by adding millimeters to the tank top. The severity of the problem depends on the strategy of the shipowner, if the owner has a policy to keep ships for 10 years and then sell them; the corrosion is not directly his problem as he gets rid of the ship before repairs are to be made. The amount of corrosion would however have an impact on the resale price. An owner whose strategy is to keep the ship for 20 years would be even more concerned about this. The repairs are costly and during dry docking, the ship is not earning anything.

I also asked about the possibility to use different materials for the plates that are most prone to corrosion, mainly the tank top. The idea seemed possible but the price of stainless or anticorrosive steel a lot higher and cost is an issue. However Mr. Labescat said that he had heard of the use of sandwich plating in bulk carriers.

Regarding the design he emphasized that it is very important to know for what type of cargo the vessel will be used for! The same design features may be good for an ore carrier, but would perhaps not work well when grain is transported. It was also important to note that it's always a balancing act, changes here affect another thing there and this has to be considered in the design.

According to Mr. Labescat a big amount of costs can be avoided by carefully selecting makers. This is not an easy task because everything in China is moving quickly and even if a year ago everything went well it is not sure this time it will be the same. Useful tips were to pay attention to details, check details, get involved as much as possible and monitor as closely as possible.