Erasmus University Rotterdam

MSc in Maritime Economics and Logistics

2010/2011

Return on investment in newly built and second hand vessels and portfolio risk management in shipping
The case of equity financed bulk carriers and tankers

by

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Acknowledgements

I would like to thank my thesis supervisor Prof. M.G. Kavussanos for assigning me this topic and for his invaluable assistance, support and guidance.

I am also indebted to the Maritime professionals from “Moore & Stephens”, “Drewry shipping consultants” and various Greek Shipping companies for the data and the useful information they provided me.

Above all, my deepest gratitude goes to my family and friends. The completion of this thesis would not have been possible without their support.

Finally, I dedicate my thesis to my father.

Athens, 21-09-2011

Panagiotis N. Stasinopoulos

Abstract

The acquisition of a vessel is a major decision for a shipping company or a shipowner. The existence of an active second hand market for all types of vessels provides an easy and quick entrance for investors in the shipping sector. However, to co-existence of a newbuilding market makes them face the dilemma of investing in a new or a second hand one. This paper examines the returns on investment in newly built and second hand bulk carriers and tankers for different operating strategies within specified investment horizons for the period of time between January 2002 and May 2011. Having modeled the returns, we end up in specific risk-return characteristics for each vessel per type, size and age and for each operating strategy. Furthermore, by estimating and reporting Sharpe ratios and utility values for investors with different risk preferences we provide a basis for comparison among them. The generated results suggest that newly built vessels have better reward to volatility and yield the maximum utility values for investors with only few exceptions. The Markowitz's portfolio theory is also applied to define the efficient shipping portfolios for successively increasing investment horizons in which more operating strategies can be included. Finally, the theory of portfolio leverage and the Capital Asset Pricing Model are applied to define the market portfolios, distinguish between the systematic and unsystematic risk of the vessels and measure their risk premiums.

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Chapter 1 Introduction

1.1 Introduction

Modern shipping companies operate in a competitive and continuously changing environment and thus can be considered as high risk enterprises. This risk that arises both from shipping market cycles and the broader economic cycles, affects their organization, decisions and funding.

An investment in shipping, can be defined as the initial capital outlay in order to obtain capacity or to create facilities, infrastructure (or maybe expand the existing ones) and purchase equipment. The underlying force that drives shipping companies to make such investments is the fact that all these things can be treated as assets that are bound to generate future cash flows.

Shipping companies can obtain capacity by investing either in new ships or in second hand ones. The decision on whether to make such investments or not, is very crucial for them not only because of the expected returns to which they are targeting, but also because of the high expenses and the implicit risks involved. The newbuilding market differs from the second hand market and the spot market differs from the time charter one. Moreover, each situation generates cash flows and involves a level of risk, which also differs depending on the type, size and age of the vessel. All these differences play an important role and should be taken into account when it comes to investment appraisal.

The newbuilding market is the market for newly built vessels or vessels that are ordered and will be delivered after the construction period which takes between several months to few years. The second hand or sale and purchase market is the market for existing and trading vessels aged between a year and 20 or more years (Alizadeh and Nomikos, 2009). A purchaser enters either of the two markets for various reasons such us to enter the shipping industry, to expand, to improve competitiveness, to replace the existing tonnage or even in expectation of resale opportunities at favorable prices in the future (Ravenko and Lapkina, 1997). When there are no second hand vessels that satisfy his/her requirements then a newly built vessel of a certain size and specification is the only available option. However, when there are suitable second hand vessels the investment decision becomes more complex. When the market conditions are firm, newbuildings prices are high because there are no available shipbuilding blocks in the shipyards. Nevertheless, second hand vessel prices are even higher since they are directly affected by the market conditions due to their instant availability. On the other hand, when we are in recession, both newbuilding and second hand prices are low because shipyards drop their prices to avoid closure and the owners of second hand vessels sell them at distress prices to raise liquidity and meet their day-to-day commitments.

At the end of the day, the decision whether to invest in a new or a second hand vessel depends on the investors' judgments regarding the future market conditions.

1.2 Aim of the paper

Given the uncertainty that characterizes shipping investments and the complexity of the decision whether to purchase a new or a second hand vessel, the aim of this paper can be summarized in the followings:

- To measure the returns on investment in newly built and second hand tankers and bulk carriers operating under different operating strategies within specified investment horizons
- To compare the returns on investment in these newly built and second vessels and rank them according to their reward to volatility (Sharpe ratio) and investors' utility functions
- To apply the modern portfolio theory and generate efficient shipping portfolios for each of the investment horizons and
- To define the market portfolios, measure the systematic and unsystematic risk of the vessels and estimate their risk premiums.

Chapter 2 Literature review and actual facts

2.1 The shipping industry

Merchant shipping is a service industry moving goods from production to consumption sites where utility is higher (Haralambides, 2010). Its development over the past decades has allowed for transportation of raw materials, manufactured goods and finished products between every corner of the globe that wouldn't otherwise been possible. More specifically, according to UNCTAD, seaborne trade accounts for almost 90% of total the world trade thus confirming that international shipping is the predominant means of transportation. The factors that contributed to this development are the liberalization of international trade, the discovery of new sources of raw materials around the world, the economic growth of nations that in turn increased the demand for goods (and thus the demand for shipping services) and of course the economies of scale in shipping which resulted in bigger and more cost-effective vessels.

The following figure illustrates the development of world seaborne trade over the past 25 years in terms of the transported commodities. As can be seen, world seaborne trade has tripled.

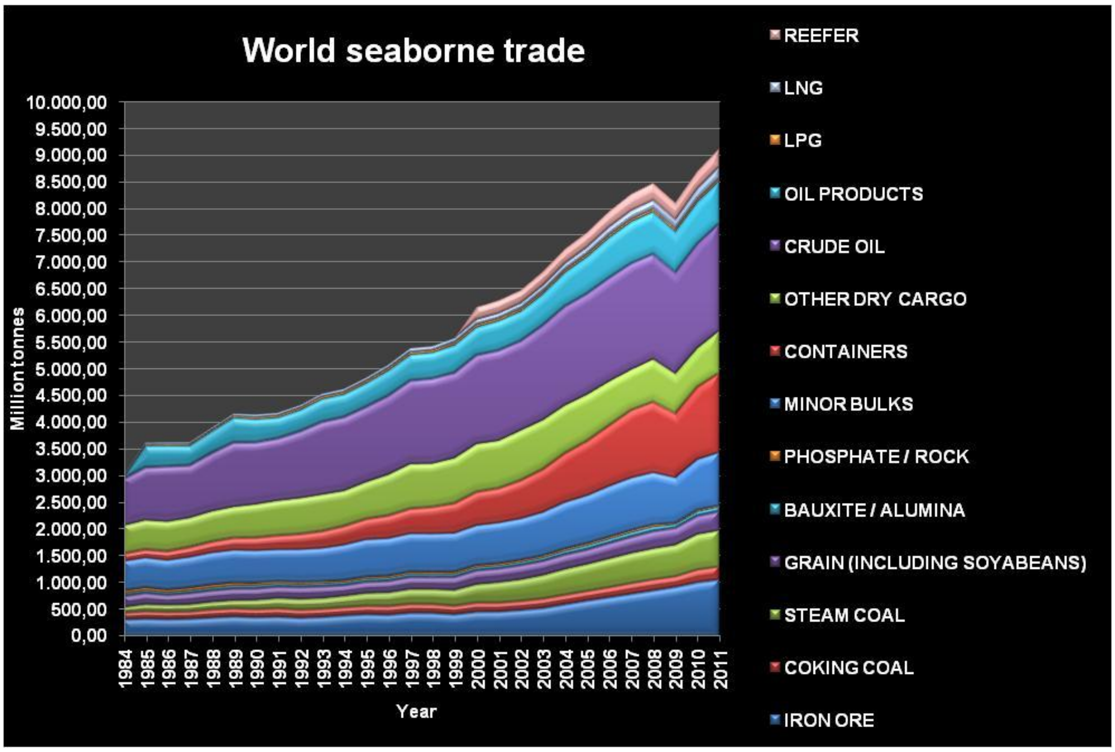


Figure 2.1 World seaborne trade (Source: Clarksons RSL)

Apparently the continuously increasing demand for shipping services resulted in the expansion of the fleet as depicted in the following figure:

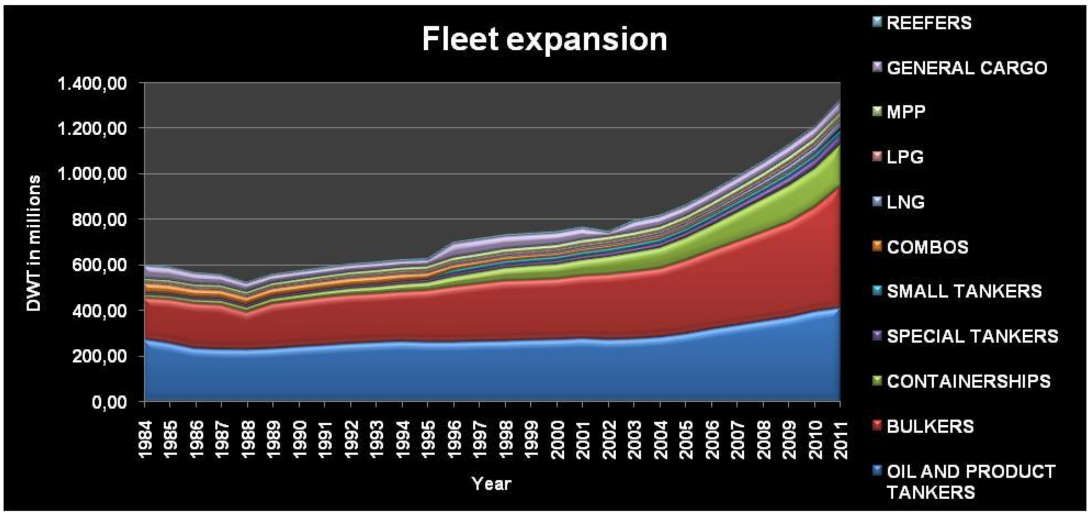


Figure 2.2 Fleet expansion (Source: Clarksons RSL)

What is also obvious in figures 2.1 and 2.2, is the fact that bulk shipping dominates the industry accounting for almost three quarters of the world merchant fleet. More specifically, as of May 2011 the world fleet's composition was the following:

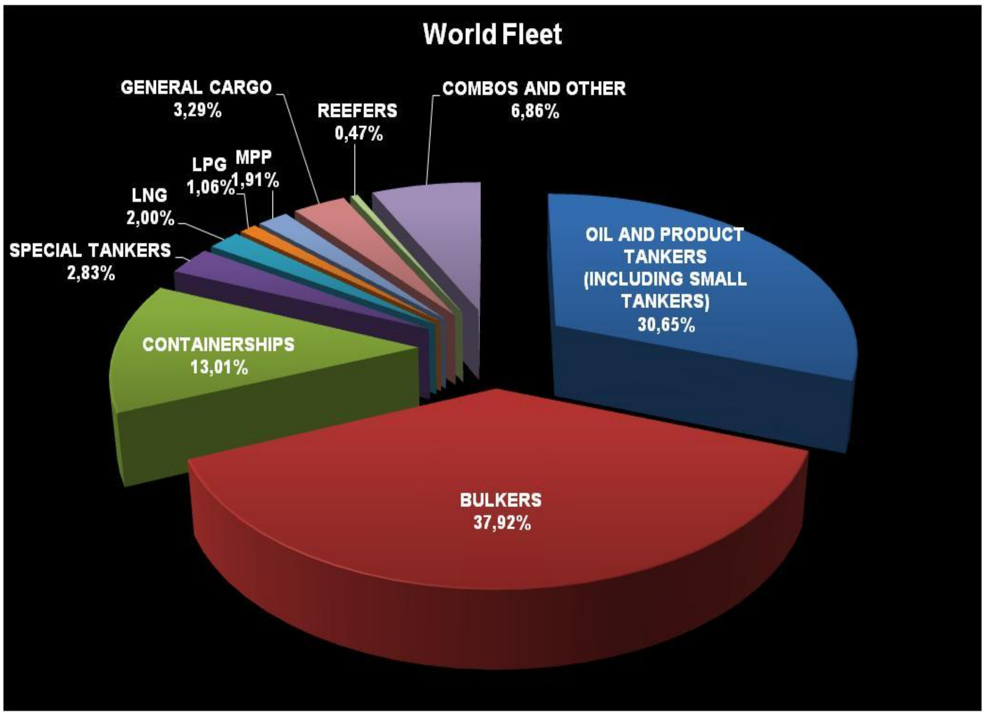


Figure 2.3 Fleet composition (Source: Clarksons RSL)

2.2 Bulk shipping

Bulk shipping facilitates the transportation of homogeneous cargoes, mainly raw materials from the source points to the industry, in large parcels by means of big vessels. It comprises of two big sectors, namely the dry and wet bulk ones which differ in the nature of the commodities transported and therefore in the vessel type employed.

2.2.1 The dry bulk sector

Iron ore, coal, bauxite/alumina, phosphate/rock and grain are the five major bulks that along with the minor bulks such as steel products, steel scrap, forest products, salt, sugar, sulphur, cement etc are transported satisfactorily in conventional bulk carriers (Stopford, 2009).

The bulk carrier sub-markets (sizes) are the following:

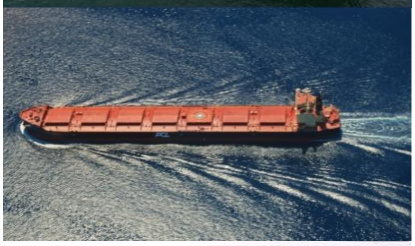
Handysize Bulk carrier		20,000 – 35,000 DWT
Handymax Bulk carrier		35,000 – 50,000 DWT
Panamax Bulk carrier		50,000 – 80,000 DWT
Capesize Bulk carrier		80,000+ DWT

Figure 2.4 Bulk carrier sub-markets

Handysizes and Handymaxes are usually geared and given their low draught requirements they are very versatile and can trade to the most ports in the world. They mostly engage in the trade of grain, bauxite/alumina, phosphate/rock and minor bulk commodities.

Panamaxes are 32.2 m wide in order to feet into Panama Canal’s locks and engage in the trade of all dry bulk commodities. However they do not serve all routes since they are bigger than Handysizes and Handymaxes and their draught restricts access to some ports.

Finally Capesizes are used mainly for iron ore and coal transportation on specific routes and only between well equipped terminals.

According to Clarksons Research Services Limited, up to May 2011 the bulk carrier fleet was comprised of 3,045 Handysizes, 2,260 Handymaxes, 1,877 Panamaxes and 1,227 Capesizes reaching a total of 561.19 million dwt. The orderbook at the same time was comprised of 735 Handysizes, 816 Handymaxes, 895 Panamaxes and 581 Capesizes resulting in another 253.98 million dwt expected to be available in the market in the forthcoming years. Meanwhile, the dry bulk commodities traded reached a total of 3415.77 mmt, out of which 1,035.04 mmt was iron ore, 922.81 mmt coal, 353.19 mmt grain, 86 mmt bauxite/alumina, 22.10 mmt phosphate/rock and 996.63 mmt minor bulk trade.

The following figures depict the bulk carrier fleet development:

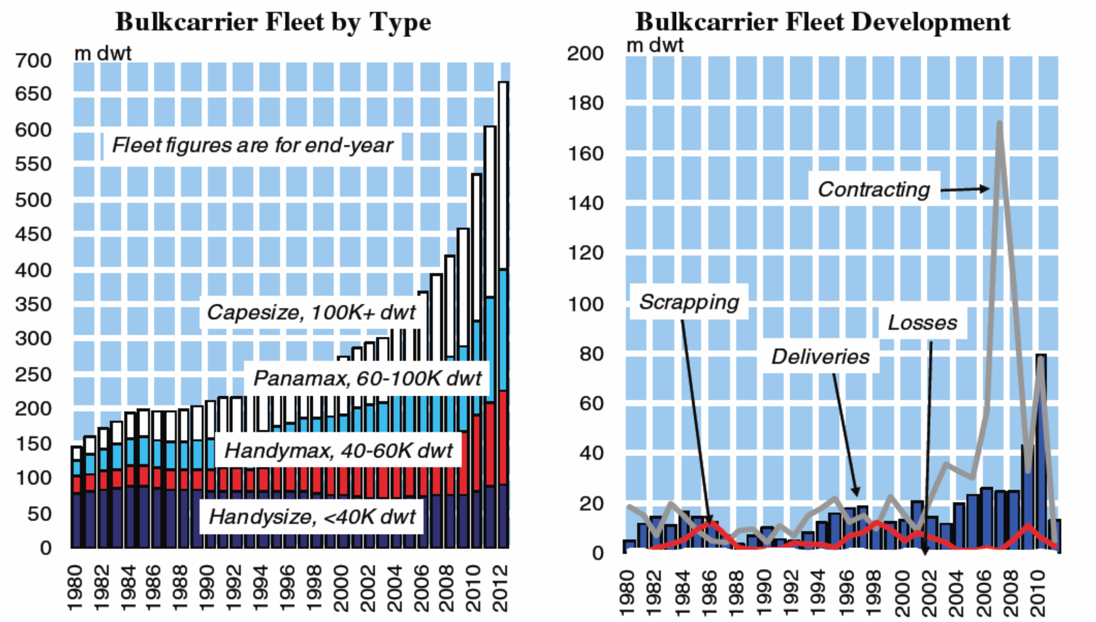


Figure 2.5 Bulk carrier fleet development (source: Clarksons RSL)

2.2.2 The wet bulk sector

Crude oil and oil products such as naphtha, jet fuel oil, gasoline, gas oil, kerosene and diesel oil constitute the main liquid bulks and are the commodities that require tanker transportation.

The tanker sub-markets (sizes) are the following (excluding small tankers and ULCCs):

Handysize Product tanker	30,000 – 55,000 DWT
Panamax tanker	55,000 – 80,000 DWT
Aframax tanker	80,000 – 120,000 DWT
Suezmax tanker	120,000 – 200,000 DWT
VLCC	200,000 – 320,000 DWT

Figure 2.6 Tanker sub-markets

Handysize and Panamax tankers engage in the transportation of clean and dirty oil products while Suezmax tankers and VLCCs are involved in crude oil transportation. However, Aframax tankers engage in the transportation of both crude oil and oil products. As in the case of bulk carriers, the smaller tankers are more flexible in their operation while the larger ones require specially equipped terminals with high draught.

According to Clarksons Research Services Limited, up to May 2011 the tanker fleet was comprised of 1,632 Handysize Product tankers, 406 Panamax tankers, 894 Aframaxes, 425 Suezmaxes and 558 VLCCs reaching a total of 420.91 million dwt. The orderbook at the same time was comprised of 468 Handysize Product tankers, 75 Panamax tankers, 123 Aframaxes, 144 Suezmaxes and 173 VLCCs resulting in a total of 111.78 million dwt. As regard the total liquid bulk trade, this was estimated to be at 2005.06 mmt for crude oil and 799.50 mmt for oil products.

The following figures depict the tanker fleet development:

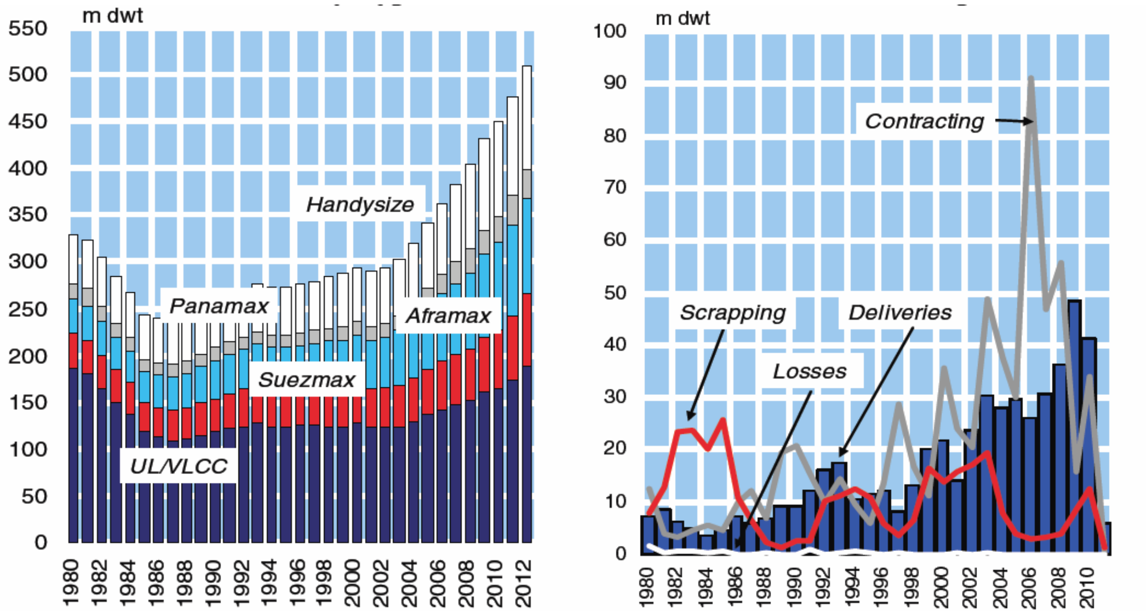


Figure 2.7 Tanker fleet development (source: Clarksons RSL)

2.3 The shipping market cycle

The shipping cycle is a mechanism that exists in order to balance supply and demand for ships.

The following figure illustrates this process:

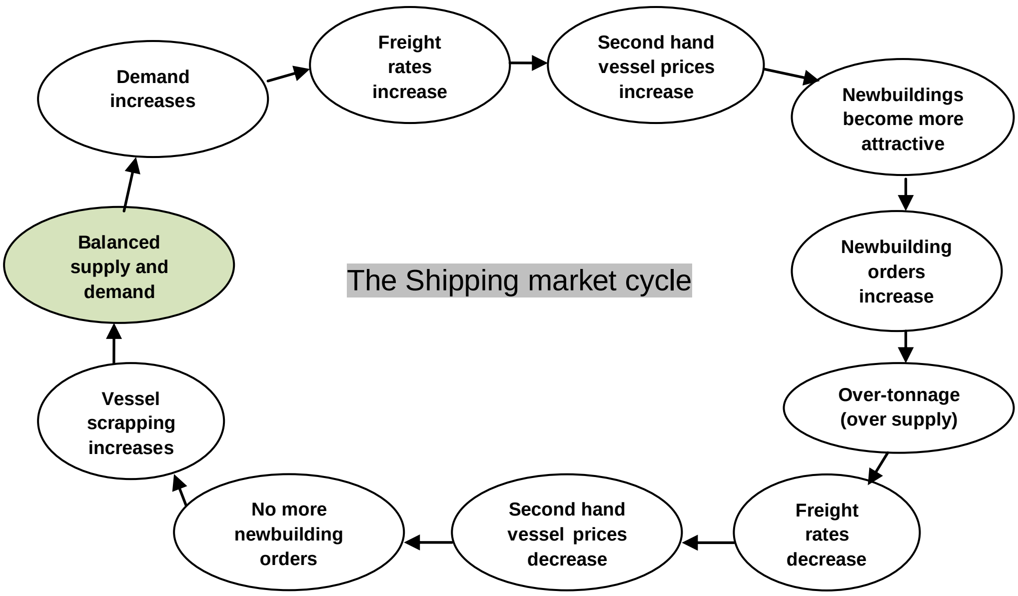


Figure 2.8 Shipping Market cycle

According to Stopford (2009) if supply is low, shipowners are rewarded with higher freight rates until new vessels are ordered. Once there is oversupply, freight rates decrease and therefore cash flow is squeezed until the older vessels are scrapped. The same procedure is repeated again and again.

Although they are classified in terms of their length, in fact shipping cycles last until the circle of the figure above closes. If shipowners misjudge the cycle and decide not to scrap the older vessels, the cycle simply lasts longer. In addition, given the fact that shipowners' decisions are based on their instinct, each cycle has its distinctive character.

The Shipping cycle has typically four stages as depicted in the following figure:

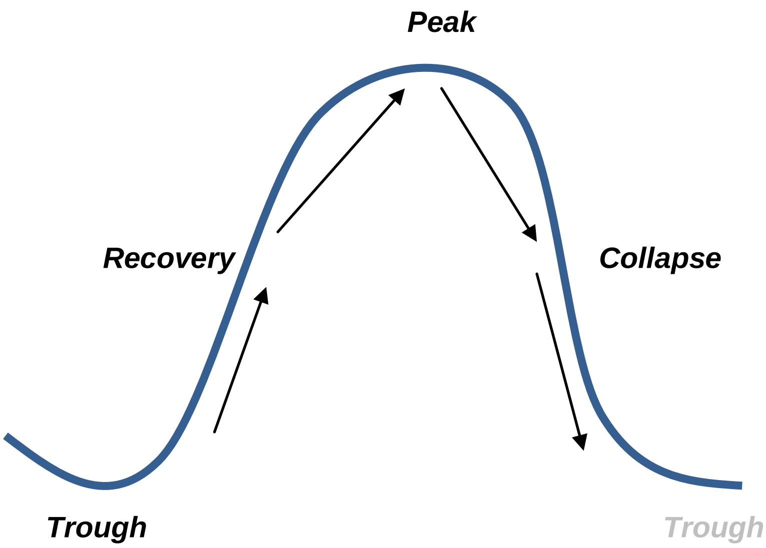


Figure 2.9 The typical course of a shipping cycle

At the stage of Trough, tonnage supply over-exceeds demand and therefore shipyards are empty, vessels are in seek of cargo and cause congestion at the loading ports while vessels that are already loaded reduce speed to save on fuel and delay their arrival at the destination ports. Freight rates are even lower than operating costs resulting in this way in negative cash flow. As a consequence, vessels are laid-up, sold at distress prices or even scrapped.

During the stage of recovery, tonnage supply decreases and therefore tends to meet demand. Freight rates rise above operating costs and vessels are back in operation. The climate is still uncertain but gradually confidence grows. Liquidity increases and so do second hand vessel prices.

At the stage of peak, supply and demand are in perfect balance. Freight rates are much higher than operating costs, three times or even ten times on rare occasions, and therefore vessels operate at full speed while only those that are not trading are laid up. Liquidity increases, banks offer financing for the acquisition of highly valued vessels and the climate is generally euphoric. Second hand vessel prices increase more and reach levels that are above the newbuilding prices. As a result newbuilding orders increase sharply. However the fear of potential oversupply is apparent.

At the stage of collapse, the vessels that were ordered in the previous stage are delivered and consequently tonnage supply overtakes demand. Freight rates decrease, vessels slow down and older vessels cannot find cargo. Liquidity remains high, however agents are in panic and do not want to accept that the peak is over. The market may collapse within weeks.

All these stages are episodic, i.e. there is no specific timing for their occurrence, irregular and of course unpredictable in terms of how long they last (Stopford, 2009).

2.4 Classification of shipping revenues

According to Stopford (2009) and Alizadeh/Nomikos (2009), the revenue the ship earns depends on the contractual agreement between the shipowner and the charterer. In general, the shipowner agrees to provide shipping services to the charterer in return for a specific reward under certain conditions and pre-arranged terms which are clearly specified in the charter party, a documentation signed by both sides. In the freight market, a variety of contracts is available, which differ in duration, payment method as well as allocation of responsibilities and costs between these parties. The different charter contracts that have been developed and used in international shipping are the following:

2.4.1 Voyage charter contracts

Under a voyage charter contract, the shipowner agrees to carry a specified amount of cargo, in a specific ship, from a designated loading port to a designated discharging port, in return for a payment arranged in advance. The charterer hires the vessel and its crew for a single voyage and pays the freight to the shipowner either on a lump-sum or on a US dollars per metric ton basis.

The negotiated freight as well as the nature and the volume of the cargo are stated in the charter party along with the loading/discharging ports, the voyage duration, the laytime, the demurrage, the despatch and other clauses especially regarding the event of default.

The laytime is the required port time to load and/or discharge the ship and is the term of the charter party that causes the majority of arguments between the charterers and the shipowners. It commences upon the master or agent of the ship gives the notice of readiness to the charterer, declaring that the ship is an arrived one ready to be loaded or discharged. If the actual time of loading or discharging the vessel exceeds the agreed one, the charterer should pay the demurrage (US dollars per day) to the shipowner for each additional day of delay. Given the fact that port delays depend on unexpected events such as congestion, weather conditions, labor strikes and cargo handling gear failures, demurrage should be set at a level equal to the equivalent daily hire rate. On the other hand if the actual loading or discharging time is less than the agreed one, the charterer should be compensated with the despatch (US dollars per day - usually half of the demurrage) by the shipowner for each of the remaining days.

In this type of charter, the shipowner undertakes all the capital, operating and voyage costs with only the cargo handling costs being possibly undertaken by the charterer. In addition, the shipowner is responsible for finding cargo and for the managing the ship until the execution of the voyage and the safe discharge of the cargo at the destination port.

2.4.2 Consecutive voyage charter contracts

Under a consecutive voyage charter contract, the shipowner agrees to perform a series of consecutive voyages between two designated ports (origin and destination), and gets paid in US dollars per metric ton of cargo by the charterer. In this case, the allocation of costs is the same as in the voyage charter contracts.

2.4.3 Contract of affreightment

Under a contract of affreightment, the shipowner agrees to carry large amounts of cargo in a series of shipments on a particular route or routes during a specified period of time by using the vessels of his choice within specified restrictions and in return for a negotiated price (in US dollars) per metric ton. The frequency of payment varies from contract to contract and is clearly specified in the charter party along with the other terms. From the shipowners' point of view, with a contract of affreightment flexible vessel scheduling to optimize the operation can be achieved as well as better vessel utilization. On the other side, the charterers are benefited from the fixed transportation cost during the period of time the shipments take place and the shippers are secured with regards to the availability of vessels for the transportation of their commodities. It is widely used for commodities like coal and iron ore that are purchased in large quantities by steel mills in Europe and Far East. In this case, the cost profile is the same as in the voyage charter contracts.

2.4.4 Trip charter contracts

Under a trip charter contract, the vessel is hired by the charterer for a period of time which is determined by a specific voyage (round trip or not) and for the carriage of a specific cargo. The shipowner earns hire per day (US dollars per day) for the same period and not a fixed price per metric ton of cargo as in voyage charter contracts. Once the vessel is discharged, the voyage is over and the contract is terminated. With a trip charter contract, apart from the capital costs, shipowners undertake the operating costs since they keep the operational control of the vessel and they are benefited by the fact that they are directly compensated for any delays. Regarding the charterers, they undertake the voyage and cargo handling costs and they can be benefited by negotiating bunker prices and port dues, as usually happens in practice.

2.4.5 Time charter contracts

Under a time charter contract, the charterer agrees to hire the vessel with its crew from the shipowner for a specific period of time in return for a fixed daily or monthly payment. The charter can be of any length, ranging from the required time for a single voyage, known as trip charter (as described above) to several months or years, known as period charter. The fixed charter rate agreed in the charter party, is expressed in US dollars per day and is payable either in the beginning or it the middle of the month.

In this type of charter, the shipowner maintains the ownership and the management of the vessel and undertakes the capital and the operating costs, whereas the charterer takes the commercial control of the vessel and pays the voyage and the cargo handling costs.

What is most important for shipowners is the fact that the time charters provide them a stable source of revenue. On the charterers' side, the benefits of the time charter contracts stem from the fact that they have the ship under their control without being shipowners which in turn provides them the flexibility to deploy the vessel on different (pre agreed and stated in the charter party) routes for several voyages without worrying about any possible delays that may result in additional payment obligations to the shipowners.

Along with the charter rate, the vessel's performance specifications such as its speed and consumption, the trading areas, the cargo capacity, the place and date of the vessel's delivery to the charterer, the charter party includes terms regarding the responsibility of the shipowner to maintain the seaworthiness of the vessel. All these terms are subject to adjustment in case the vessel fails to provide the quality of service agreed. In the case of unexpected events, such as engine failures, the vessel may not be operational for a period of time during which it is considered off-hire or laid-up and the charter rate is either not paid by the charterer or reimbursed by the shipowner. Last but not least, under certain conditions the contract can also be terminated by the charterer.

2.4.6 Bareboat or demise charter contracts

Under a bareboat or demise charter contract, the shipowner purchases a vessel and hands it over to a charterer for a specific period of time, which is usually as long as the whole economic life of the vessel. This type of charter suits best for charterers that are willing to have the full operational control of a vessel but do not want to purchase it and for shipowners who are only interested in the shipping investment and the possible tax benefit from it but do not want to get involved in its operation. This type of charter takes the form of a long term lease agreement, where the shipowner is the lessor and the charterer the lessee. The latter operates the vessel as if he owns it in return for regular payments (usually every month) to the former on a US dollars per day basis. All operational, voyage and cargo-handling costs are paid by the charterer and the ship owner undertakes only the capital costs. Therefore, the bareboat charter rates can be set to a level that is sufficient for the shipowner to cover these capital costs and yield a constant profit.

2.5 Spot and Time charter rate formation

Spot rates are determined by the interactions between supply and demand for shipping services. At any point in time they reflect the equilibrium point between them. In order to explain the freight rate mechanism we need to depict the supply and demand curve as follows:

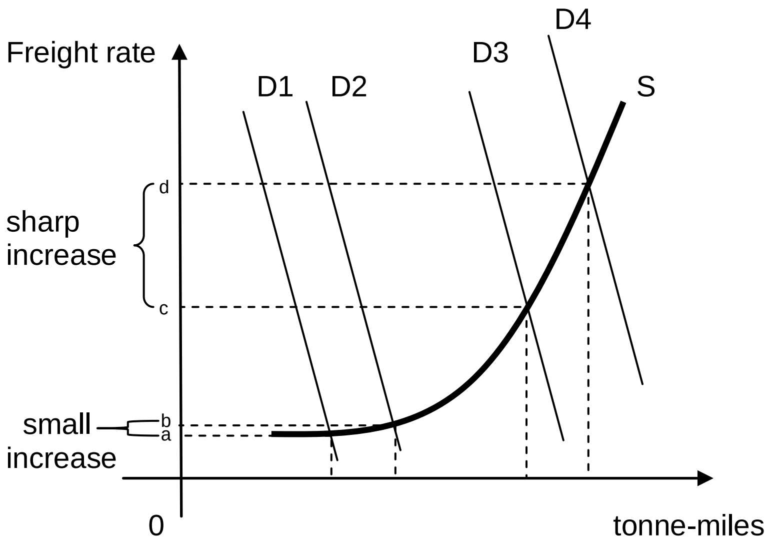


Figure 2.10 Spot rate formation

As can be seen the demand for shipping services (derived demand) in inelastic. On the other hand the supply for shipping services is J shaped and constant (Tinbergen and Koopmans). Its elastic part denotes that the shipping market is in recession. This means that there is idle tonnage and freight rates are at low levels. When demand is D1 the freight rates are set to level “a” which is very low. If we move from D1 to D2 due to a change in one of the demand’s determining factors, e.g. an external shock, the already high excess capacity absorbs demand and the freight rates move to level “b” which is slightly higher than “a”. As market recovers, more and more vessels are employed again and further increase in demand results in higher freight rates. Once the vessels are fully utilized, let’s say when demand is D3, further increase in demand, to D4, can only be absorbed by increasing fleet productivity and therefore freight rates increase sharply, i.e. from level “c” to level “d”. Since supply and demand depend on other factors (see Stopford 2009, page 136-160), freight rates reflect the consequences of their changes.

On the other hand, time charter rates are determined through the expectations of the market’s agents about the future spot rates.

2.6 Classification of shipping costs

According to Stopford (2009), shipping costs can be classified in 5 mail categories namely operating, voyage, cargo-handling, periodic maintenance and capital costs.

2.6.1 Operating costs

Operating costs are the expenses incurred in the day-to-day running of the vessel and are considered as prerequisites of a fully operational vessel with crew, spares, supplies and protection against all kinds of danger. Additionally, they are independent of the trade the vessel engages in and are generated either it is active or idle. In all charter types the shipowner is the one who bears the burden of their payment with the only exception being bareboat charters. The operating costs of a vessel consist of five sub-categories of costs, namely crew, stores and consumables, repairs and maintenance, insurance and administration costs.

According to Moore and Stephens (OpCost report 2010), crew costs is the major cost item for all vessel types (Bulk carriers, Tankers, Containerships), accounting for even more than half of the operating costs of some specific size class categories of vessels. All the other sub-categories of costs account for around 5% to 20% without any steady ranking among them.

Crew costs

Crew costs consist of all direct and indirect expenses borne by the shipowner for the manning of the vessel.

The direct expenses include:

- crew wages and bonus
- overtime charges
- life insurances
- pensions
- leave expenses
- travel expenses
- training
- union fees
- victuals and
- repatriation expenses

The indirect expenses include:

- crew agency fees
- crew selection
- establishment costs
- crew expenses at port
- working uniforms
- social contributions
- communications/bank fees
- working allowances
- medical expenses and
- accident prevention insurances

The manning costs depend on several factors such as:

- the type, size and age of the vessel
- the level of automation of the vessel
- the type of cargo the vessel carries and the route on which it is deployed
- the level of the vessel's maintenance
- the employment policy adopted by the owner and the flag state
- the size of the crew and
- the nationality of the crew

Given the fact that these costs account for almost half of the operating costs of some vessels, shipowners do the utmost to minimize them basically by choosing a flag of convenience under which employment regulations are less strict.

Older vessels generate higher manning expenses because they require a larger crew.

Operating costs do not fluctuate over time but are just adjusted for inflation.

Stores and consumables

There are two types of consumable supplies, lubricating oils and general stores. Lubricating oils are necessary for the vessel's main and auxiliary engines and other mechanical equipment in order for them to run smoothly. General stores include deck stores, engine room stores, cabin stores and several items used on board ship such us supplies, chemicals etc.

Repairs and maintenance

This category covers the costs incurred for routine maintenance as well as for any repairs and spares' replacements in the day-to-day running of the vessel. Their level depend on the respective policy followed by the shipowner and are generated in order for the vessel to be maintained at the minimum standard condition required by the charterers and the classification society. Main engine's and auxiliary equipment's maintenance, inspection costs and steel renewal while the vessel is at sea are included in this category. Repairs of unexpected breakdowns and damages are included as well along with the replacement of engine and on board machinery parts. The unexpected breakdowns and damages are more costly simply because apart from the costs of the repair, the shipowner loses money during the period of time the ship is out of operation. Older vessels require more provision for repairs and maintenance. Drydock costs are not included in this category of costs.

Insurance costs

It is of paramount importance for shipowners to be protected against any type of danger through insurance coverage. Hull and machinery insurance protects them against physical loss or damage in the vessel's hull, machinery and equipment while Protection and Indemnity insurance protects them against third party liabilities such as environmental pollution, cargo damage, injuries or death of crew members and passengers, collisions, port damages, fines and legal expenses. Additional insurance can also protect them against loss of earnings, war risks and strikes. These costs increase with the increase in the vessel's age.

Administration costs

According to Moore & Stephens (OpCost report, 2010) administration costs include the annual ship registration fees, the national authorities' fees, the in-house management and third party ship management fees and miscellaneous non-voyage expenses.

2.6.2 Voyage costs

These are variable costs that arise during a particular voyage undertaken by the vessel and should be continuously monitored since they determine whether the voyage generates profit or loss. They consist of fuel costs, port charges, pilotage and canal dues, with fuel costs accounting for almost 50% of the total depending on the vessel's fuel consumption and the fuel prices. Fuel consumption in turn depends on the type and the size of the vessel, the design of its main engine, its hull's condition, its speed, its load level, the weather and the type and quality of the fuel.

2.6.3 Cargo handling costs

Cargo handling costs include the cost of loading and discharging of cargo as well as its stowage and a cost allowance for cargo claims.

2.6.4 Periodic maintenance costs

Periodic maintenance costs refer to the cash payments required for regular and special surveys through drydocking of the vessel that take place every two and four years respectively in order to determine its seaworthiness. Especially, during special surveys all its machinery and the thickness of its steel are inspected and assessed as to whether they comply with the required standards. Certificate of seaworthiness is issued for a vessel only after any observed defection on it is fixed. Periodic maintenance costs increase with the increase in the age of the vessel.

2.6.5 Capital costs

Capital expenses are associated with the acquisition of a vessel and cover the interest and principal repayment. They depend on the value of the vessel acquired (which depends on the vessel's type, size, age and condition), the debt to equity ratio (the lower the debt to equity ratio, the lower the capital costs), the loan terms (creditworthy shipowners enjoy better financing terms and covenants), the repayment profile (it depends on the loan amount, the creditworthiness of the shipowner, the covenants and the interest rates), the economic life of the vessel (and therefore on the loan duration), the residual value of the vessel, the interest rates (capital costs may vary due to changes in the interest rates) and the tax fees.

2.7 Risks associated with shipping

The market for shipping services has traditionally been viewed as one of volatile cyclical fluctuations. The size and frequency of these fluctuations suggest that risk has a pervasive influence over the decisions that shipping companies and shipowners make (Cullinane, 1995).

The main risks associated with shipping are the following:

Freight rate risk

This type of risk affects directly the profitability of the shipping company / shipowner and stems from the volatility in freight rates. Adverse movement of freight rates results in lower earnings or even losses while favorable movement increases the shipping company's / shipowner's liquidity. This type of risk is the most important risk factor shipowners face given the fact that from their perspective the revenue is what determines their success.

Bunker price risk

This type of risk refers to the cost of fuel oil required for the operation of the vessel. As described in section 2.7.2 of this chapter it accounts for almost 50% of the total voyage costs and therefore is the most important factor that affects the operating profitability of the vessel. It stems from the volatility in world oil prices which is severe.

Asset price risk

In shipping the assets are the vessels and their value fluctuate significantly over time. This affects both the shipping companies' balance sheets as well as their creditworthiness since the vessels are used as collaterals in ship-finance transactions (Alizadeh and Nomikos, 2009).

Physical risk

It is also known as pure risk and refers to physical damages and losses due to force majeure, collisions, third party liabilities, human error etc. It may result in underperformance of the vessel, significant reduction in its value or even total extinction. In this category of risk can also be included the shipping company's/shipowner's liability for environmental pollution. This is also why vessels are insured (H & M, P& I).

Interest rate risk

Interest rates determine the cost of debt financing. Given the fact that they fluctuate over time and shipping loans are agreed on the basis of floating rates, any adverse movement of them can significantly affect the shipping company's cash flow and thus viability. Interest rate swaps can protect shipping companies from this type of risk.

Exchange rate risk

The universally used currency in shipping is the US dollar. However, several other currencies are used worldwide. Given the fact that exchange rates fluctuate, significant losses may be suffered in the conversion of freight income or principal and interest repayment from dollars to each of the other currencies and vice versa.

Debtor risk

It refers to the possibility that debtors will not fulfill their obligations towards the shipping company / shipowner both in terms of adequacy and timing.

Chapter 3 Modeling returns

3.1 Definition and necessity of returns

A portfolio analysis begins with the development of a time series of returns for all the investment alternatives available to a potential investor. In finance (as described by Sharpe, Alexander and Bailey, 1999), the rate of return or simply the return shows the growth in an investor's wealth as a result of a specific investment, usually during a specific time interval. For instance, suppose that an investor purchases at time t=0 one unit of a security, let's say one share of a firm's common stock. The purchase price of this share is the investor's beginning-of-period wealth. After one period, at time t=1, the market value of the share along with any dividends paid to the investor indicate his/her end-of period wealth. If we subtract the beginning-of-period wealth from the end-of-period wealth and divide with the former, the result is the one period rate of return. We can follow the same procedure for a collection (portfolio) of securities as well. In this case, the beginning-of-period wealth is the aggregate purchase price of the collection of securities and the end-of-period wealth their aggregate market value along with the aggregate dividends paid to the investor. The rate of return is usually expressed as a percentage in order to be easily compared across different investments.

Mathematically the one period rate of return of a share can be expressed as follows:

$$r_1 = \frac{p_1 - p_0}{p_0} + \frac{d_1}{p_0} = = \frac{p_1 - p_0 + d_1}{p_0} \qquad (3.1)$$

Where,

r_1 = the one period rate of return

p_0 = the purchase price of the share at time t=0

p_1 = the market value of the share at time t=1 and

d_1 = the dividends paid for the period of time between t=0 and t=1

That is, the return on investment is comprised of two things. One is the cash payment in dividend form and the other it the capital gain or loss represented by the difference between the market and the purchase value of the share (capital gain if $p_1 > p_0$ and capital loss if $p_1 < p_0$. If $p_1 = p_0$, then the return on investment is the return on the dividends paid or in other words, the dividend yield).

In shipping, when we talk about investment alternatives we refer to all the available vessels a potential shipowner can consider acquiring. The necessity of this time series of returns stems from the fact that it provides the basis for deriving the measures of the shipping portfolio's risk and return (Cullinane, 1995).Investors in the shipping industry, like investors in any other sector of the economy, are not only interested in the income generated from the day-to-day operation of the vessels but also in gains from capital appreciation in their value (Alizadeh and Nomikos, 2009). However, given the cyclicality that characterizes the shipping industry, the possibility of suffering losses due to lower generated revenue compared to the incurred costs and/or capital depreciation in the value of the vessels is always existent.

Based on equation (3.1), the time series of returns over a specified period of time for each of the available vessels can be calculated as follows:

$$R_t = \frac{P_t - P_{t-k} + \Pi_t}{P_{t-k}} \qquad (3.2)$$

Where,

k indicates the investment or holding period

P_{t-k} is the value of the vessel in time t-k (the time of acquisition),

P_t is the value of the vessel in time t (end of holding period) and

Π_t is the operating profit of the vessel during the investment period. It is either the difference between the revenue generated through operating the vessel under a time charter contract minus the operating costs incurred during the period of the time charter (similarly for trip Charter contracts) or the difference between the revenue generated through operating the vessel under a voyage contract minus the voyage costs and the operating costs incurred during this voyage (or during consecutive voyages).

The difference $P_t - P_{t-k}$ gives the gains or losses due to the capital appreciation or depreciation respectively in the value of the vessel acquired.

3.2 The units of examination

The units of examination in this paper are the vessels. More specifically we focus on the dry and wet bulk sector and we assess bulk carriers and tankers of different sizes and ages ranging from newly built to 15 year-old ones. The assessment is performed on the basis of different operating strategies, which are defined by the freight contract or the series of a specific freight contract under which the vessels operate. The duration of the freight contracts or of the series of a specific freight contract also defines the investment or holding period indicated by letter k in formula (3.2). Conversely, a predefined holding period requires either the operation of the vessels under a freight contract of the same duration or under series of a specific freight contract of shorter duration. No combinations of freight contracts within a predefined holding period are assessed in this paper.

3.2.1 The vessels under assessment

From the dry bulk sector, the vessels under assessment are the following:

- newly built, 5-year old, 10-year old and 15-year old Handysize bulk carriers
- newly built, 5-year old, 10-year old and 15-year old Handymax bulk carriers
- newly built, 5-year old, 10-year old and 15-year old Panamax bulk carriers and
- newly built, 5-year old, 10-year old and 15-year old Capesize bulk carriers

And from the wet bulk sector:

- newly built, 5-year old and 10-year old “MR” product tankers

- newly built and 5-year old Panamax "Coated" tankers
- newly built, 5-year old, 10-year old and 15-year old Aframax tankers
- newly built, 5-year old and 10-year old Suezmax tankers and
- newly built, 5-year old, 10-year old and 15-year old VLCCs

3.2.2 The freight contracts under assessment

For the bulk carriers, the freight contracts under assessment are the following:

- Voyage contracts for Panamax and Capesize bulk carriers (assuming 1 month duration)
- Trip charter contracts for Handymax bulk carriers (assuming 1 month duration)
- 6-month time charter contracts
- 1-year time charter contracts and
- 3-year time charter contracts

And for the tankers:

- Voyage contracts (assuming 1 month duration)
- 1-year time charter contracts
- 3-year time charter contracts (only for newly built tankers)

3.2.3 The period of assessment

The period of assessment is the period of time between January 2002 and May 2011. The criterion for selecting it was to perform an analysis based on the same number of observations for all vessels, since there was not enough data available for the previous years. Additionally, this period of time contains sufficient historical information in order to achieve the objectives of this paper and produce reliable results. Specific information regarding the period of assessment is given section 4.2.1 of chapter 4.

3.3 Description of the available data

In the following sub-sections a brief description of the data obtained and used is presented based on the sources and methods of the respective providers.

3.3.1 The vessel price data

For the purpose of this paper, a monthly data set comprising newbuilding, second hand and scrap prices for all the above mentioned bulk carriers and tankers was provided by Clarksons Research Services Limited for the period of time between January 2002 and May 2011.

All prices are benchmark prices and refer to the average standard vessel of each type and size. More specifically, newbuilding prices relate to concluded contracts independent of the country of built, delivery and ship specification. With respect to the second hand prices, the obtained 5, 10 and 15-year old vessel prices relate to reported market sales for vessels in average condition, built at good Far East/European shipyards but without taking into account their survey status.

Similarly, scarp prices relate to reported market sales. In case no market transaction took place, broker's best estimates were considered as the respective prices.

3.3.2 The freight data

Freight data was collected the same way as vessel price data, i.e. monthly data sets of time charter rates, trip charter rates (only for Handymax bulk carriers) and time charter equivalents of voyage rates for the same period of time from Clarksons Research Services Limited.

The obtained time charter rates of 6 months, 1 year and 3 years duration for bulk carriers as well as the ones of 1 and 3 years duration for tankers, relate to the latest, at each point in time, rate for each vessel type and size or to the estimated likely rate a shipowner would have accepted in the absence of any fixtures. For all bulk carriers and tankers, we collected time charter rates for modern and older standard vessels for all time charter durations apart from the 3-year time charter rates for tankers which were only available for modern ones. Trip charter rates for older and modern Handymax bulk carriers were collected as well.

Similarly, the time charter equivalent rates collected, are calculated on the basis of standard vessel types and sizes and estimated for both modern and older standard vessels. The formula for the calculation of the Time charter equivalent rates is the following:

$$TCE = \frac{(FR \times T_c) - (VC + Com + F_t)}{d_v} \tag{3.3}$$

Where,

TCE = Time charter equivalent rate

FR = Freight rate per ton of cargo

T_c = Tons of cargo loaded

VC = Voyage costs

Com = Commissions

F_t = Freight tax and

d_v = Voyage days

The obtained time charter equivalent rates are calculated per vessel type and size for each route without taking into account the payment of commissions, the days off-hire and the waiting times at port. As voyage costs are considered only the bunker costs which are based on prices at representative regional bunker ports as well as the estimated port and canal costs. No other voyage related costs are taken into account. In essence, the time charter equivalent rates provide an estimation of the daily earnings of ships implied by the current level of spot rates (Ansari, 2006). They are not precise earnings of the vessels but only benchmark indications of them. In this paper we used the average time charter equivalent rates of all the available routes for each of the older and modern standard vessels.

3.3.3 The cost data

Cost data was kindly provided by Drewry shipping consultants and Moore & Stephens along with the respective reports containing other useful facts, definitions and information regarding the future expectations. The cost data obtained relate to operating expenses of each vessel type and size for different ages as well as to drydocking costs for each vessel type and size.

Operating expenses were obtained for each year from 2002 until 2010 whereas Drydocking costs cover the period of time between 2005 and 2009. An average number of days a vessel of each size class category per vessel type was out of operation during the drydock was also provided for the respective period of time.

3.4 Data treatment and assumptions

3.4.1 Basic assumptions and scenarios

We assumed that on the first day of each month during the period of assessment, a potential shipowner can acquire either a newly built or a second hand (5-year old, 10-year old or a 15-year old) vessel of the type and size of his/her preference. Once the vessel is acquired, it is also available in the freight market and a freight contract can be signed instantly without having the shipowner in seek of potential charterers. This assumption seems logical only for second hand vessels. However we did make it for newly built vessels as well, because we couldn't find a way to model the time gap between the contract time and the time of delivery. More specifically, we assumed that a newly built vessel can be acquired either from a shipyard which has it readily available due to a cancelation of a previous order or from a shipowner to whom it is just delivered from a shipyard and who is willing to sell it at the prevailing newbuilding price before operating him/herself.

Moreover, we assumed that the available freight contracts for each vessel type, size and age in the freight market are those described in section 3.2.2 of this chapter. Each of the freight contracts or each of the series of a specific freight contract defines the holding period for the calculation of returns and vice versa. Given these facts, three different scenarios were constructed and assessed, all of which differ in the holding period. For each scenario we selected the respective freight contracts or series of a specific freight contract that cover this predefined holding period.

In the first scenario, we considered a holding period of one month. Therefore, we assumed that an investor purchases a vessel on the first day of each month, operates it under a voyage contract of 1 month duration (under a trip charter contract of one month duration for Handymax bulk carriers) and at the end of the same month he/she sells it as a 1-month older vessel. In this case the vessel earns the respective Time charter equivalent rate per day for this month minus the respective monthly operating costs.

In the second scenario, we considered a holding period of 1 year. In this case, we assumed that the vessel is purchased on the first day of each month, operates under a 1-year time charter contract or 2 consecutive 6-month time charter contracts (only for bulk carriers) or 12 consecutive voyage contracts of 1 month duration (12 trip charter contracts of 1 month duration for Handymax bulk carriers) and at the end of the 12^{th} month it is sold as a 1-year older vessel. During this holding period the vessel earns the 1-year Time charter rate per day (the one in the beginning of the holding period) for the whole year or the respective 6-month time charter rates per day for the first and the next 6 months (the 6-month time charter rates in the beginning of two hypothetical holding periods of 6 months) or the respective time charter equivalent rates (trip charter rates for Handymax bulk carriers) per day for every month. The costs incurred in all these three cases are the sum of the monthly operating costs for the respective 12 months.

In the third scenario we consider a holding period of three years. Again the vessel is purchased on the first day of each month and operates under a 3-year time charter contract, or 3 consecutive 1-year time charter contracts, or 6 consecutive 6-month time charter contracts (only for bulk carriers) or 36 consecutive voyage contracts (36 trip charter contracts for Handymax bulk carriers) of 1 month duration and at the end of the 3rd year it is sold as a 3-year older vessel. The revenues and the respective costs were calculated in similar way as in the second scenario.

Finally, we constructed on more scenario (extra scenario), especially for bulk carriers, assuming a holding period of 6 months in which the operating alternatives are a 6-month time charter contract or 6 consecutive voyage contracts (6 consecutive trip charter contracts for Handymax bulk carriers) of 1 month duration and the vessel is sold as a 6-month older vessel at the end of the 6th month. In this scenario, we also assumed that tankers operate only under 6 consecutive voyage contracts of 1 month duration. Again the calculation of the respective revenues and costs was done as in the previous scenarios.

In all the scenarios we assumed that the triptych “purchase-operation-sale” of a vessel takes place every month for the whole period of assessment and for all types, sizes and ages of vessels, so that we could generate a time series of returns for each of them by means of formula (3.2). In addition, we only deducted the operating costs from the total revenues because first of all, under a time (or trip) charter contract the voyage costs are undertaken by the charterer and secondly, in cases where the vessel operates under a voyage contract, the voyage costs which are undertaken by the shipowner are already deducted in the calculation of the time charter equivalent rates. Moreover, by assessing not only individual freight contracts but also series of a specific freight contract, we made operating strategies of different duration comparable. Especially, a comparison between the returns over a period of time for two different operational strategies, one of which is a time charter of the same duration and the other a number of consecutive voyages or even a number of time charters of smaller duration, is in fact a comparison between a hedged and an unhedged (against risk) strategy (Alizadeh and Nomikos did this for the first time. More specifically they compared the returns on equity for different second had tankers and bulk carriers operating under 3 year time charter contracts and consecutive voyage contracts for 3 years. These were the hedged and unhedged strategy respectively. For more details please see Cullinane 2010, page 121-141). Last but not least, we calculated only unlevered returns which means that we considered equity financed vessel acquisitions rather than debt financed ones. The reason why we did not take into account debt financed acquisitions of vessels, is the fact that by considering a maximum of a 3-year holding period, a 3-year loan deal should have also been considered. In this case, principal and interest payments should have been squeezed in the same period of time producing in this way unrealistic results (especially for bigger vessels which are more expensive and for periods when the vessel prices were very high) contrary to what happens in practice.

Additional assumptions regarding the vessels, the freight contracts and the costs are given bellow:

3.4.2 The vessels and their resale value

In this paper we did not examine vessels of a specific deadweight tonnage from each size class category but the size class categories themselves. Given the fact that the actual size of the vessels within a size class category changes from time to time, we assessed the vessels with the latest size specifications for each age category taking into account their average year of built. In other words, we assumed that investors consider acquiring only the most modern available vessels from each vessel age. For example the average year of built for 170K DWT Capesize bulk carriers was 2000. Therefore, as newly built Capesize bulk carriers, we considered only the vessels of this deadweight tonnage. In contrast, as 5 year old Capesize bulk carriers we considered the ones with a deadweight tonnage of 150K until the end of 2004 and the ones with 170K onwards. In the same way we treated all 5-year old vessels and some of the 10 year-old ones. As 15-year-old vessels were considered only the older standard vessels. For more information regarding the average year of built and the size specifications of all tankers and bulk carriers, please see Clarksons Sources and Methods (October 2010).

Having presented the method and defined the holding periods for the calculation of returns, what requires further explanation is the estimation of the resale value, P_t, of the vessels in formula (3.2). The resale value of each vessel was adjusted for depreciation or appreciation by means of linear extrapolation between the reported prices of the vessels within the age of which the age of the vessel under assessment is at the end of the investment period. Take for instance the following example:

Table 3.1 shows the prices of 5 and 10 year old Panamax bulk carriers in 2005.

Date	5yo Panamax BC($)	10yo Panamax BC ($)
2005-01	45,000,000	35,500,000
2005-02	45,500,000	37,000,000
2005-03	45,500,000	37,000,000
2005-04	46,000,000	38,000,000
2005-05	44,000,000	35,000,000
2005-06	42,150,000	33,250,000
2005-07	39,000,000	28,500,000
2005-08	38,000,000	27,500,000
2005-09	36,500,000	27,500,000
2005-10	36,500,000	27,500,000
2005-11	32,500,000	27,000,000
2005-12	29,500,000	24,000,000

Table 3.1: 5 and 10 year old prices of Panamax bulk carriers in 2005
Source: Clarksons Research Services Limited

Suppose that an investor buys (without debt) on January 2005 a 5 year old Panamax bulk carrier for 45 million $, holds it for 6 months (the vessel operates either under a 6 month time charter contract or 6 consecutive voyages of 1 month duration) and sells it at the end of June 2005 as a 5,5 year old vessel. In this case the resale value of the vessel is:

$$P_{(5,5yo)30\text{-}06\text{-}05} = P_{(5yo)30\text{-}06\text{-}05} + \left[\left(\frac{P_{(5yo)30\text{-}06\text{-}05} - P_{(10yo)30\text{-}06\text{-}05}}{\text{Age difference between a 5 and 10 year old vessel}}\right) \text{x holding period}\right] = \qquad (3.4)$$

$$= 42{,}150{,}000 + \left[\left(\frac{33{,}250{,}000-42{,}150{,}000}{5}\right) \text{x } 0{,}5\right] =$$

$$= 42{,}150{,}000 - 890{,}000 = \$\ 41{,}260{,}000$$

The linear extrapolation method could be used between age ranges as defined by the obtained data. The age ranges considered are the following:

- [newly built, 5 year old vessel),
- [5 year old vessel, 10 year old vessel)
- [10 year-old vessel, 15 year-old vessel)
- [15 year-old vessel, 20-year old vessel) or [15 year-old vessel, end of economic life) and
- [20 year old vessel, end of economic life)

In all these cases the fraction in the above formula had the same denominator since the age difference in all ranges is five years. The only exception was the alternative range for the calculation of the resale value of 15-year old vessels. In this case the denominator was equal to the difference between the scrap age of the vessels and their actual age (15 years). According to Clarksons, the average scrap age was 31 years for bulk carriers and 26 for tankers in 2010. These were assumed to be the average scrap ages for the whole period of assessment for all vessels. The last age range was considered only for the estimation of the drydocking costs and the days required for periodic maintenance. Further explanations are given in section 3.4.4 of this chapter. Moreover, in cases where the data was not sufficient to estimate the resale value by means of linear extrapolation, we assumed a 5% annual depreciation/appreciation in the reported value of the vessels at the end of the holding period and then we estimated the respective depreciation/appreciation for the holding period. The calculation of the resale value was done in the same way for all holding periods and vessels (of each type, size and age) by altering formula (3.4) and changing the respective (highlighted) value in it accordingly.

3.4.3 Income sources and calculation of the revenue

The way we treated the income sources is in line with the one for the vessels. Since we assessed the vessels with the latest size specifications according to their age (older or modern standard vessels) at each point in time, we also made use of the respective time charter equivalent rates or trip charter rates or time charter rates. Coming back to the example of the 5 year old Capesize bulk carriers, the time charter and time charter equivalent rates used until 2004 were the ones for the older standard vessels whereas from 2005 onwards the ones for the modern standard vessels (average year of built for older standard vessels: 1990). In cases where the average year of built was not later than 1997, newly built and 5-year old vessels were considered to be of the same size specifications and therefore we used the same rates for them (e.g. Handymax bulk carriers). Similarly, we treated all 5-year old vessels and some of the 10-year old ones (where applicable). For the rest of the 10-year old as well as for all the 15-year old vessels we used the same rates, i.e.

the ones for the older standard vessels, for the whole period of assessment. Although a 15 year old vessel in 2000 was the one built in 1985, we used the rates for vessels that were built in 1990 assuming that the age of the vessel does not affect the level of the time charter or freight rates as well as ignoring the fact that these older vessels may differ in size specifications. All the 15 year old vessels were treated in similar way for all income sources. In addition, for handymax bulk carriers we made this assumption for all age ranges. Last but not least, for modern Aframax, Suezmax tankers and VLCCs we used the time charter and time charter equivalent rates for selected routes where this was applicable. For more information regarding the routes, their changes during the period of assessment and the respective rates please see Clarksons sources and methods (October 2010).

The revenue for each vessel was calculated by taking into account the holding period, the freight contract under which it was employed and the calendar days of the respective holding period after deducting the days the vessel was out of operation for regular and periodic maintenance. No days in lay-up or off-hire for any other reason were considered for the vessels. In essence, we assumed that a freight contract is always available and therefore the vessels are fully employed for the whole holding periods unless maintenance (regular or periodic) is required. A numerical example will be given after explaining the way we estimated the days out of operation in the next section.

3.4.4 Costs and days out of operation

Given the fact that this paper assesses equity financed vessels (and therefore no calculation of capital expenses was required), under a time charter contract the voyage costs are undertaken by the charterer and the obtained time charter equivalent rates are adjusted for voyage costs, the only costs that should have been taken into account for the calculation of the returns are the operating costs. However, after consultation with a maritime professional from Moore and Stephens through e-mail correspondence, we decided to deduct drydocking costs as well from the revenue generated from each income source. More specifically, we assumed that instead of being paid in the year they occur, drydocking costs can be equally spread throughout the year and thus a monthly equivalent amount of them can be deducted from the income in the same way as the operating costs. In fact, the estimation and charge of accrual drydocking costs on a monthly basis is a policy widely followed by shipping companies. The drydocking costs provided were annual average values for each vessel type and size independent of the age of the vessels. In order for us to be in line with reality, in which drydocking costs increase with the age of the vessel, we estimated them for the five age ranges according to the following example:

In 2005 the average drydocking costs for Panamax bulk carriers were 674.932 $. Assuming that the sample from which this value was generated contains equal number of vessels (let's say λ) from all the age ranges [0-5YO), [5-10YO), [10-15YO), [15-20YO), [20YO-end of economic life) (although we didn't assessed 20-year old vessels, we considered this age range for the estimation of the drydocking costs since there were and are vessels of this age available in the market) and the drydock costs were equal to X for the first age range, X+0,25X for the second, X+0,70X for the third, 2X for the fourth and 2,5X for the fifth, we ended up with the following equation:

$$\frac{\lambda X+\lambda(X+0.25X)+\lambda(X+0.70X)+2\lambda X+2.5\lambda X}{5\lambda}=674,932 \Leftrightarrow$$

$$\frac{X+(X+0.25X)+(X+0.70X)+2X+2.5X}{5}=674,932 \Leftrightarrow$$

$$\frac{8.45X}{5}=674,932 \Leftrightarrow$$

$$X=\$\ 399,368 \text{ per year}$$

Therefore, the drydock costs for each age range were:

- [0 – 5YO)
  $ 399,368 per annum or $ 33,281 per month
- [5 – 10YO)
  399,368 + (0.25 x 339,368) = $ 499,210 per annum or $ 41,601 per month
- [10 – 15YO)
  399,368 + (0.70 x 339,368) = $ 678,926 per annum or $ 56,577 per month
- [15 – 20YO)
  2 x 399,368 = $ 798,736 per annum or $ 66,561 per month
- [20YO – End of economic life)
  2.5 x 399,368 = $ 998,420 per annum or $ 83,202 per month

The respective operating costs per day provided by Drewry shipping consultants were exclusively for newly built, 5-year old, 10-year old, and 15-year old vessels. However, we assumed that these costs correspond to the above age ranges since, generally speaking, had we adjusted them for different ages of the vessels under assessment (during the holding periods the vessels grow older), no significant difference to the results would have been observed.

In 2005 the operating costs for a 5-year old Panamax bulk carrier were 5.290$ per day. Therefore, for the holding period between the 1st of January 2005 and the 30th of June 2005 the total operating costs plus the respective drydocking costs were:

[(31+28+31+30+31+30) x 5,290] + (6 x 41,601) = 957,490 + 249,606 = $1,207,096

Between 2000 and 2004 as well as 2010 and 2011 for which no relevant data was available, we estimated drydocking costs by assuming that every year they are 5% higher than in the previous year. Regarding the operating expenses for 2011, we assumed a 3.2% increase for tankers and 3.6% increase for bulk carriers compared to the ones in 2010 (Moore & Stephens OpCost report, 2010).

As regards the estimation of the days the vessels were out of operation for regular and periodic maintenance we assumed the followings:

For all bulk carriers and tankers the required days per month for regular and periodic maintenance increase with the size of the vessels and more importantly with their age.

With respect to the required days for regular maintenance, starting with 2 days per month for a Handysize bulk carrier of the first age range, [0-5YO), the respective days for all other bulk carriers and tankers of the same age were estimated as a percentage above this number as follows: 2.10 days (5% higher) for Handymax bulk carriers, 2.20 days (10% higher) for Panamax bulk carriers, and 2.40 days (20%

higher) for Capesize bulk carriers, 2.10 days (5% higher) for “MR” Product tankers, 2.20 days (10% higher) for Panamax “Coated” tankers, 2,30 days (15% higher) for Aframax tankers, 2,40 days (20% higher) for Suezmax tankers and 2.50 days (25% higher) for VLCCs. Then the aging factor was accounted by assuming that the days required for regular maintenance for the vessels of the next age ranges were 10%, 35%, 50% and 75% higher than the ones required for the vessels of the first age range. For example the five year old Panamax bulk carrier required 2.20 + (2.20x0.10) = 2.42 days per month for regular maintenance in 2005.

Concerning the required days for periodic maintenance, these were given by Moore and Stephens for all vessels types and sizes but again without accounting for the vessels’ age. Therefore we estimated them in the same way as the drydocking costs for each age range. For example, in 2005 the average number of days required for periodic maintenance for Panamax bulk carriers was 24 days. Assuming again that the sample from which this value was generated contains equal number of vessels (let’s say λ) from all the age ranges and Z, Z+0.10Z, Z+0.35Z, 1.5Z, 1.75Z represent the respective required days for periodic maintenance for vessels of all age ranges then:

$$\frac{\lambda Z+\lambda(Z+0,10Z)+\lambda(Z+0,35Z)+\lambda(1,5Z)+\lambda(1,75Z)}{5\lambda}=24 \Leftrightarrow$$

$$\frac{Z+Z+0,10Z+Z+0,35Z+1,5Z+1,75Z}{5}=24 \Leftrightarrow$$

$$\frac{6.70Z}{5}=24 \Leftrightarrow$$

$$Z = 17.91 \text{ days per year}$$

Therefore, the required days for periodic maintenance for all age ranges were:

- [0-5YO): 17.91 days per year or 1.49 days/month
- [5-10YO): 17.91 +(0.10x17.91) = 19.70 days per year or 1.64 days/month
- [10-15YO): 17,91 +(0.35x17.91) = 24.18 days per year or 2.01 days/month
- [15-20YO): 1.5x17.91 = 26.87 days per year or 2.24 days/month
- [20YO-EOEL): 1.75x17.91 = 31.34 days per year or 2.61 days/month

For the years we didn’t have drydocking costs we also didn’t know the required drydock days per year. Therefore, between 2002-2004 and 2010-2011 the respective required days were assumed to be the average number of days required for the years we did have data.

Thus, in 2005 the 5 year old Panamax bulk carrier was assumed to be on average (2.42+1.64=) 4.06 days per month out of operation for regular and periodic maintenance. This means that during the 6-month holding period, the vessel of our example was 24.37 days out of operation. For the remaining days (156.63 days) we assumed full employment and the vessel earned the January’s 6-month time charter rate for these 156.63 days, or more specifically $ 26,625 per day x 156.63 days = $ 4,170,273 for the 6-month holding period. Had the vessel been employed under 6 consecutive voyage contracts of 1 month duration, it would have earned the respective time charter equivalent rate for 24.37 days of each month and incurred the same costs as in the former operating strategy. More specifically the vessel would have earned:

$$(31-4.06) \times 31{,}896 = 26.94 \times 31{,}896 = 859{,}221$$

$$(28-4.06) \times 31{,}272 = 23.94 \times 31{,}272 = 748{,}596$$

$$(31-4.06) \times 35{,}872 = 26.94 \times 35{,}872 = 966{,}327$$

$$(30-4.06) \times 29{,}323 = 25.94 \times 29{,}323 = 760{,}586$$

$$(31-4.06) \times 21{,}983 = 26.94 \times 21{,}983 = 592{,}183$$

$$\underline{(30-4.06) \times 19{,}357 = 25.94 \times 19{,}357 = 502{,}086}$$

$$\$\ 4{,}428{,}999$$

Recall that operating costs are paid for the whole calendar days of a month no matter if the vessel is idle or active. Similarly, the estimated equivalent monthly amounts of the drydocking costs in our case are paid independent of the vessel's status. In contrast, the vessel earns money only for the days it is active. This was the way our model calculated the operating income, $\Pi_{t,}$ required for the calculation of the returns by means of formula (3.2).

The same procedure was followed for all vessels of all types.

3.4.5 Calculating the return on investment

After making all the above mentioned assumptions and defining or estimating all the parameters contained in formula (3.2), we can now calculate the return on investment in a the 5 year old Panamax bulk carrier that was acquired on the 1st of January 2005 without debt, employed under a 6-month time charter contract and sold on the 30th of June 2005 as a 5.5 year old vessel as follows:

$$R_t = \frac{(41{,}260{,}000 - 45{,}000{,}000) + (4{,}170{,}273 - 1{,}207{,}096)}{45{,}000{,}000} =$$

$$= \frac{-3{,}740{,}000 + 2{,}963{,}177}{45{,}000{,}000} = = \frac{-776{,}823}{45{,}000{,}000} = -0.0173 \text{ or } -1.73\%$$

Had the vessel been employed under 6 consecutive voyages of 1 month duration, the respective return would have been:

$$R_t = \frac{(41{,}260{,}000 - 45{,}000{,}000) + (4{,}428{,}999 - 1{,}207{,}096)}{45{,}000{,}000} =$$

$$= \frac{-3{,}740{,}000 + 3{,}221{,}903}{45{,}000{,}000} = = \frac{-518{,}097}{45{,}000{,}000} = -0.0115 \text{ or } -1.15\%$$

The returns for all vessels of all types, sizes and ages as well as for all operating strategies were calculated in the same way. The result of this procedure was the generation of the required time series of returns that will be analyzed in the next chapter.

Chapter 4 Data analysis and results

4.1 Tools for analysis

The analysis of the data and the results was basically conducted by means of descriptive statistics for selected samples. Additionally, the results were analyzed by means of two more tools, namely the Sharpe ratio and the investors' Utilities. Further details regarding the tools for analysis are given below:

4.1.1 Descriptive statistics

Shipping is considered as one of the most volatile industries where agents are exposed to substantial financial and business risks (Alizadeh and Nomikos, 2009). These risks stem from the fluctuations in vessel prices, and daily earnings among others. Since the return on shipping investment predominantly depends on these two elements, an analysis was required in order to assess how these fluctuations differ across different vessel ages, sizes and types. Similarly, once the returns were calculated further analysis was performed in order to assess the magnitude of these fluctuations to the outcome.

The analyses were performed by means of descriptive statistics which in general use single numbers to summarize and report information about the distributional properties of a variable or a data set. The most important statistics used in this study are the mean as a measure of location, the variance and the standard deviation as measures for dispersion and the coefficients of skewness and kurtosis to define the shape of the generated distributions.

4.1.2 Sharpe ratio

The Sharpe ratio, named after its developer W. Sharpe (1966), is a precise measure of risk-adjusted performance for individual investments and portfolios. Its significance stems from the fact that it takes into account the existence of a risk free asset, i.e. an asset which yields a return for virtually zero standard deviation (further explanations will be given in chapter 6). By subtracting the rate of return of the risk free asset from the rate of return of any other individual (risky) investment or portfolio and dividing by the standard deviation of the latter, the generated result measures excess return (reward) per unit of risk.

The Sharpe ratio for any individual investment or portfolio is calculated according to the following formula:

$$SR_x = \frac{r_x - R_f}{Stdev_x} \qquad (4.1)$$

Where,

SR_x = the Sharpe ratio of an individual investment or portfolio x

r_x = the expected or average (for historical data) rate of return on the individual investment or portfolio x

R_f = the best available rate of return on a risk free asset (usually we use US treasury bills as risk free assets)

$Stdev_x$ = the standard deviation of r_x

The difference r_x - R_f gives us the excess return or risk premium

In this paper we calculated the Sharp ratios of all individual vessels and used them as a basis for comparison across different vessel ages per vessel type and size as well as across different vessel types and sizes. These Sharpe ratios are exhibited in tables 4.18 – 4.34 of section 4.3 of this chapter.

4.1.3 Risk aversion and Utility

Risk is the probability that the realized return is not the expected one. Generally speaking, when investors place a certain amount of initial wealth into risky investment alternatives, they know or they should know that there are more than one possible outcomes. In addition, under the assumption of nonsatiation, they are more interested in gains than losses. This means that, given two investment alternatives with the same level of risk or the same level of expected return, they would definitely select the one with the higher expected return or the less risky one respectively. However, they don't know which one to select in cases where the expected return increases along the risk involved.

In essence, the investors expect to earn a (positive) risk premium, i.e. a compensation for the risk they take compared to the one they would have taken, had they invested in a risk-free asset, such as US Treasury bills. The investors whose decisions are affected by the risk involved in the investment alternatives and undertake only specific levels of risk in pursue of a favorable risk-return trade-off, can be defined as speculators. On the other hand, there are also investors who are gamblers and undertake risk "just for the fun of it". In other words, speculators are interested in positive risk premia, and gamblers are simply indifferent to the outcome.

Nevertheless, apart from speculative prospects and gambles, investors can also consider fair games, i.e. investments which have zero risk premiums. On this basis, we can define the risk-averse investor as the one who doesn't engages in fair games or gambles and considers only risk-free investments or speculative prospects with positive risk premia. That is, the risk-averse investor penalizes the expected return of a risky investment or portfolio by a certain percentage to account for the risk involved. The greater the risk, the larger the penalty (Bodie, Kane and Marcus, 2008).

Assuming that an investor can be assigned a welfare score or utility for each of the competing individual investments or portfolios based on their risk (expressed as variance)-return profile, a ranking of them can be achieved. In fact, investors chose the individual investments or portfolios that maximize their utility. The utility is calculated according to the following formula:

$$U = E(r) - \frac{1}{2}A\sigma^2 \qquad (4.2)$$

Where,

U = the investor's utility or welfare score

E(r) = the expected return of the individual investment or portfolio

σ^2 = the variance of the individual investment's or portfolio's returns

½ = a scaling convention and

A = the degree of risk aversion

The degree of risk aversion affects the investor's risk-return trade off. It is a number the value of which depends on the individual investor's attitude towards risk. For a risk-averse investor, coefficient A takes values higher than zero (A>0). The higher the value of A the higher the risk aversion and the expected return of a risky investment or portfolio is penalized more severely. For gamblers or risk lovers A is negative and the lower its value the higher the upward adjustment of the expected return. Finally, those investors who judge individual investments or portfolios based solely on their expected return, A is equal to zero. These are the risk-neutral investors.

In this paper we considered 3 investors who are willing to place their money in the shipping market and differ in their risk tolerance. Since, the Markowitz portfolio theory that will be explained in chapter 5 assumes that investors are risk averse, these 3 investors were considered as such. The degrees of risk aversion considered are A=1 for the first investor, A=3 for the second and A=5 for the third. The effect of the degree of risk aversion in their utilities is presented in tables 4.18 -4.34 of section 4.3 of this chapter.

4.2 The bulker and tanker data

4.2.1 The period of time between 2002-present

Following the dot.com crisis in early 2001, the low levels that freight rates reached, remained until the end of 2002. The fact that VLCC and Capesize earnings fell below $ 10,000 per day is indicative of the prevailing market situation at that time. In the beginning of 2003, China went on a serious infrastructure development and consequently its demand for raw materials increased significantly. Its extensive iron ore and steam coal requirements were the reasons for the boom observed the dry bulk sector and especially in Capesize and Panamax sub-markets. With respect to the wet bulk sector, the impending war in Iraq influenced positively the rates. In general, the emerging economies of China India and Brazil in conjunction with the underinvestment and underdevelopment of the shipping fleet in the previous years (Alizadeh and Nomikos, 2011) created a mismatch between supply and demand which brought about remarkable increase in both tanker and bulker rates.

This general upturn lasted for almost five years, until 2008, with some small troughs in between due to the slowdown of the Chinese economy later on, the invasion in Iraq and other events. Martin Stopford (2010), argued that "without doubt, this was the best boom in living memory, and possibly one of the best ever", in an attempt to describe the record levels the shipping market reached. The increase in the rates resulted also in the increase in the second hand vessel prices, especially between 2006 and 2008 and mostly in the dry bulk sector where even 15-year old bulk carriers were more expensive that newly built ones. This of course was not the case for the wet bulk sector, in which the accidents of "Erika" and "Prestige" (in 1999 and 2002 respectively) brought about the application of strict regulations regarding the tonnage ageing and tonnage selection as well as the gradual replacement of the single hulled vessels. As a result, tanker supply and thus tanker rates (and thus tanker prices) didn't reach such high levels as the ones of bulk carriers.

Martin Stopford (2011) also reported that the boom induced heavy investment in new vessels which took place between 2007 and 2008, when newbuilding prices (although lower than second hand prices for bulk carriers and at almost the same level with them for tankers) were at record high level. Afterwards, the credit crisis caused a sharp drop in the rates, at levels even lower than the ones in 2002. For example, in mid 2008 Capesize bulk carriers were earning $ 190,000 per day and six months later less than $ 5,000 per day. Similar sharp drops observed in the respective vessel prices. The world economy was in the downturn and this was also depicted in the economic indicators.

Currently there is excess supply in the shipping market and this will probably be the case for the next couple of years. This fact along with the unresolved structural problems in OECD countries which account for half of the seaborne trade, constitute what Martin Stopford (2011) describes as "unbalanced 2010s". Meanwhile, freight rates and vessel prices have shown signs of recovery.

4.2.2 Analysis of the vessel prices and vessel earnings by means of figures and descriptive statistics

The figures below present historical vessel prices along with the respective time charter and time charter equivalent rates (trip charter rates for Handymax bulk carriers). In cases where for different vessel ages, different freight data were available, the figures refer only to one vessel age. With the exemption of Handysize bulk carriers and Panamax "coated" tankers, there are also figures that present only historical prices of newly built and second hand vessels of all ages. Moreover, the tables present descriptive statistics for the changes in vessels' prices and daily earnings. The presented measures are annualized.

Handysize bulk carriers

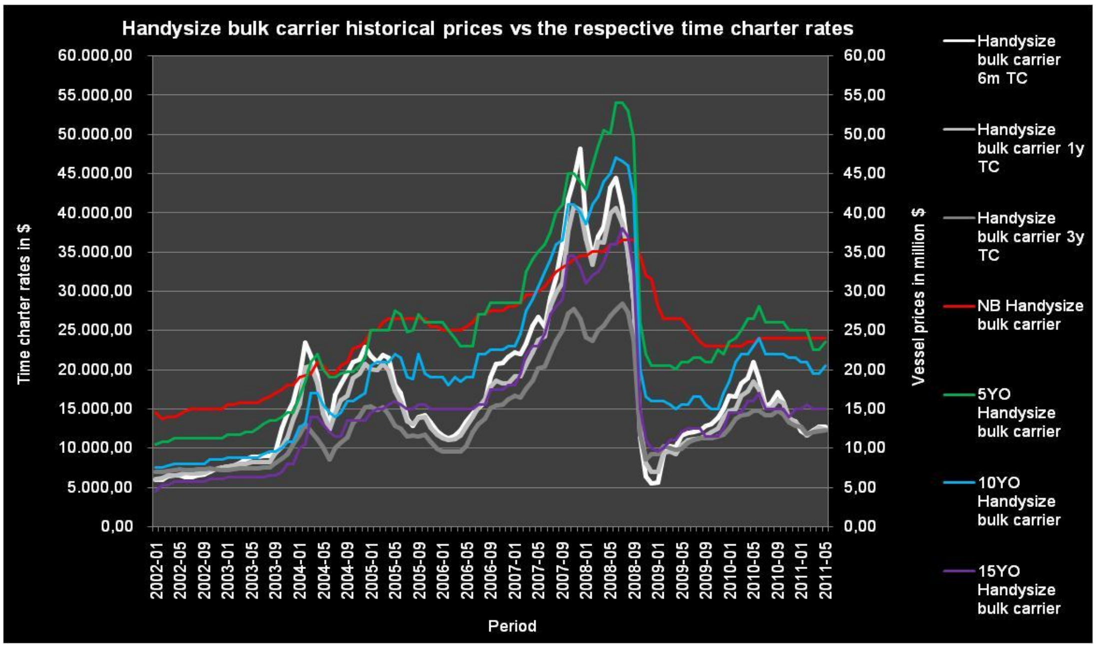


Figure 4.1: Handysize bulk carrier newbuilding and second hand historical prices and time charter rates

Vessel type/size class	Handysize bulk carriers			
Vessel age	NB	5YO	10YO	15YO
Average vessel price (mln $)	24,31	24,68	20,14	15,28
Mean percentage change	5,83%	12,02%	15,58%	18,53%
Standard deviation (volatility)	9,09%	23,67%	28,41%	30,77%
Sample variance	0,83%	5,60%	8,07%	9,47%
Kurtosis	4,1739	22,6293	17,3262	14,9840
Skewness	-0,8460	-3,0055	-1,9445	-1,7371

Table 4.1: Descriptive statistics for Handysize bulk carrier historical prices

Vessel type/size class	Handysize bulk carriers		
Vessel age	All		
Freight contract	6m TC	1Y TC	3Y TC
Average earnings' level ($)	17.335,53	16.225,50	13.309,33
Mean percentage change	20,14%	15,88%	10,82%
Standard deviation (volatility)	46,34%	37,80%	28,29%
Sample variance	21,4773%	14,2881%	8,0052%
Kurtosis	7,8142	7,5077	14,7714
Skewness	-0,3492	-1,3222	-2,5554

Table 4.2: Descriptive statistics for Handysize bulk carrier historical earnings from different freight contracts

Handymax bulk carriers

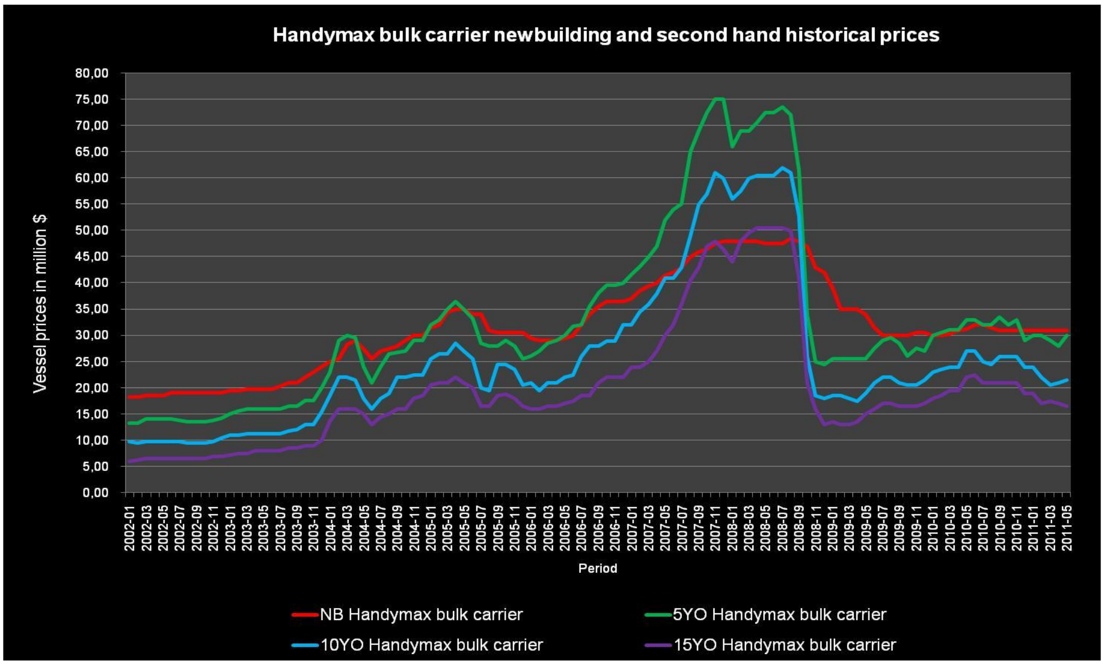


Figure 4.2: Handymax bulk carrier newbuilding and second hand historical prices

Vessel type/size class	Handymax bulk carriers			
Vessel age	NB	5YO	10YO	15YO
Average vessel price (mln $)	31,66	32,78	25,53	19,84
Mean percentage change	6,29%	13,21%	14,29%	16,19%
Standard deviation (volatility)	10,93%	27,96%	31,60%	30,70%
Sample variance	1,19%	7,82%	9,99%	9,42%
Kurtosis	2,7971	10,3673	10,0895	11,0707
Skewness	-0,5883	-1,8797	-1,7795	-1,3967

Table 4.3: Descriptive statistics for Handymax bulk carrier historical prices

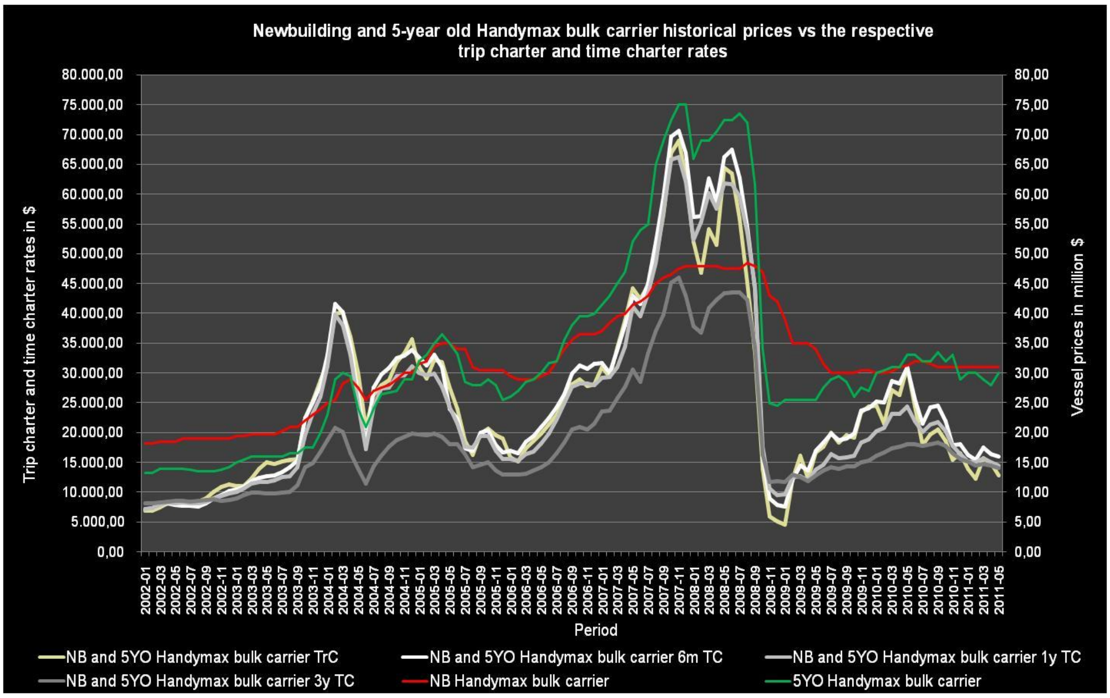


Figure 4.3: Newbuilding and 5-year old Handymax bulk carrier historical prices, trip charter rates and time charter rates

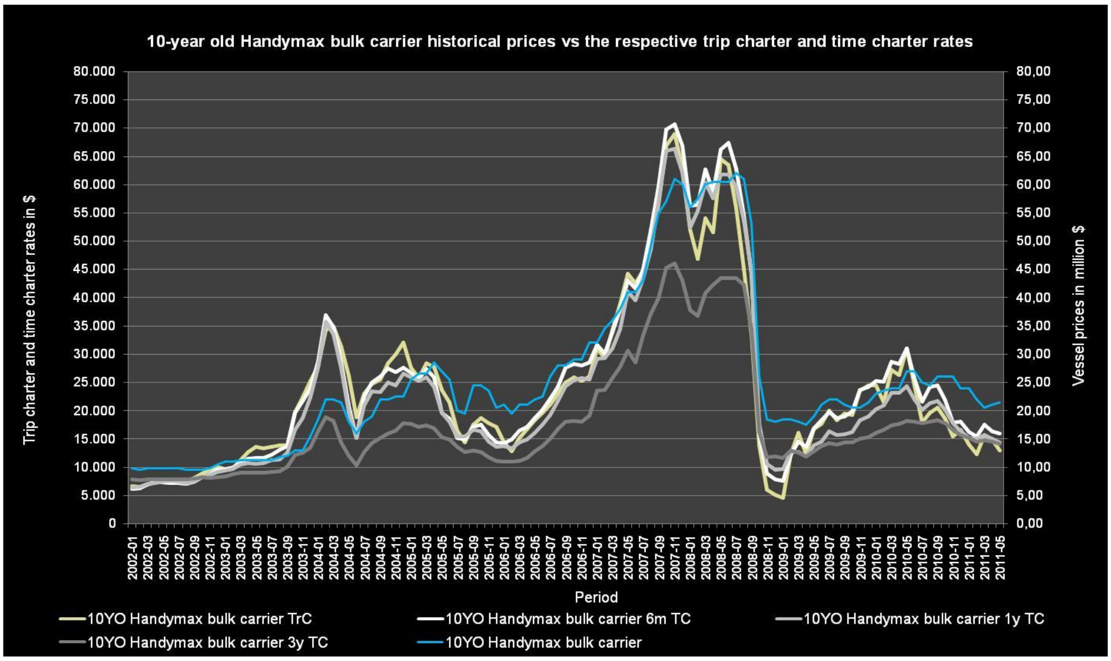


Figure 4.4: 10-year old Handymax bulk carrier historical prices, trip charter rates and time charter rates

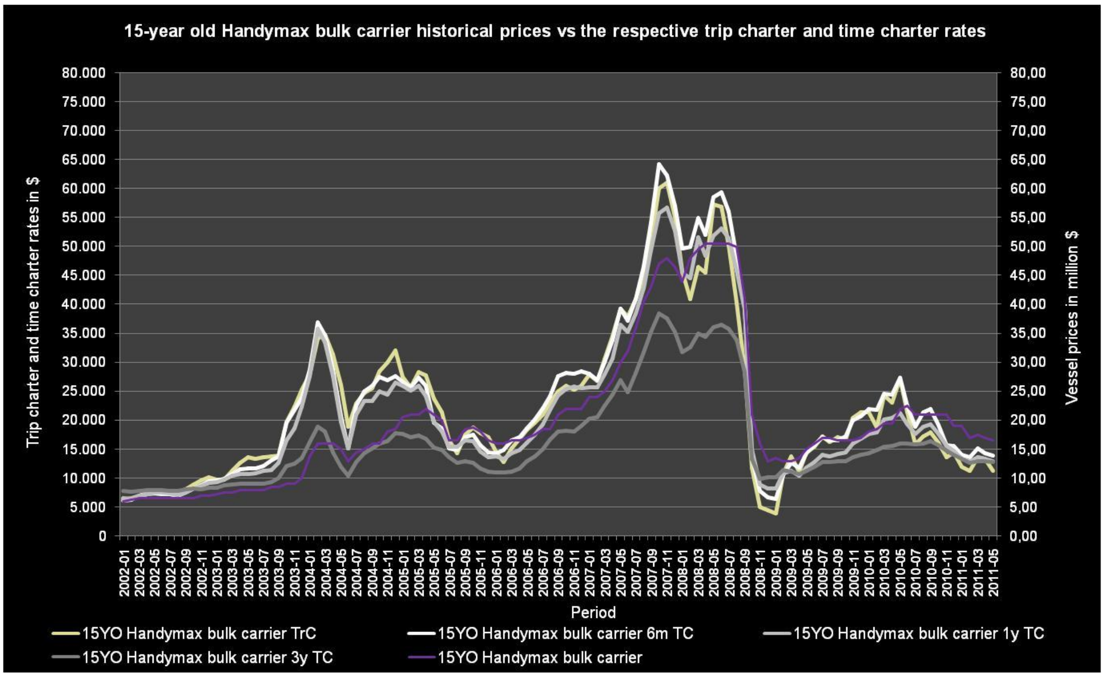


Figure 4.5: 15-year old Handymax bulk carrier historical prices, trip charter rates and time charter rates

Vessel type/size class	Handymax Bulk carriers											
Vessel age	Newly built and 5-year old				10-year old				15-year old			
Freight contract	TrC	6m TC	1Y TC	3Y TC	TrC	6m TC	1Y TC	3Y TC	TrC	6m TC	1Y TC	3Y TC
Average earnings' level ($)	25.204,02	26.258,99	24.389,02	18.582,04	23.983,35	24.812,32	23.068,21	17.709,05	22.347,88	23.025,66	21.182,70	16.168,10
Mean percentage change	31,18%	24,11%	18,95%	11,99%	31,60%	25,49%	20,19%	12,63%	29,69%	24,53%	19,19%	11,15%
Standard deviation (volatility)	77,27%	53,34%	44,76%	32,43%	77,12%	52,54%	44,46%	32,85%	76,66%	53,60%	44,39%	31,55%
Sample variance	59,7053%	28,4568%	20,0308%	10,5160%	59,4766%	27,6054%	19,7700%	10,7943%	58,7723%	28,7296%	19,7062%	9,9534%
Kurtosis	26,9976	5,4385	5,7211	9,9195	27,1650	5,1962	5,4929	9,3347	29,1876	5,9716	6,1178	11,0978
Skewness	3,3711	-0,1078	-0,9005	-1,7934	3,3798	-0,2747	-1,0099	-1,6723	3,5550	-0,0627	-1,0741	-1,9675

Table 4.4: Descriptive statistics for newly built and second hand Handymax bulk carrier historical earnings from different freight contracts

Panamax bulk carriers

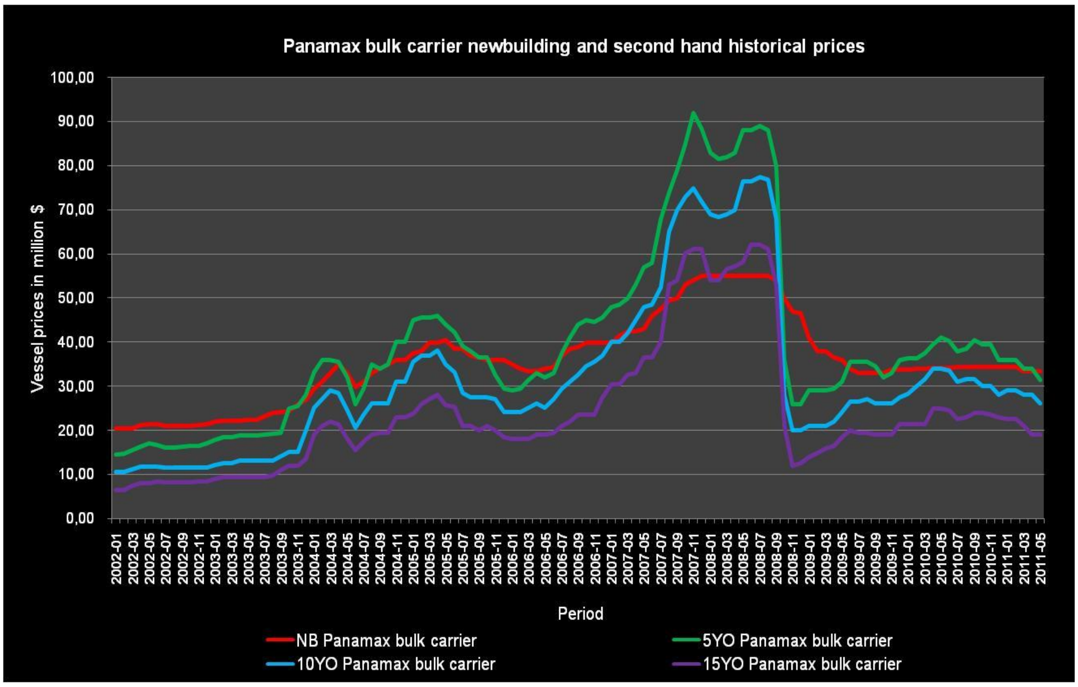


Figure 4.6: Panamax bulk carrier newbuilding and second hand historical prices

Vessel type/size class	Panamax bulk carriers			
Vessel age	NB	5YO	10YO	15YO
Average vessel price (mln $)	35,67	39,41	31,40	23,71
Mean percentage change	5,90%	14,16%	16,48%	20,18%
Standard deviation (volatility)	11,19%	31,01%	33,04%	37,46%
Sample variance	1,25%	9,62%	10,91%	14,03%
Kurtosis	2,4532	14,5004	15,3720	12,7323
Skewness	-0,5942	-2,1685	-2,0329	-1,7266

Table 4.5: Descriptive statistics for Panamax bulk carrier historical prices

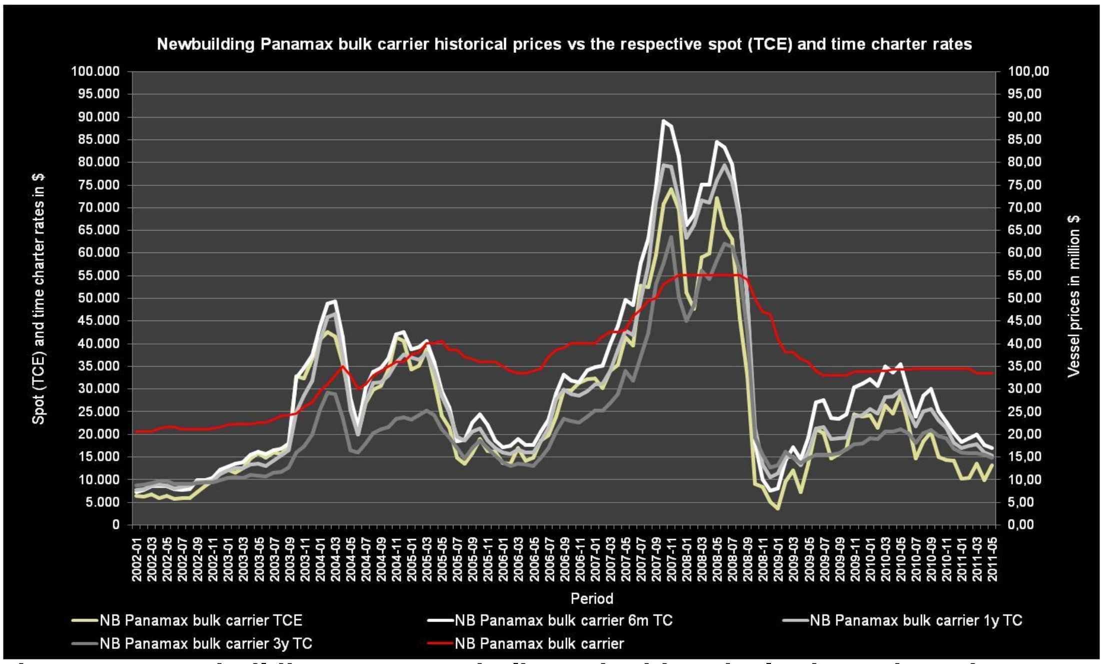


Figure 4.7: Newbuilding Panamax bulk carrier historical prices, time charter equivalent rates and time charter rates

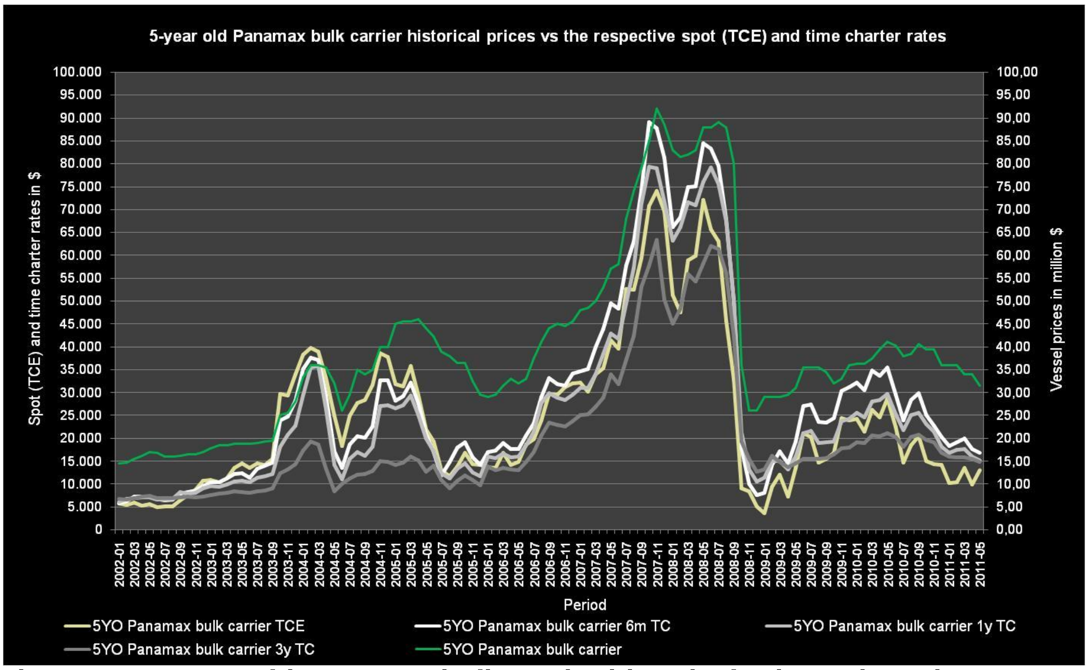


Figure 4.8: 5-year old Panamax bulk carrier historical prices, time charter equivalent rates and time charter rates

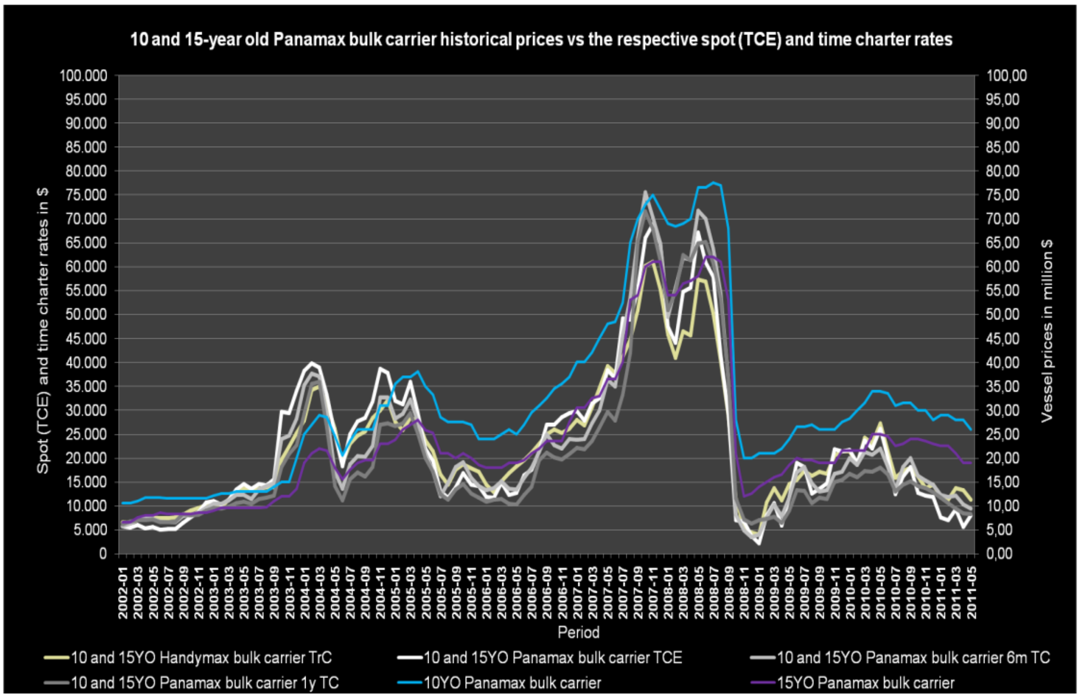


Figure 4.9: 10 and 15-year old Panamax bulk carrier historical prices, time charter equivalent rates and time charter rates

Vessel type/size class	Panamax Bulk carriers											
Vessel age	Newly built				5-year old				10 and 15-year old			
Freight contract	Spot	6m TC	1Y TC	3Y TC	Spot	6m TC	1Y TC	3Y TC	Spot	6m TC	1Y TC	3Y TC
Average earnings' level ($)	25.343,22	31.124,96	28.268,09	22.003,22	24.584,21	28.512,26	25.616,61	19.769,35	22.940,99	22.809,02	20.430,91	13.726,09
Mean percentage change	46,25%	29,48%	21,26%	14,69%	47,96%	33,71%	27,28%	19,33%	56,11%	35,16%	24,90%	12,62%
Standard deviation (volatility)	95,03%	63,36%	50,73%	39,79%	95,37%	65,26%	57,18%	44,28%	120,39%	74,16%	63,16%	48,33%
Sample variance	90,3120%	40,1445%	25,7344%	15,8294%	90,9580%	42,5898%	32,6958%	19,6077%	144,9362%	55,0000%	39,8974%	23,3581%
Kurtosis	11,5772	5,4542	2,9768	4,5278	11,3112	3,2749	2,2115	3,8820	26,1065	3,6340	2,7541	3,4316
Skewness	2,1496	0,6714	-0,3054	-1,0648	2,1065	0,2516	-0,1956	-0,7253	3,7469	0,3380	0,0075	-0,8644

Table 4.6: Descriptive statistics for newly built and second hand Panamax bulk carrier historical earnings from different freight contracts

Capesize bulk carriers

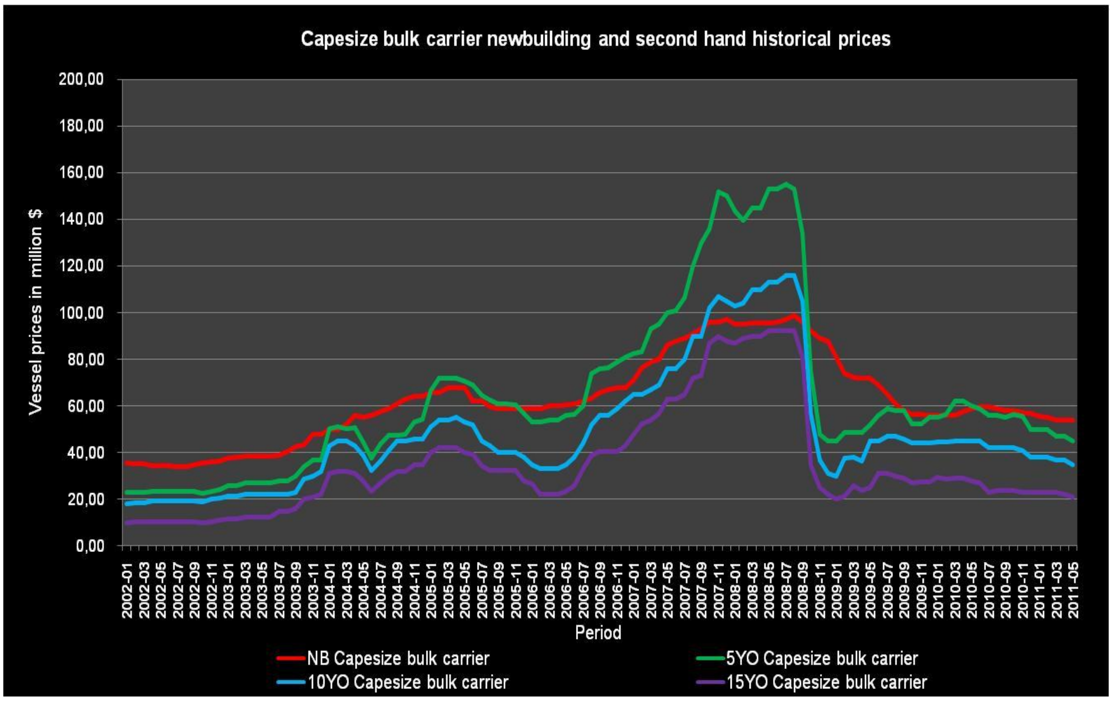


Figure 4.10: Capesize bulk carrier newbuilding and second hand historical prices

Vessel type/size class	Capesize bulk carriers			
Vessel age	NB	5YO	10YO	15YO
Average vessel price (mln $)	62,34	63,45	48,14	34,82
Mean percentage change	5,02%	12,23%	12,82%	15,77%
Standard deviation (volatility)	10,22%	30,38%	32,24%	37,12%
Sample variance	1,04%	9,23%	10,39%	13,78%
Kurtosis	2,4340	10,3547	8,4350	8,9750
Skewness	-0,2467	-1,0486	-0,8804	-0,8556

Table 4.7: Descriptive statistics for Capesize bulk carrier historical prices

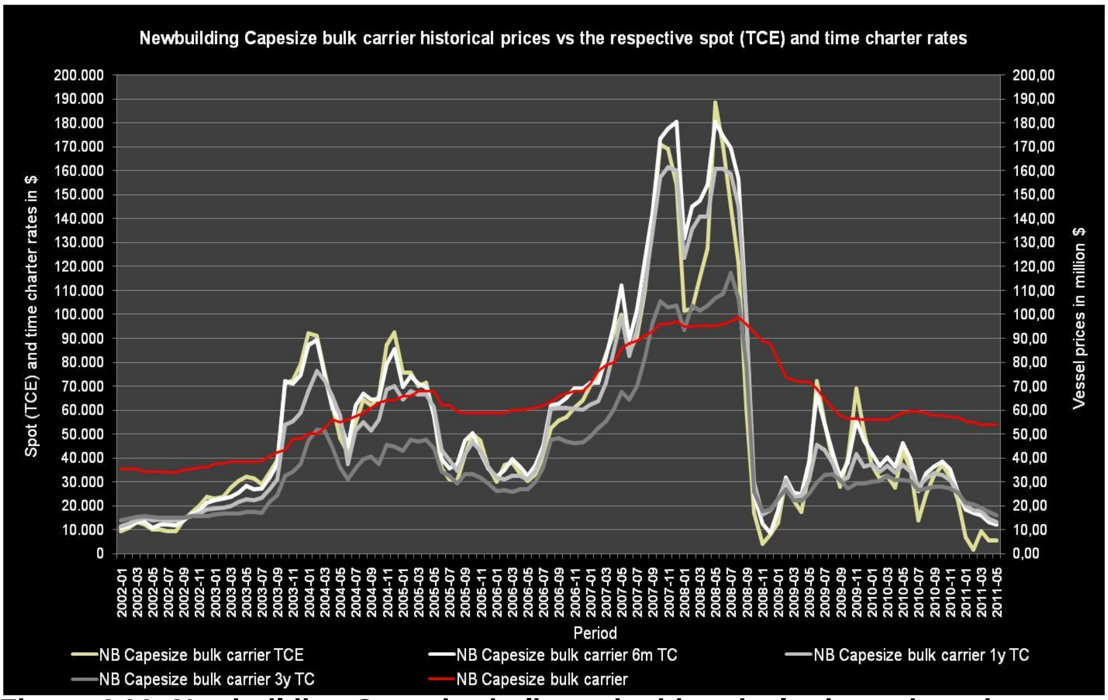


Figure 4.11: Newbuilding Capesize bulk carrier historical prices, time charter equivalent rates and time charter rates

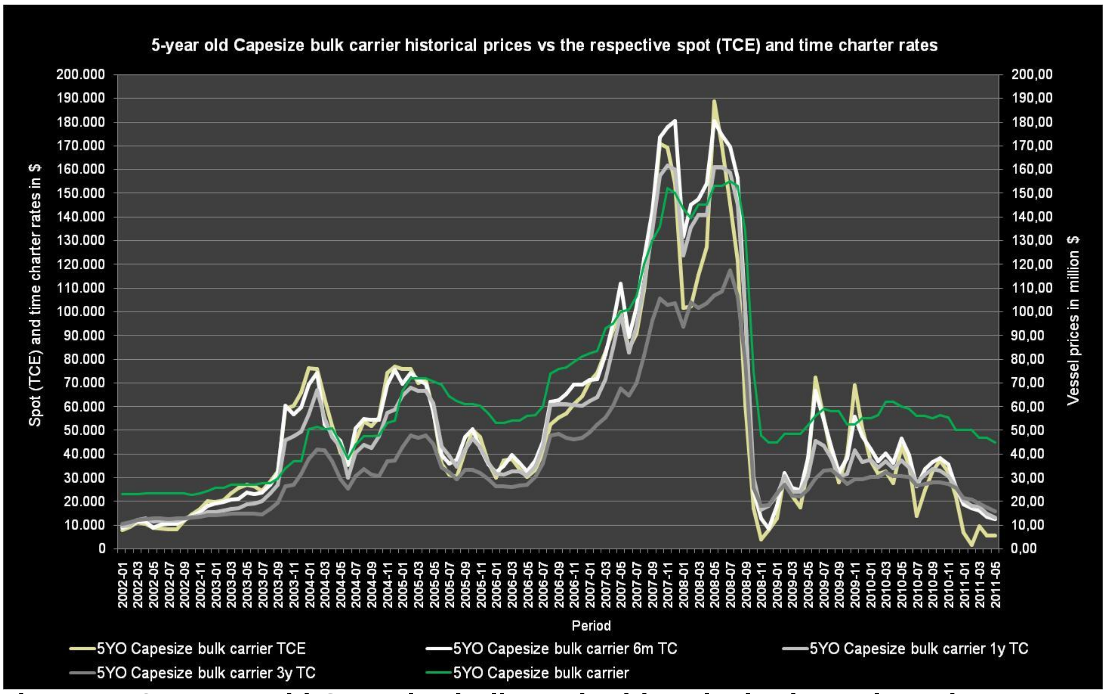


Figure 4.12: 5-year old Capesize bulk carrier historical prices, time charter equivalent rates and time charter rates

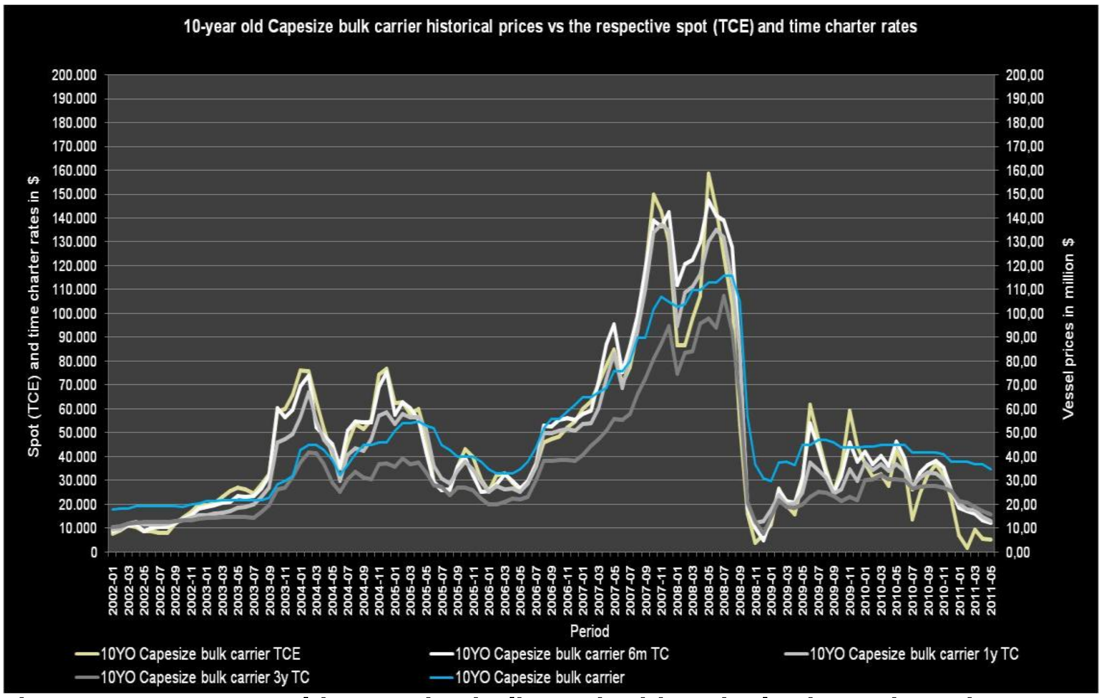


Figure 4.13: 10-year old Capesize bulk carrier historical prices, time charter equivalent rates and time charter rates

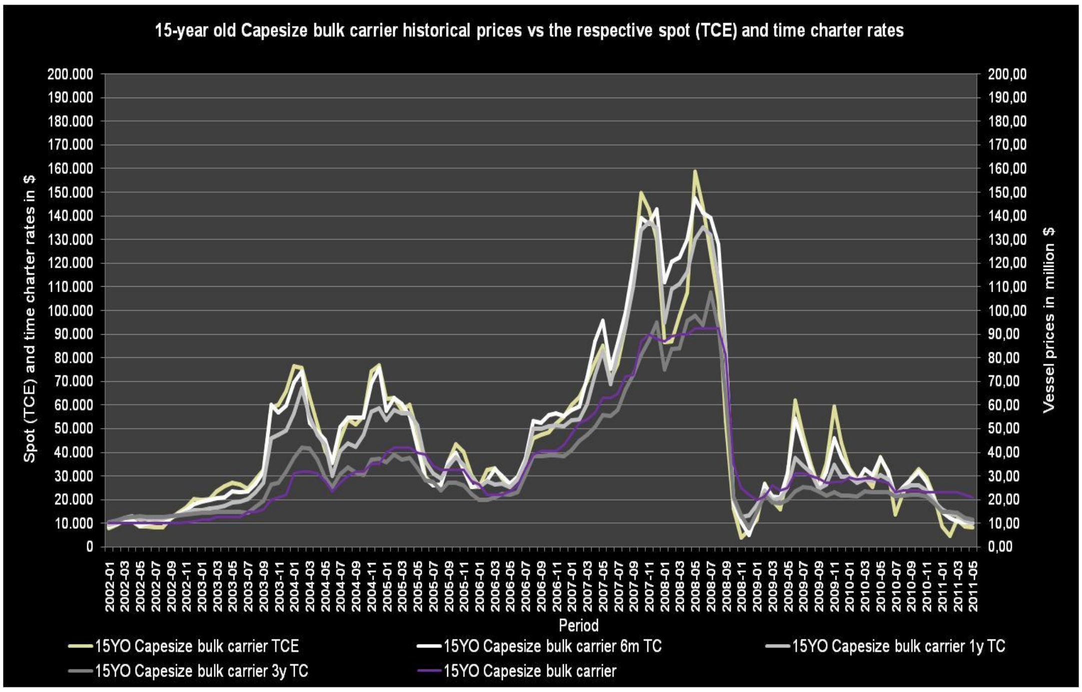


Figure 4.14: 15-year old Capesize bulk carrier historical prices, time charter equivalent rates and time charter rates

Vessel type/size class	Capesize Bulk carriers							
Vessel age	Newly built				5-year old			
Freight contract	Spot	6m TC	1Y TC	3YTC	Spot	6m TC	1Y TC	3YTC
Average earnings' level ($)	53.292,48	57.556,38	52.495,68	39.986,42	51.160,00	55.325,50	50.483,00	38.468,85
Mean percentage change	99,60%	37,30%	22,52%	13,16%	101,10%	39,78%	24,50%	16,30%
Standard deviation (volatility)	191,97%	86,41%	61,97%	43,66%	191,66%	86,31%	61,66%	43,79%
Sample variance	368,5078%	74,6645%	38,4027%	19,0632%	367,3198%	74,4902%	38,0209%	19,1775%
Kurtosis	39,2906	4,6586	4,0568	7,5834	39,5138	4,3885	3,6325	7,5153
Skewness	5,0669	1,1561	0,0537	-1,2098	5,0841	1,0721	-0,0429	-1,2781

Table 4.8: Descriptive statistics for newly built and 5-year old Capesize bulk carrier historical earnings from different freight contracts

Vessel type/size class	Capesize Bulk carriers							
Vessel age	10-year old				15-year old			
Freight contract	Spot	6m TC	1Y TC	3YTC	Spot	6m TC	1Y TC	3YTC
Average earnings' level ($)	45.846,35	48.002,83	44.055,54	33.639,74	45.642,85	47.031,04	43.153,03	32.648,81
Mean percentage change	96,99%	48,84%	26,43%	21,78%	66,75%	46,78%	23,32%	17,74%
Standard deviation (volatility)	188,90%	103,32%	63,09%	57,26%	120,70%	103,38%	62,55%	56,17%
Sample variance	356,8373%	106,7485%	39,8074%	32,7900%	145,6885%	106,8709%	39,1250%	31,5507%
Kurtosis	42,0023	14,2194	3,8714	8,6945	3,3523	14,2324	4,0823	9,4635
Skewness	5,2680	2,4543	-0,1198	0,6678	1,2125	2,4624	-0,1019	0,6521

Table 4.9: Descriptive statistics for 10 and 15-year old Capesize bulk carrier historical earnings from different freight contracts

"MR" product tankers

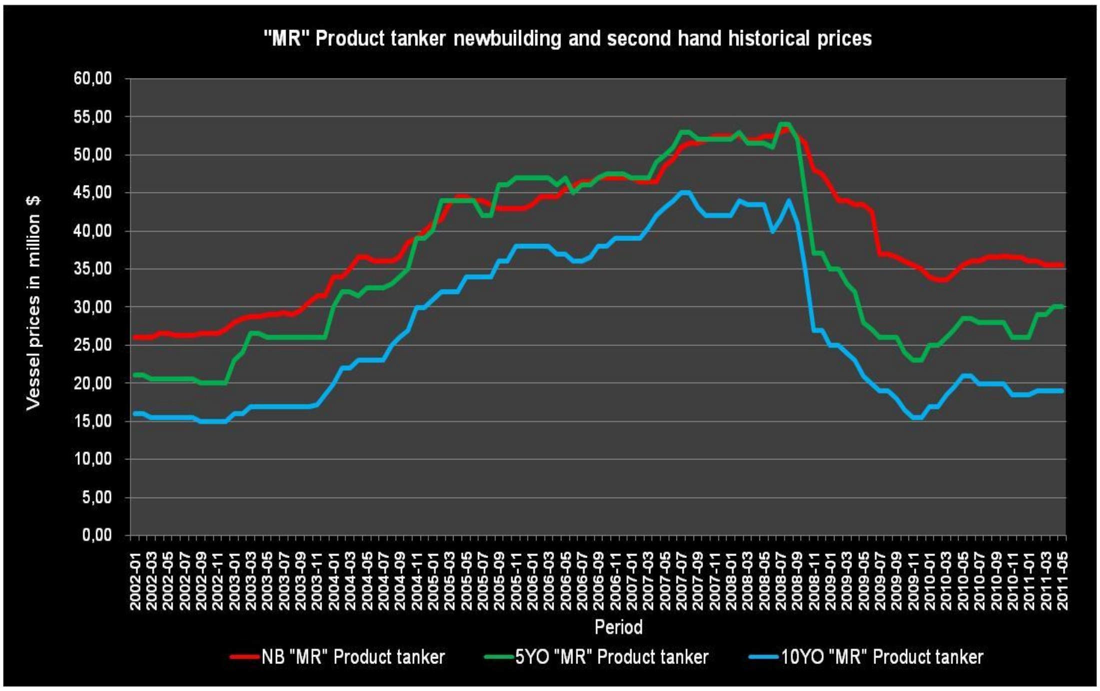


Figure 4.15: "MR" Product tanker newbuilding and second hand historical prices

Vessel type/size class	"MR" Product tankers		
Vessel age	NB	5YO	10YO
Average vessel price (mln $)	39,61	35,81	27,34
Mean percentage change	3,65%	5,08%	3,19%
Standard deviation (volatility)	7,86%	15,85%	16,16%
Sample variance	0,6184%	2,5125%	2,6122%
Kurtosis	11,2055	4,4511	5,5042
Skewness	-1,4981	0,0274	-1,1493

Table 4.10: Descriptive statistics for "MR" Product tanker historical prices

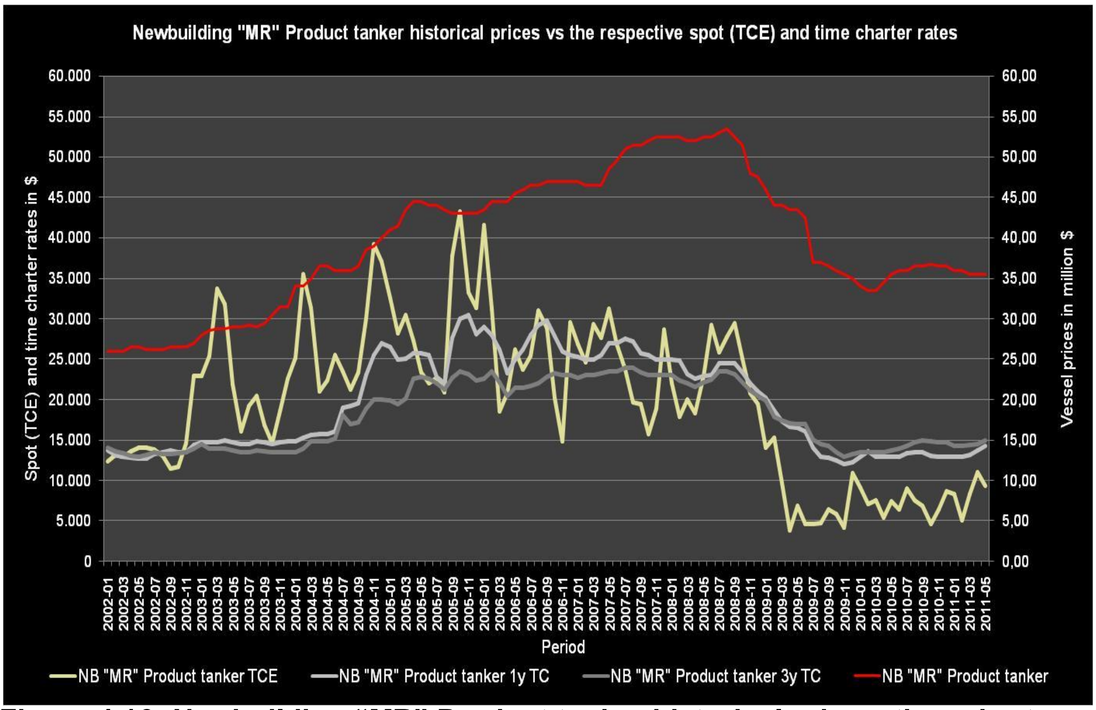


Figure 4.16: Newbuilding "MR" Product tanker historical prices, time charter equivalent rates and time charter rates

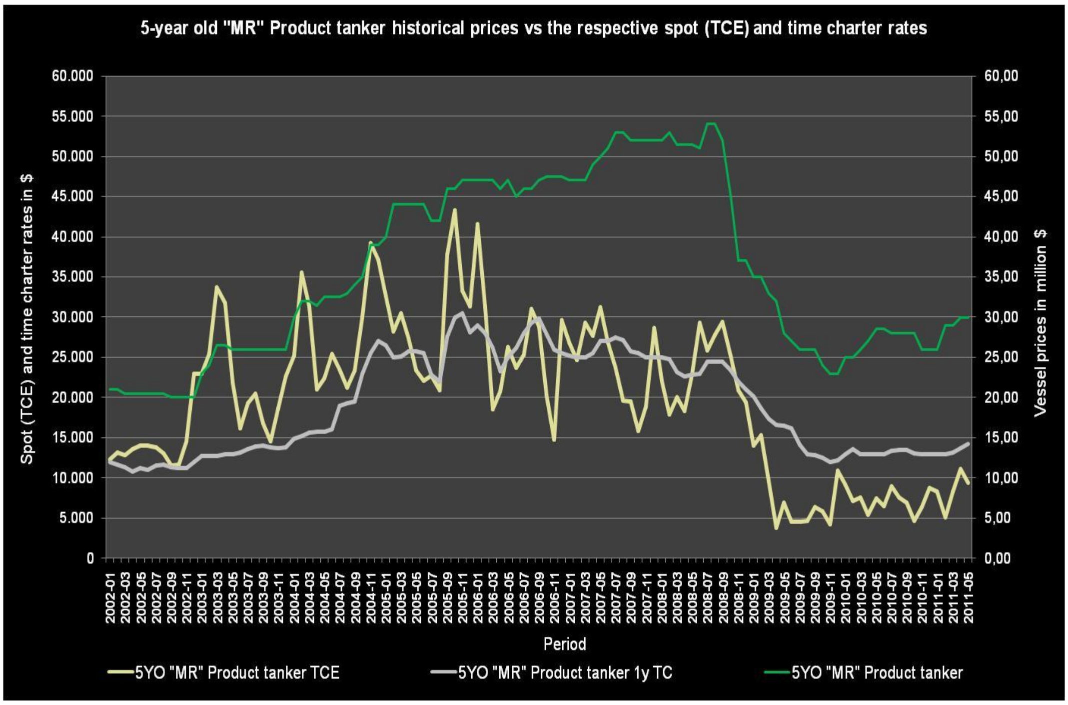


Figure 4.17: 5-year old "MR" Product tanker historical prices, time charter equivalent rates and time charter rates

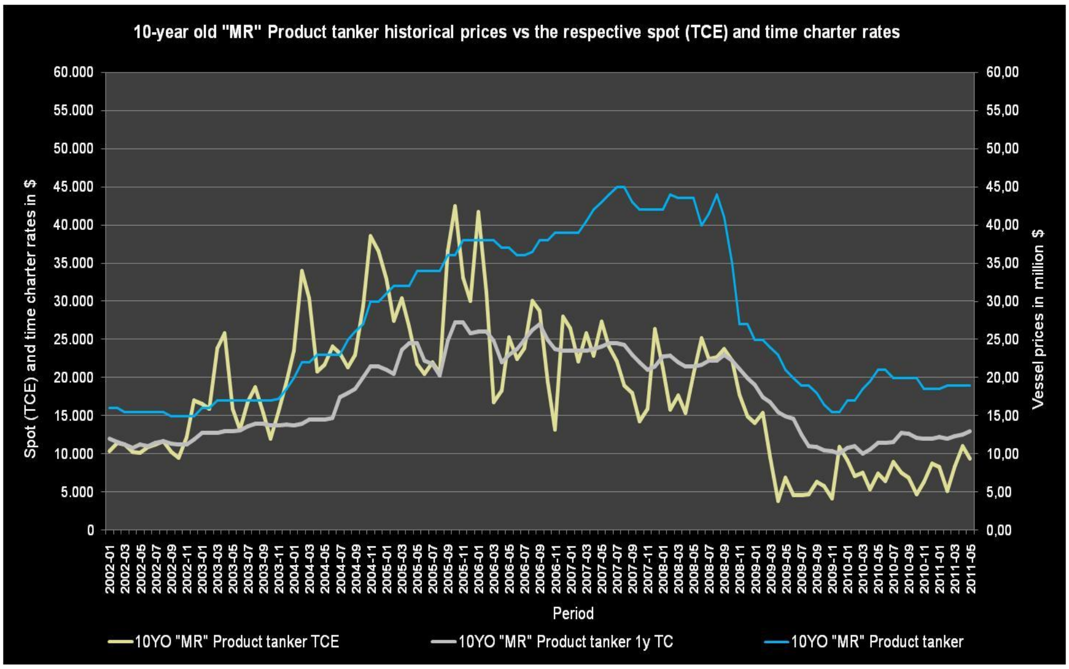


Figure 4.18: 10 year old "MR" Product tanker historical prices, time charter equivalent rates and time charter rates

Vessel type/size class	"MR" Product tankers						
Vessel age	Newly built			5-year old		10 year old	
Freight contract	Spot	1Y TC	3Y TC	Spot	1Y TC	Spot	1Y TC
Average earnings' level ($)	19.683,33	19.482,13	18.003,85	19.683,33	19.134,31	18.050,94	17.580,80
Mean percentage change	42,23%	1,97%	1,46%	42,23%	3,50%	47,23%	2,51%
Standard deviation (volatility)	105,14%	18,29%	12,97%	105,14%	18,63%	108,71%	18,62%
Sample variance	110,5451%	3,3450%	1,6822%	110,5451%	3,4690%	118,1726%	3,4652%
Kurtosis	6,3656	5,7489	6,9661	6,3656	5,0516	5,6795	3,3101
Skewness	1,7971	1,3788	1,2028	1,7971	1,2673	1,7156	0,7978

Table 4.11: Descriptive statistics for newly built and second hand "MR" Product tanker historical earnings from different freight contracts

Panamax "Coated" tankers

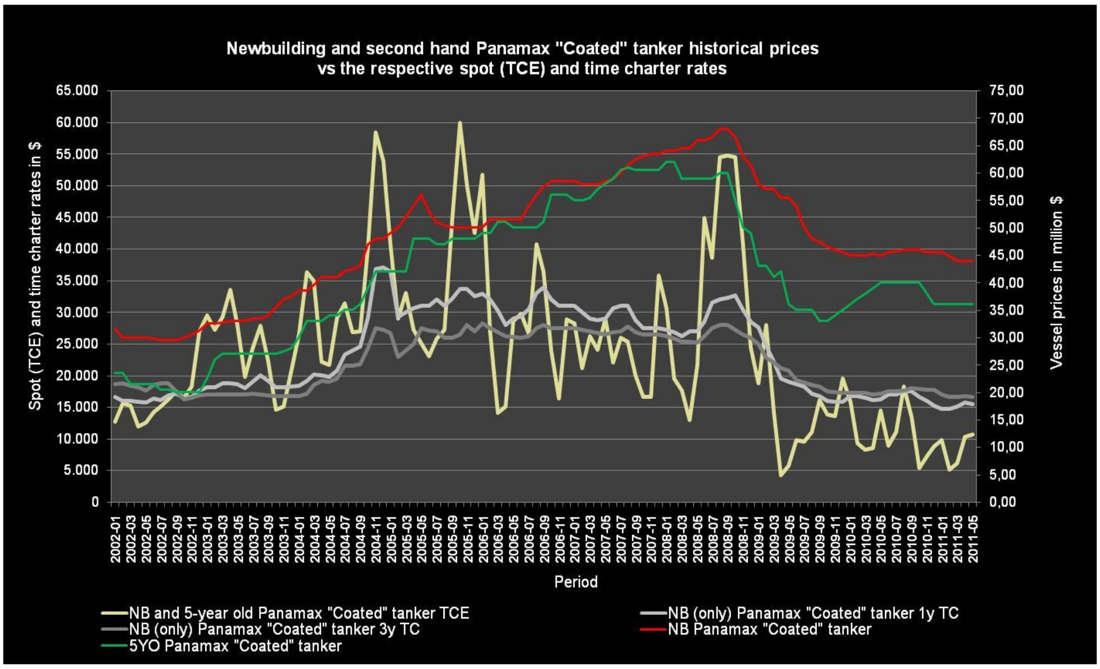


Figure 4.19: Newbuilding and 5-year old Panamax "coated" tanker historical prices, time charter equivalent rates and time charter rates

Vessel type/size class	Panamax "Coated" tankers	
Vessel age	NB	5YO
Average vessel price (mln $)	48,14	41,24
Mean percentage change	3,89%	5,58%
Standard deviation (volatility)	7,86%	14,26%
Sample variance	0,6181%	2,0346%
Kurtosis	3,0854	4,6795
Skewness	-0,1007	0,2991

Table 4.12: Descriptive statistics for Panamax "coated" tanker historical prices.

Vessel type/size class	Panamax "Coated" tankers		
Vessel age	Newly built and 5-year old		
Freight contract	Spot (for both)	1Y TC (only for NB)	3Y TC (only for NB)
Average earnings' level ($)	23.979,08	23.719,49	21.987,43
Mean percentage change	65,01%	1,00%	-0,45%
Standard deviation (volatility)	119,79%	18,73%	12,44%
Sample variance	143,5065%	3,5070%	1,5471%
Kurtosis	0,6287	6,7511	4,3576
Skewness	0,6863	0,8760	0,4624

Table 4.13: Descriptive statistics for newly built and 5-year old Panamax "coated" tanker historical earnings from different freight contracts

Aframax tankers

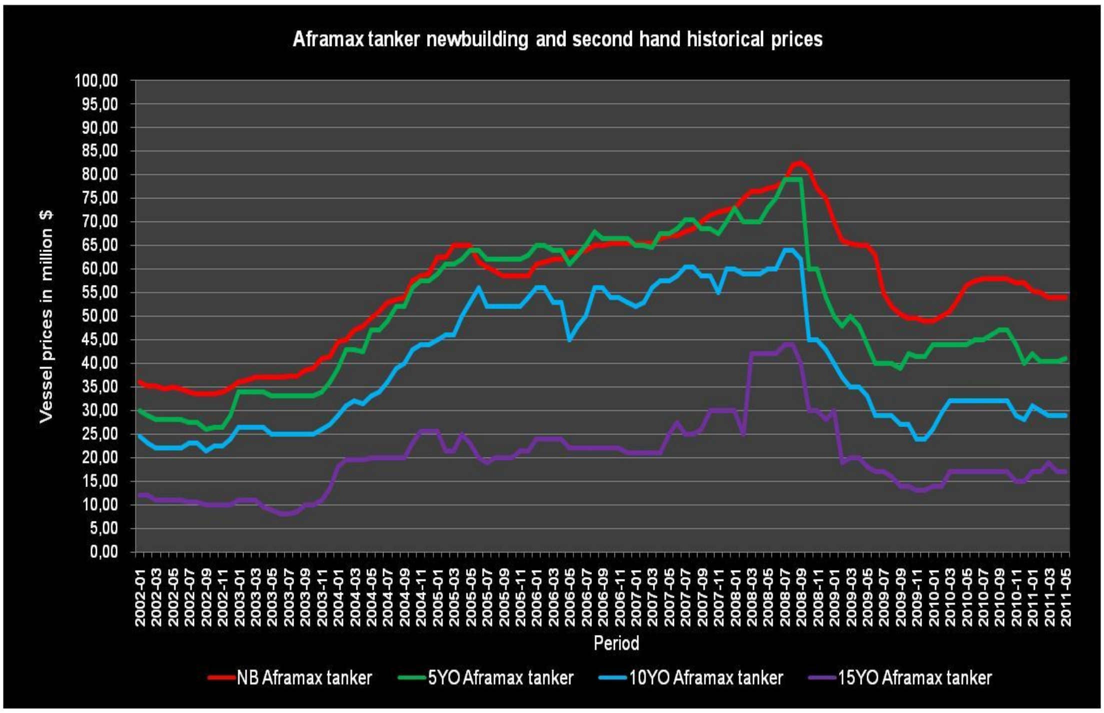


Figure 4.20: Aframax tanker newbuilding and second hand historical prices

Vessel type/size class	Aframax tankers			
Vessel age	NB	5YO	10YO	15YO
Average vessel price (mln $)	56,42	51,03	39,95	20,03
Mean percentage change	4,79%	4,67%	3,75%	10,33%
Standard deviation (volatility)	9,30%	16,05%	19,29%	38,06%
Sample variance	0,8652%	2,5767%	3,7217%	14,4843%
Kurtosis	5,1028	7,7245	5,1650	13,3057
Skewness	-1,0113	-0,8877	-1,1261	1,9676

Table 4.14: Descriptive statistics for Aframax tanker historical prices

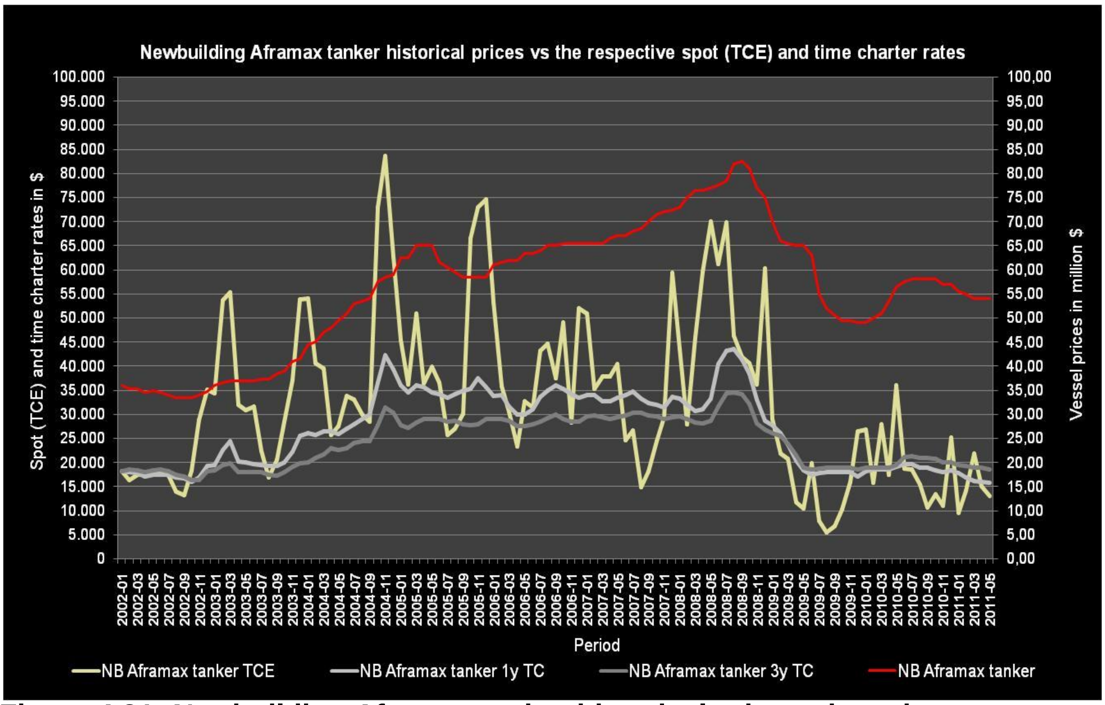


Figure 4.21: Newbuilding Aframax tanker historical prices, time charter equivalent rates and time charter rates

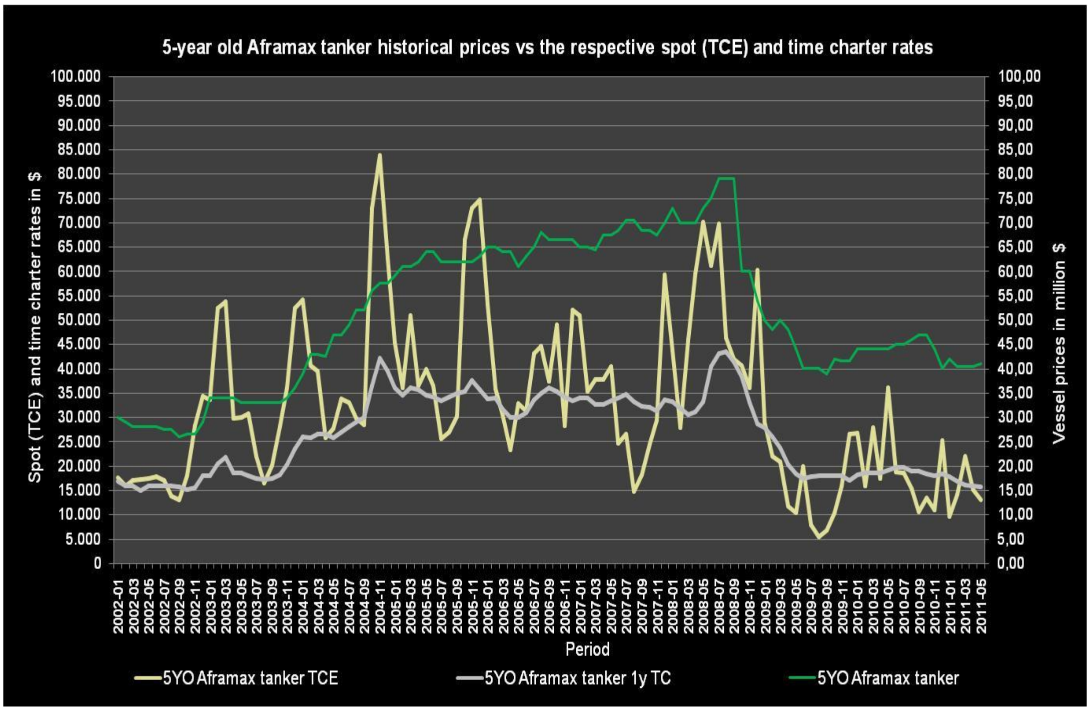


Figure 4.22: 5-year old Aframax tanker historical prices, time charter equivalent rates and time charter rates

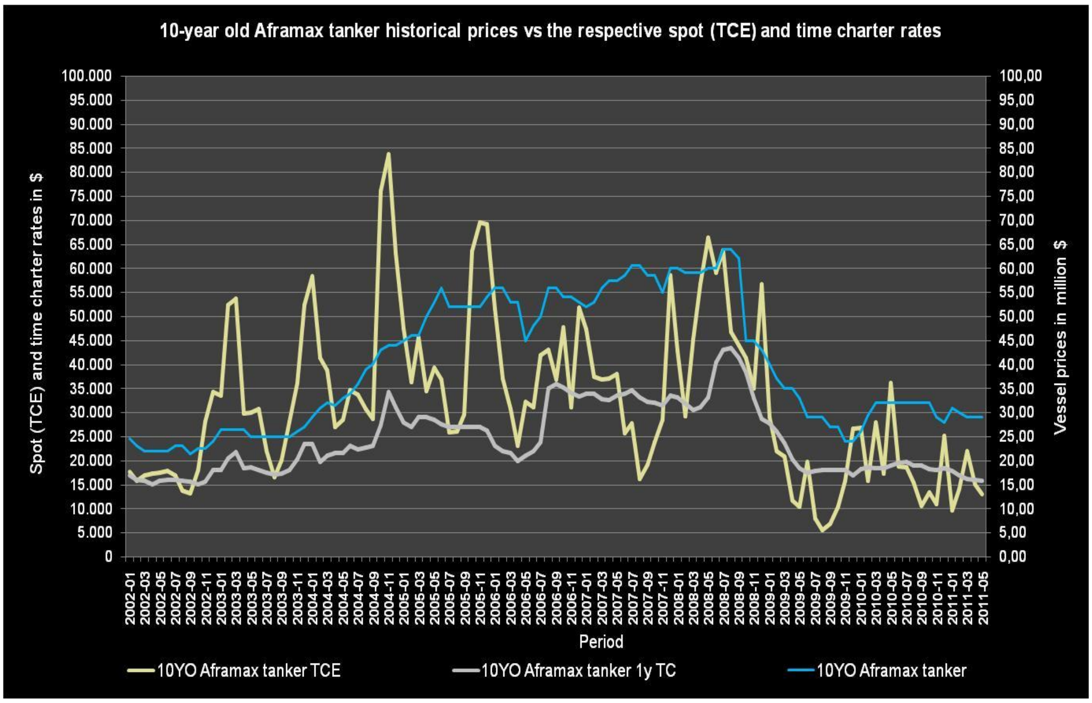


Figure 4.23: 10-year old Aframax tanker historical prices, time charter equivalent rates and time charter rates

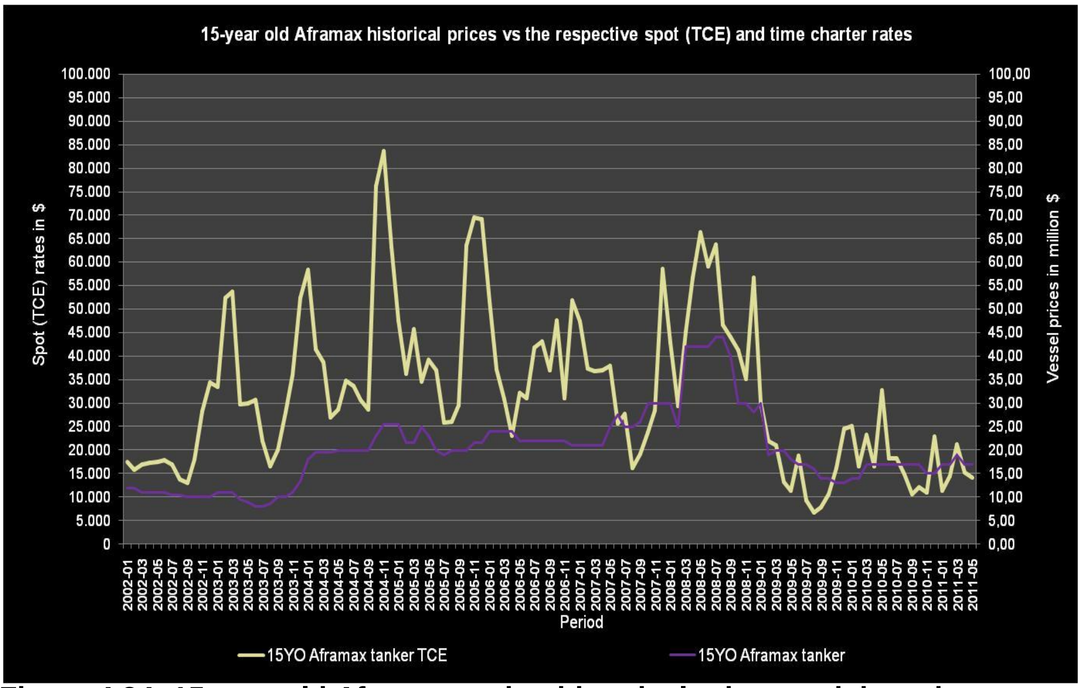


Figure 4.24: 15-year old Aframax tanker historical prices and time charter equivalent rates

Vessel type/size class	Aframax tankers							
Vessel age	Newly built			5-year old		10-year old		15-year old
Freight contract	Spot	1Y TC	3Y TC	Spot	1Y TC	Spot	1Y TC	Spot
Average earnings' level ($)	32.618,49	26.714,27	24.045,25	32.470,90	26.357,19	32.217,08	24.290,15	32.159,26
Mean percentage change	80,20%	0,82%	1,22%	80,60%	1,62%	75,66%	2,84%	64,57%
Standard deviation (volatility)	142,09%	21,68%	14,27%	142,03%	21,90%	139,10%	27,94%	128,74%
Sample variance	201,8910%	4,7007%	2,0375%	201,7390%	4,7952%	193,5012%	7,8053%	165,7339%
Kurtosis	1,6518	2,5864	2,7713	1,6558	2,2784	2,3740	10,0424	3,1623
Skewness	1,1637	0,7361	0,2801	1,1585	0,8199	1,3148	2,1296	1,4400

Table 4.15: Descriptive statistics for newly built and second hand Aframax tanker historical earnings from different freight contracts

Suezmax tankers

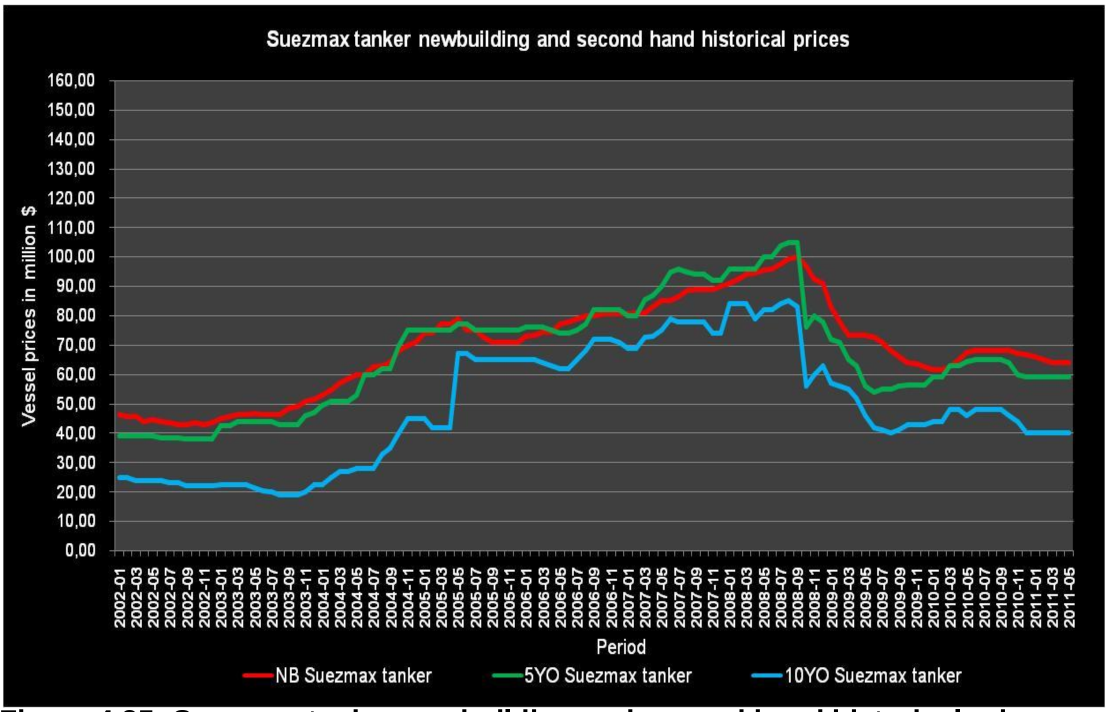


Figure 4.25: Suezmax tanker newbuilding and second hand historical prices

Vessel type/size class	Suezmax tankers		
Vessel age	NB	5YO	10YO
Average vessel price (mln $)	68,95	66,54	49,08
Mean percentage change	3,75%	5,64%	8,39%
Standard deviation (volatility)	8,09%	14,98%	27,43%
Sample variance	0,6540%	2,2428%	7,5233%
Kurtosis	2,0841	16,8583	29,5062
Skewness	-0,7457	-2,0486	3,2502

Table 4.16: Descriptive statistics for Suezmax tanker historical prices

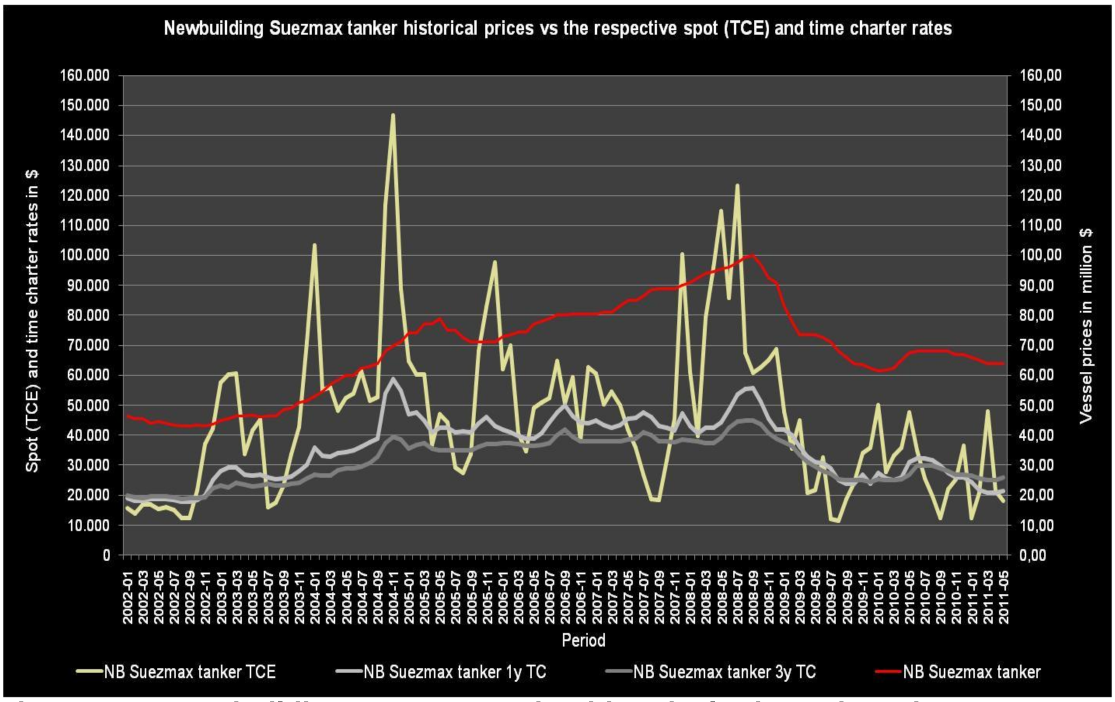


Figure 4.26: Newbuilding Suezmax tanker historical prices, time charter equivalent rates and time charter rates

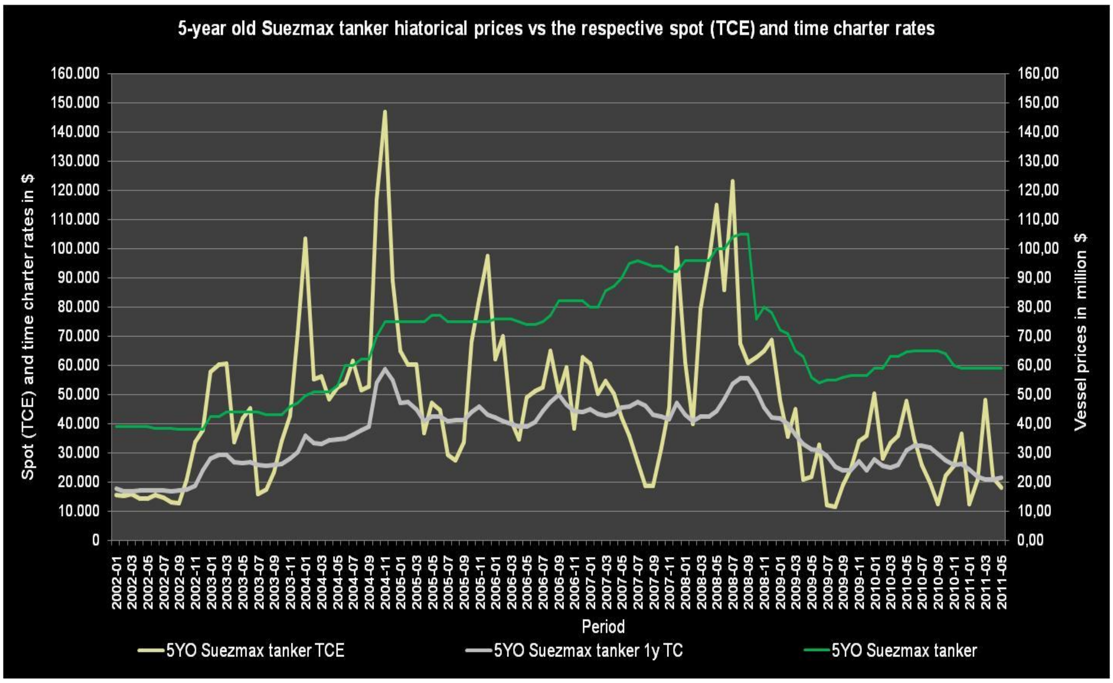


Figure 4.27: 5-year old Suezmax tanker historical prices, time charter equivalent rates and time charter rates

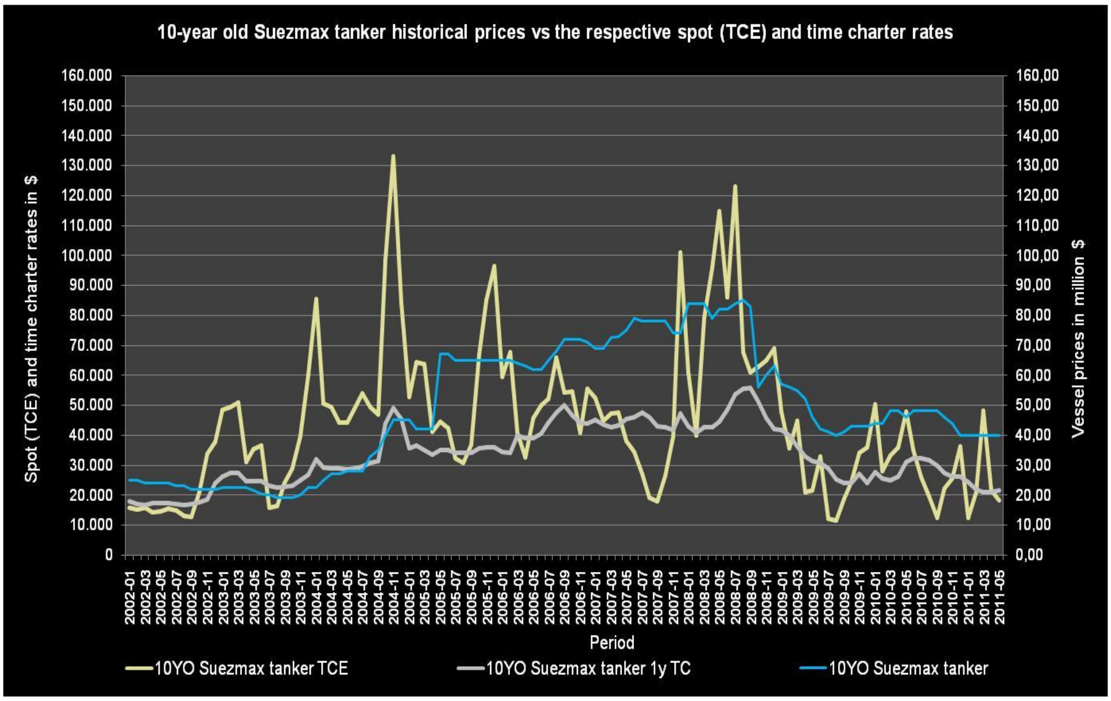


Figure 4.28: 10-year old Suezmax tanker historical prices, time charter equivalent rates and time charter rates

Vessel type/size class	Suezmax tankers						
Vessel age	Newly built			5-year old		10-year old	
Freight contract	Spot	1Y TC	3Y TC	Spot	1Y TC	Spot	1Y TC
Average earnings' level ($)	46.095,04	35.399,45	31.345,25	45.983,04	35.258,74	44.044,42	33.252,77
Mean percentage change	88,92%	4,60%	3,75%	88,20%	5,40%	81,90%	5,59%
Standard deviation (volatility)	138,76%	26,60%	13,88%	137,93%	27,23%	134,39%	27,87%
Sample variance	192,5423%	7,0782%	1,9259%	190,2459%	7,4126%	180,6122%	7,7665%
Kurtosis	0,7888	5,6994	1,6118	0,8275	5,5750	1,9362	5,5751
Skewness	0,7755	1,6153	0,7653	0,7722	1,6584	0,9855	1,4784

Table 4.17: Descriptive statistics for newly built and second hand Suezmax tanker historical earnings from different freight contracts

VLCCs

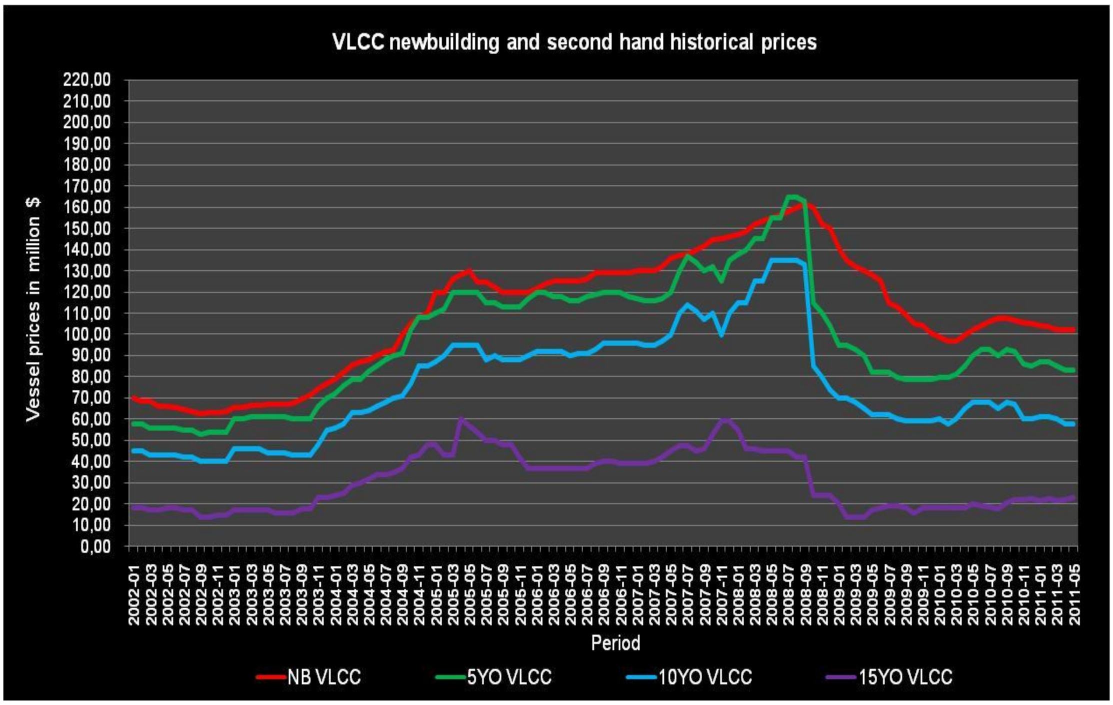


Figure 4.29: VLCC newbuilding and second hand historical prices

Vessel type/size class	VLCCs			
Vessel age	NB	5YO	10YO	15YO
Average vessel price (mln $)	109,86	97,12	75,60	30,59
Mean percentage change	4,39%	5,15%	4,72%	8,31%
Standard deviation (volatility)	8,37%	15,58%	19,01%	32,75%
Sample variance	0,7006%	2,4260%	3,6157%	10,7285%
Kurtosis	2,7483	17,2954	17,4553	7,0937
Skewness	0,0687	-2,3233	-2,2062	-0,2033

Table 4.18: Descriptive statistics for VLCC historical prices

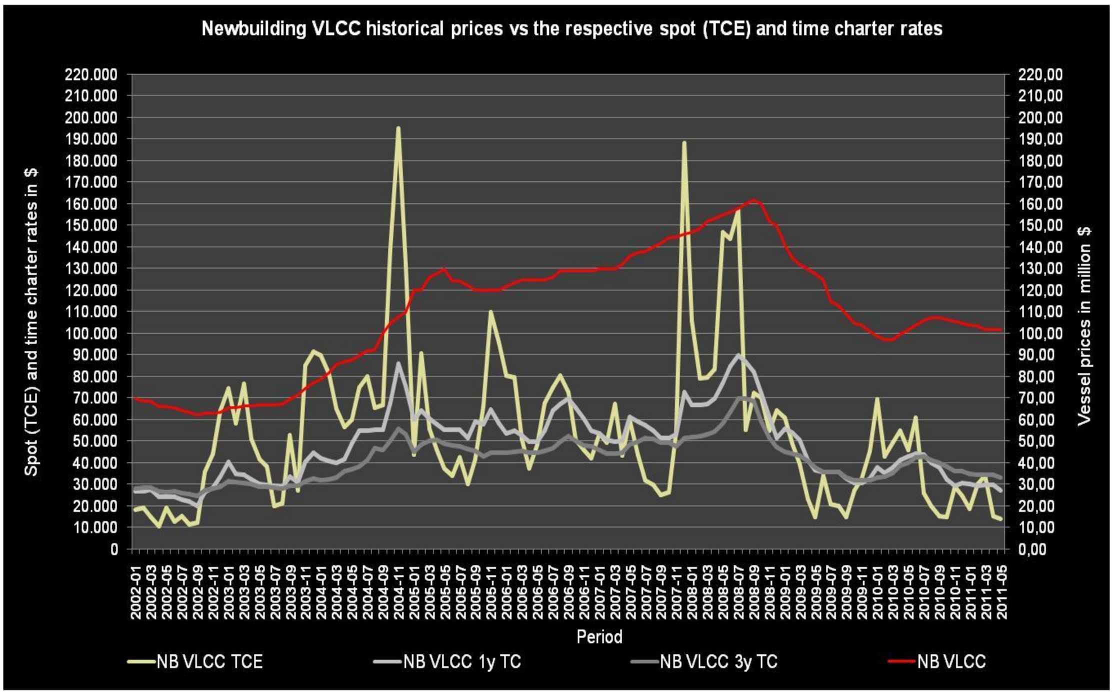


Figure 4.30: Newbuilding VLCC historical prices, time charter equivalent rates and time charter rates

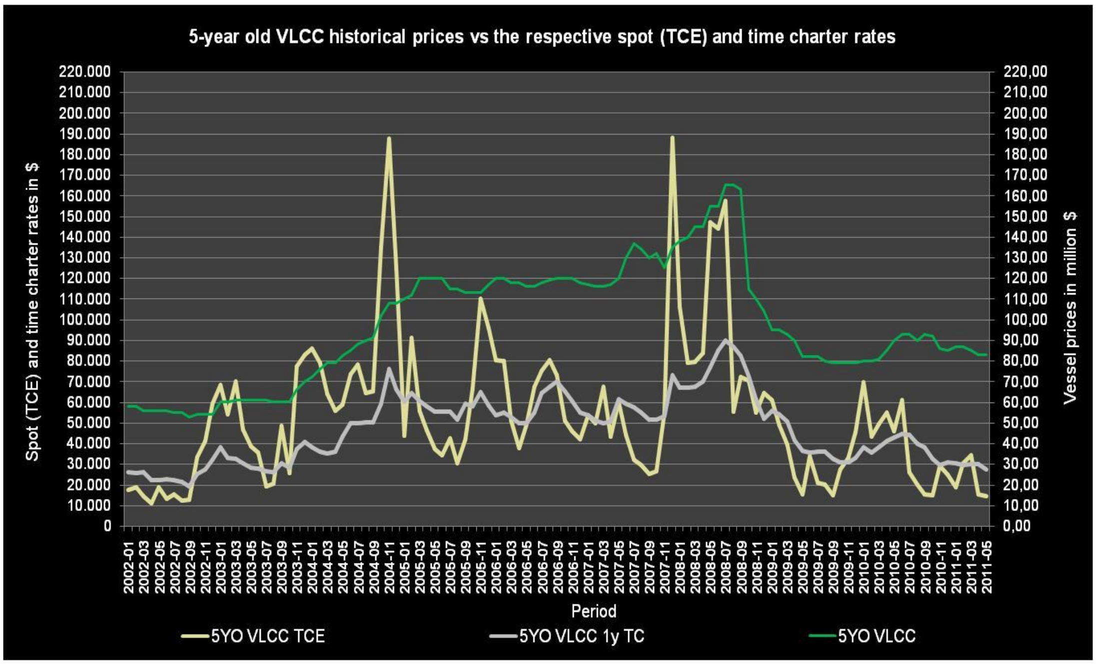


Figure 4.31: 5-year old VLCC historical prices, time charter equivalent rates and time charter rates

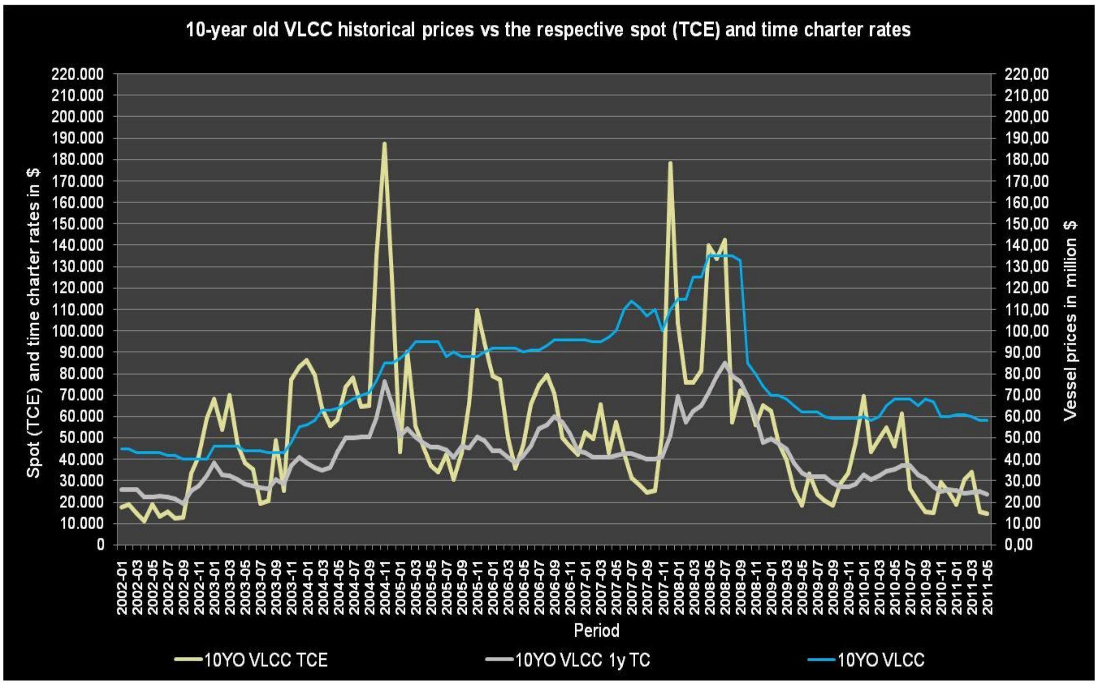


Figure 4.32: 10-year old VLCC historical prices, time charter equivalent rates and time charter rates

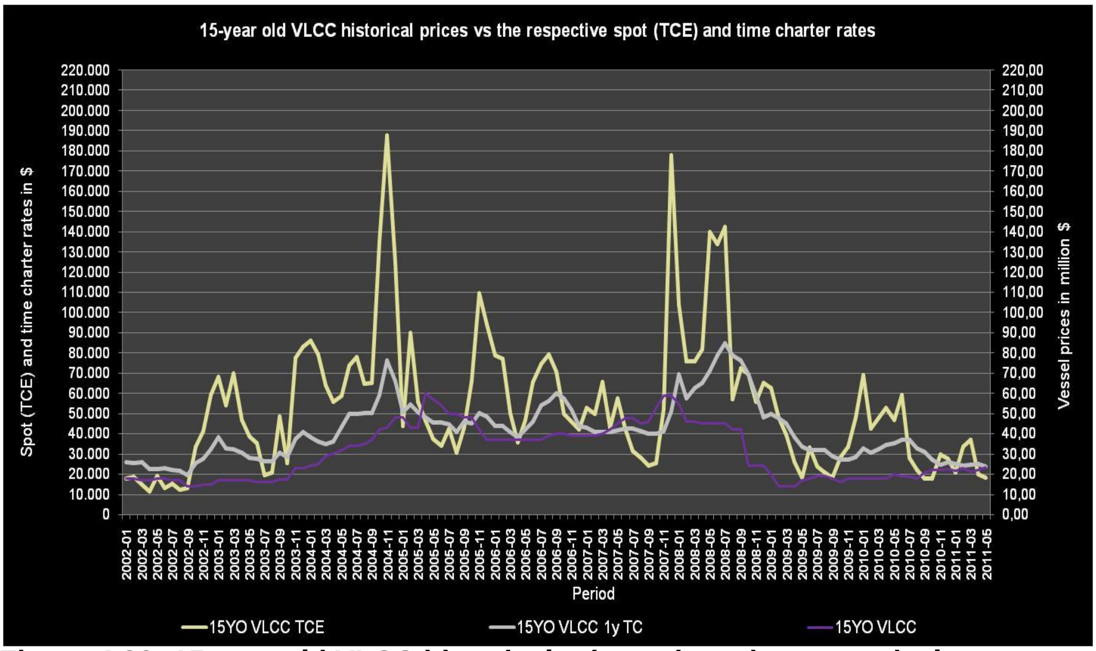


Figure 4.33: 15-year old VLCC historical prices, time charter equivalent rates and time charter rates

Vessel type/size class	VLCCs								
Vessel age	Newly built			5-year old		10-year old		15-year old	
Freight contract	Spot	1Y TC	3Y TC	Spot	1Y TC	Spot	1Y TC	Spot	1Y TC
Average earnings' level ($)	54.878,48	47.916,33	41.523,33	54.010,63	46.825,12	53.386,47	41.298,04	53.583,19	41.298,04
Mean percentage change	112,85%	6,01%	3,33%	108,11%	6,43%	101,03%	5,41%	100,13%	5,41%
Standard deviation (volatility)	183,09%	35,73%	17,37%	177,26%	35,79%	171,71%	37,03%	169,62%	37,03%
Sample variance	335,2372%	12,7667%	3,0188%	314,2280%	12,8072%	294,8302%	13,7130%	287,7134%	13,7130%
Kurtosis	5,2384	1,5889	0,7316	5,1676	1,7234	5,7926	1,3361	6,1582	1,3361
Skewness	1,9954	1,0539	-0,0030	1,9472	1,1682	2,0357	0,9142	2,0954	0,9142

Table 4.19: Descriptive statistics for newly built and second hand VLCC historical earnings from different freight contracts

In all the above figures, the consequences of the actual facts described in the beginning of this section are clearly visible. An upward trend between 2003 and 2008, with some ups and downs in between, was followed by a steep downward movement in late 2008. Shortly afterwards, the market started rising again. Furthermore, the figures show that there is a long term positive correlation between vessel prices and freight rates. This can be attributed to the fact that a vessel's price reflects the present value of its future profits through freight operations plus the present value of its expected resale price (Alizadeh and Nomikos, 1997b). In addition, along with the increase in the vessels' prices and daily earnings, especially after 2003, a substantial increase in the volatility of both is noticeable. While bulk carrier vessel prices and time charter rates appear to be more volatile than the ones of tankers, the opposite is true for the spot rates (time charter equivalent rates). In particular, spot rate volatility is extremely higher in the tanker market. Moreover, in both dry and wet bulk sectors, spot rates are obviously more volatile than time charter rates and time charter rates' volatility is lower for higher time charter durations. Last but not least, a deterministic seasonality pattern in bulker and tanker freight rates can be observed which is stronger for larger vessels and weaker for higher contract durations (Kavussanos and Alizadeh, 2001).

Although figures provide significant information which is directly accessible, the analysis of the percentage changes in vessels' prices and daily earning is definitely more important than their exact levels. This analysis is given below based on tables 4.1 – 4.19:

4.2.3 Volatility in vessel prices

With respect to the dry bulk sector, the average prices of all 5-year old vessels were found to be higher than the ones of newbuildings, whereas the prices of 10 and 15-year old vessels moderately lower. However, the boom in the market during the period of time between 2003 and 2008 was of such magnitude that even 10 and 15-year old bulk carriers occasionally recorded higher prices than the respective newbuildings. This can be attributed to the fact that during booming periods, second hand vessels are more attractive than new ones simply because there are readily available in the market and shipowners can immediately reap the benefits from the prevailing high rates.

Furthermore, second hand vessel prices were found to be more volatile than newbuilding prices and this volatility increases along with the increase in the age of the vessels. This can be explained by the fact that due to their immediate delivery, second hand vessels are more sensitive to the market conditions. In addition, technical obsolescence is the underlying reason why volatility in vessels' prices increases with their age.

Moreover, the prices of the larger vessels (both newly built and second hand) are not only higher but also more volatile than those of the smaller ones due to their limited versatility in terms of the commodities they carry and the routes they serve (Kavussanos, 1997). This was also the case for all bulk carriers of all ages during the period under assessment except for Capesizes, the prices of which were found to be less volatile than the ones of Panamaxes, as tables 4.1, 4.3, 4.5 and 4.7 confirm. This lower volatility in the prices of Capesize bulk carriers can possibly be attributed to the fact that the increased Chinese requirements in iron ore and steam coal provided stability in their services.

In the tanker market, the average second hand prices for each size class category were lower than the newbuilding ones. However, the prices of five year old tankers were occasionally higher than them. This proves that shipping cycles do not move at same pace for all markets. In addition, the more strict regulations applied regarding the choice of the tanker tonnage after the accidents of "Erika" and "Prestige" was an additional factor that kept second hand prices, especially the ones of 10 and 15 year old tankers, at lower levels. Furthermore, the older vessels, being technically obsolete, were found to have increased price volatility compared to the newly built or younger ones.

As regards the level and the volatility of newbuilding and second hand prices across different vessel sizes, larger vessels are typically more expensive and more volatile. While this pattern is confirmed in our case in terms of price levels, several were the exceptions regarding the price volatility. For instance the volatility in Aframax tanker prices was found to be even higher than the volatility in VLCC prices, possible due to idiosyncratic factors involved in each sub-market.

Last but not least, in comparing the dry bulk with the wet bulk sector, it is clearly obvious is that tanker prices are quite higher than bulker prices. However, the latter were found to be more volatile than the former. This can be attributed to the respective market conditions during the period of assessment.

4.2.4 Volatility in vessels' daily earnings

In the dry bulk sector and more specifically for all bulk carrier types, sizes and ages, the volatility in daily earnings was found to decrease with the increase in contract durations. This is known in the literature as "volatility term structure" (Alizadeh and Nomikos, 2009). In other words, while spot rates are sensitive to the prevailing market conditions and fluctuate significantly, time charter rates reflect the future expectations and therefore fluctuate, first of all, less than spot rates and secondly less for longer time charter periods. All these facts are evident in the reported (annualized) standard deviations of the respective freight rate changes in tables 4.2, 4.4, 4.6 and 4.8-4.9.

The average spot rates were lower than the average 6-month time charter rates and higher than the average 1 and 3-year time charter rates. Additionally, the average time charter rates were found to decrease with the increase in the time charter duration. Based on Kavussanos and Alizadeh (2002b) this happens because of the higher risk associated with short-termed contracts. Therefore, shipowners are willing to accept lower rates for long-termed contracts and this attitude is time-varying depending on the market conditions.

A comparison across different vessel ages showed that as the vessels' age increases the respective daily earnings from all contract durations decrease. This indicates that vessels' earnings are also affected by the condition of the vessels among others as well as that they are generally higher for modern vessels.

Although the volatility term structure mentioned above is confirmed for all vessel ages we couldn't observe any specific pattern on how volatility in the vessels' daily earnings changes across different vessel ages. Should the vessel size specifications within a size class category were not subject to changes from time to time, the volatility of their respective daily earnings would have been higher for older vessels given the fact that the dry bulk market was booming and taking into account the consequences of ageing. However, the individual sub-markets' conditions, should not be neglected. During the period of assessment, only the Panamax bulk carriers appeared to follow this pattern.

Contrary to our findings regarding the price volatilities of different bulk carrier sizes, volatility in daily earnings was found to be higher for larger vessels for all contract durations (Kavussanos, 1997). Especially, the volatility in the spot rates of both newly built and (all) second hand Capesizes far exceeds the Panamax spot rate volatility, possibly due to the interchangeable boosts and slowdowns in the Chinese economic activity throughout the period of assessment given also the limited routes Capesizes engage in compared to Panamaxes.

As far as tanker earnings are concerned, both the average spot and time charter rates were found to decrease with the increase in the vessels' age for all tanker sub-markets. Moreover, the average daily earnings were found to be negatively related to the duration of the freight contracts, in line again with Kavussanos and Alizadeh propositions (2002b).

As in the dry bulk sector, volatility term structure is also observed in the tanker market. In fact tanker spot rate volatility is extremely higher than time charter rate volatility. This can be attributed to higher seasonality in the spot tanker market compared to the tanker time charter market and to the trading activities of active companies in the market (Alizadeh and Nomikos, 2011). In addition, the tanker market depends on oil production and oil prices which in general are affected by other exogenous factors, such us political factors let alone the fact that oil reserves tend to be exhausted. Furthermore, volatility in daily earnings is higher for larger tankers. Only the Aframax and Suezmax tankers appeared not to follow this pattern and interchange with each other in terms of volatility in daily earnings which is acceptable according to Kavussanos (2003).

What is also worth mentioning is that, spot rate volatilities were found to decrease with the increase in the vessels' age whereas time charter rate volatilities were found to increase with the increase in the vessels' age, facts which are attributable to the general tanker market conditions as well as possibly to the gradual phase out of the older tanker tonnage.

Finally, volatility term structure is steeper in the tanker market than in the bulker market and the reason for this might be the higher degree of mean reversion in the tanker market (Alizadeh and Nomikos, 2007a).

4.2.5 Non-normality and necessity of the analysis

The coefficients of Kurtosis and skewness provide the measures for non-normality by explaining the distributional properties of the changes in vessels' prices and daily earnings.

In the dry bulk sector, the coefficient of skewness indicates that the vessels' price changes are negatively skewed, especially the second hand ones. Moreover, it indicates that trip charter rate changes for Handymax bulk carriers and spot rate changes for Panamax and Capesize bulk carriers are positively skewed whereas the time charter rate changes are mostly negatively skewed for smaller vessels and mostly positively skewed for larger ones. As regards the 6-month time charter rate changes for 15-year old Handymax bulk carriers, the 1-year time charter rate changes for newly built and 5-year old Capesize bulk carriers and the 1-year time charter rate changes for 10 and 15-year old Panamax bulk carriers, the respective coefficient does not indicate significant skewness.

In the wet bulk sector, newbuilding price changes are negatively skewed for all tankers except for VLCCs, the price changes of which are slightly (positively) skewed. As for the second hand price changes, first of all, there is no significant indication of skewness for 5-year old "MR" Product tankers. Secondly, all of them are negatively skewed for VLCCs and thirdly, for all other tankers, 5-year old vessel price changes are positively skewed for smaller vessels and negatively skewed for larger ones whereas the opposite can be confirmed for 10-year old vessel price changes. Indication of positive skewness is observed for the price changes of 15-year old Aframax tankers as well. Finally, the changes in the vessels' daily earnings are positively skewed for all tankers with the exception of 3-year time charter rate changes of newly built VLCCs for which there is no indication of skewness (in fact its coefficient of skewness is -0.0030).

Concerning the coefficient of kurtosis, this indicates positive excess kurtosis for all changes in vessels' prices and daily earnings in both dry and wet bulk sector.

In essence the coefficients of skewness and kurtosis confirmed that changes in vessels' prices and daily earning from all freight contracts are not normally distributed. More specifically, indication of positive skewness for changes in vessels' prices and daily earnings means that the risk associated with them was overestimated because extreme positive deviations increased their volatility. On the other hand, in cases where negative skewness was observed, the respective risk was underestimated. Furthermore, the positive excess kurtosis observed means that the standard deviations of the changes in vessels' prices and daily earnings underestimated (to great extent in some cases in which the coefficient of kurtosis was very high) the likelihood of extreme events: large losses or large gains (Bodie, Kane and Markus, 2008).

To conclude, the importance of the analysis provided above stems from the fact that when shipping investors, especially the risk-averse ones, are aware of the risks involved in the vessel prices and daily earnings, they can diversify by choosing to invest more in younger and smaller vessels as well as by employing vessels under longer contract durations.

4.3 The bulker and tanker results

The following tables present descriptive statistics for monthly, semi-annual, annual and 3-year-end returns on tankers and bulk carriers. They refer to both specific freight contracts and series of a specific freight contract, i.e. for all considered operating strategies. Sharpe ratios and utilities of investors with different risk preferences (A=1, A=3 and A=5) are presented as well.

4.3.1 Monthly returns

Vessel type/size class	Handymax bulk carriers				Panamax bulk carriers				Capesize bulk carriers			
Contract type	Trip charter of 1 month duration				Voyages of 1 month duration				Voyages of 1 month duration			
Vessel age	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO
Average return	1,4581%	0,9593%	1,0064%	0,9660%	1,2370%	0,4674%	0,3517%	0,2597%	1,6391%	1,0028%	0,8599%	1,0107%
Standard Deviation (Risk)	1,1953%	0,7612%	0,8728%	1,2154%	1,2958%	0,7846%	1,0517%	1,4545%	1,5454%	1,0425%	1,2602%	1,5832%
Sample Variance	0,0143%	0,0058%	0,0076%	0,0148%	0,0168%	0,0062%	0,0111%	0,0212%	0,0239%	0,0109%	0,0159%	0,0251%
Kurtosis	-0,2126	-0,2310	-0,3393	0,0323	-0,5854	-0,7976	-0,0800	-0,3362	-0,1711	-0,3093	-0,5211	-0,0012
Skewness	0,4617	0,0170	-0,3276	-0,0083	0,4480	-0,0774	0,1858	0,0785	0,5662	0,2099	-0,0429	-0,1237
Range	5,3140%	3,5034%	3,9409%	6,0139%	5,3478%	3,1001%	4,9636%	6,3168%	6,9640%	4,6781%	5,2049%	7,2918%
Minimum	-0,8722%	-0,8230%	-1,1631%	-1,9829%	-1,0226%	-1,0503%	-1,7829%	-2,5323%	-1,0172%	-0,9605%	-1,5053%	-2,2247%
Maximum	4,4417%	2,6804%	2,7778%	4,0309%	4,3253%	2,0498%	3,1808%	3,7846%	5,9468%	3,7176%	3,6997%	5,0671%
Observations	113	113	113	113	113	113	113	113	113	113	113	113
Sharpe ratio	1,0347	0,9694	0,8995	0,6127	0,7838	0,3136	0,1240	0,0264	0,9174	0,7495	0,5067	0,4986
Utility (A=1)	0,014509	0,009564	0,010026	0,009586	0,012286	0,004643	0,003462	0,002491	0,016272	0,009973	0,008520	0,009982
Utility (A=3)	0,014367	0,009506	0,009950	0,009439	0,012118	0,004581	0,003351	0,002280	0,016033	0,009865	0,008361	0,009731
Utility (A=5)	0,014224	0,009448	0,009873	0,009291	0,011950	0,004520	0,003241	0,002068	0,015794	0,009756	0,008202	0,009481

Table 4.20: Descriptive statistics, Sharpe ratios and Utilities for bulk carrier monthly returns

Contract type	Voyages of 1 month duration															
Vessel type/size class	"MR" Product tankers			Panamax "coated"		Aframax tankers				Suezmax tankers			VLCCs			
Vessel age	NB	5YO	10YO	NB	5YO	NB	5YO	10YO	15YO	NB	5YO	10YO	NB	5YO	10YO	15YO
Average return	0,5898%	0,3294%	0,0810%	0,5468%	0,4096%	0,8922%	0,6986%	0,7843%	1,5025%	1,2244%	0,7790%	1,2054%	0,8138%	0,6472%	0,7748%	2,3246%
Standard Deviation (Risk)	0,8565%	0,8004%	0,9735%	0,7657%	0,8086%	0,9345%	0,8973%	1,0792%	2,2897%	1,0388%	0,9440%	1,4883%	0,9519%	0,8807%	1,0614%	2,3919%
Sample Variance	0,0073%	0,0064%	0,0095%	0,0059%	0,0065%	0,0087%	0,0081%	0,0116%	0,0524%	0,0108%	0,0089%	0,0222%	0,0091%	0,0078%	0,0113%	0,0572%
Kurtosis	-0,6446	-0,5733	-0,5629	-0,0116	-0,2956	0,2106	0,2850	1,0169	0,7215	1,9996	1,3389	3,6220	1,3117	1,0483	1,1612	-0,2097
Skewness	-0,0735	-0,1982	-0,0033	0,4969	0,3954	0,6181	0,6076	0,8461	0,8436	1,1507	0,9195	1,5662	1,0924	0,9991	1,0573	0,6785
Range	3,4640%	3,4007%	4,0239%	3,5458%	3,5052%	4,0949%	4,1378%	5,1516%	11,6541%	5,6071%	4,7254%	8,6624%	5,1204%	4,5158%	5,4595%	10,3313%
Minimum	-0,9988%	-1,2683%	-1,8916%	-0,8435%	-1,0517%	-0,7192%	-0,9498%	-1,2245%	-2,4944%	-0,4278%	-0,6791%	-0,7638%	-0,6335%	-0,6534%	-0,7542%	-1,0336%
Maximum	2,4652%	2,1324%	2,1323%	2,7023%	2,4534%	3,3757%	3,1880%	3,9271%	9,1597%	5,1793%	4,0463%	7,8986%	4,4869%	3,8624%	4,7053%	9,2977%
Observations	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113
Sharpe ratio	0,4302	0,1350	-0,1441	0,4251	0,2329	0,7179	0,5319	0,5216	0,5595	0,9656	0,5907	0,6612	0,6224	0,4836	0,5214	0,8793
Utility (A=1)	0,005862	0,003262	0,000763	0,005439	0,004064	0,008878	0,006946	0,007784	0,014763	0,012190	0,007745	0,011943	0,008093	0,006434	0,007692	0,022960
Utility (A=3)	0,005788	0,003198	0,000668	0,005380	0,003998	0,008791	0,006865	0,007668	0,014238	0,012082	0,007656	0,011722	0,008002	0,006356	0,007579	0,022388
Utility (A=5)	0,005715	0,003134	0,000574	0,005322	0,003933	0,008703	0,006785	0,007551	0,013714	0,011974	0,007567	0,011500	0,007912	0,006279	0,007466	0,021816

Table 4.21: Descriptive statistics, Sharpe ratios and Utilities for tanker monthly returns

According to tables 4.20 and 4.21, risk increases along with the increase in the vessels' age for all second hand bulk carriers and tankers while the risk of newly built vessels lies between the risk of 10 and 15-year old vessels in the dry bulk sector and between the risk of 5 and 10-year old vessels in the wet bulk sector. Only the risk of newly built Panamax "Coated" tankers was found to be lower than the risk of 5-year old ones.

Moreover, the average returns on all bulk carriers decrease with the increase in the vessels' age, with the only exceptions being 5-year old Handymaxes, the average return on which was lower than the average returns on the respective older vessels and 15-year old Capesizes which reported higher average return than 10 year-old ones. Similarly, the average returns on “MR” Product and Panamax “Coated” tankers decrease with the increase in the vessels’ age. On the other hand, the average returns on second hand Aframaxes, Suezmaxes and VLCCs, increase with the increase in vessels’ age, though the average returns of the respective newly built vessels were found to be higher than the average returns on 10-year old ones.

Furthermore, a comparison across different vessel sizes revealed that in the dry bulk sector risk is higher for larger vessels of all ages while in wet bulk sector, VLCCs were found to be less risky than Suezmaxes (for all ages) and Aframaxes (except for newly built and 15-year old vessels) and newly built “MR” Product tankers more risky than newly built Panamax “Coated” tankers. In addition, newly built bulk carriers were found to be riskier than the newly built tankers whereas the opposite is true for the majority of the respective second hand vessels.

The coefficient of skewness indicates that the distribution of the returns on bulk carriers and tankers deviate from normality, thus resulting in overestimation or underestimation of the respective risks. However, several are the cases where this indication is slight or even insignificant (e.g. 15-year old Handymax bulk carriers and 10-yaer old “MR” Product tankers). Additionally, the coefficient of kurtosis indicates underestimation of the likelihood of returns which are closer to the average return (negative excess kurtosis) for bulk carriers, “MR” Product tankers and Panamax tankers and underestimation of the likelihood of extreme returns, either positive or negative (positive excess kurtosis), for the rest of the tankers. Both coefficients are higher (in absolute terms) in the wet bulk sector. Moreover, the minimum and maximum statistic measures indicate the highest and lowest, respectively, monthly returns observed for all vessels during the period of assessment.

In addition, as it is evident in tables 4.20 and 4.21, Sharpe ratios indicate that all newly built vessels (bulk carriers and tankers) are better investment alternatives in terms of their reward to volatility than any of the respective second hand vessels. Only the Sharpe ratio of 15-year old VLCCs is higher than the Sharpe ratio of the respective newly built vessels. Moreover, Sharpe ratio decreases with the increase in the vessels’ age for all second hand bulk carriers as well as for second hand “MR” Product, Panamax “Coated” and Aframax tankers (excluding 15-year old Aframax tankers which have higher Sharp ratio than the respective 5 and 10-year old ones). On the contrary, Sharpe ratio increases with the increase in the vessels’ age for second hand Suezmax tankers and VLCCs (the respective rankings can be obtained accordingly).

What is also worth mentioning is the negative Sharp ratio of 10-year old “MR” Product tankers. It means that the risk free asset yielded higher average monthly return and thus it was better investment alternative compared to these vessels during the period of assessment. Furthermore, Handymaxes of all ages were found to have the highest Sharp ratios in the dry bulk sector with Capesizes and Panamaxes being second and third best respectively. However in the wet bulk sector the ranking is different for each vessel age. The respective rankings are Suezmax/Aframax/VLCC/”MR” Product/Panamax for newly built vessels, Suezmax/Aframax/VLCC/(Panamax)/”MR” Product for 5 and 10-year old vessels and VLCC/Aframax for 15-year old vessels.

As can also be seen, utility values produced different results compared to Sharpe ratios for the ranking of vessels of each sub-market according to their age. Additionally, they produced different results for investors with different risk preferences. Nevertheless, there are also cases where the respective rankings are all the same independent of the ranking basis. For example, the ranking of Capesize bulk carriers according to Sharpe ratio is Newly built/5-year old/10-year old/15-year old whereas according to the utilities of two risk-averse investors with a different degree of risk aversion (A=1 and A=3) is Newly built/15-year old/5-year old/10-year old and Newly built/5-year old/15-year old/10-year old respectively. However, the ranking of "MR" Product tankers is newly built/5-year old/10-year old no matter the ranking method. Capesizes (except for 10-year old ones) and Suezmaxes of all ages were found to maximize the investors' utilities in the dry and wet bulk sector respectively while generally utilities are higher for bulk carriers than tankers. Only the 15-year old VLCCs were found to give the maximum utility for all risk preferences.

The rankings of all bulk carriers and tankers according to Sharpe ratio and the utilities of investors with different risk preferences can be obtained from tables 4.20 and 4.21.

4.3.2 Semi-annual returns

Contract type	6-month Time charter															
Vessel type/size class	Handysize bulk carriers				Handymax bulk carriers				Panamax bulk carriers				Capesize bulk carriers			
Vessel age	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO
Average return	9,74%	10,06%	11,65%	12,68%	12,56%	13,01%	14,12%	15,42%	13,22%	11,84%	11,44%	12,13%	13,98%	14,17%	13,71%	16,40%
Standard Deviation (Risk)	11,71%	19,86%	23,51%	25,73%	14,46%	23,93%	25,82%	29,13%	15,64%	25,72%	29,83%	30,69%	15,76%	26,33%	29,08%	33,39%
Sample Variance	1,37%	3,94%	5,53%	6,62%	2,09%	5,73%	6,67%	8,48%	2,45%	6,61%	8,90%	9,42%	2,48%	6,93%	8,45%	11,15%
Kurtosis	0,1564	2,4214	1,6801	3,3806	-0,3981	2,0567	1,5317	1,5421	0,0403	1,3421	2,1662	1,6803	-0,6960	0,9852	1,0325	0,4131
Skewness	-0,5119	-0,8623	-0,4334	-0,0458	-0,3202	-0,1144	-0,2607	0,0996	0,0125	-0,2136	0,3621	0,2204	-0,2195	-0,0670	0,2687	0,2820
Range	55,12%	111,95%	134,63%	172,85%	65,96%	137,12%	145,62%	161,01%	76,69%	144,60%	169,00%	164,85%	67,21%	145,22%	162,85%	173,22%
Minimum	-23,07%	-54,24%	-58,27%	-65,91%	-24,72%	-55,80%	-59,18%	-62,99%	-24,28%	-59,37%	-65,43%	-68,61%	-22,10%	-56,95%	-60,49%	-62,43%
Maximum	32,04%	57,71%	76,36%	106,95%	41,24%	81,32%	86,44%	98,02%	52,41%	85,23%	103,57%	96,24%	45,11%	88,27%	102,35%	110,79%
Observations	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108
Sharpe ratio	0,7450	0,4553	0,4522	0,4534	0,7982	0,5010	0,5076	0,4944	0,7800	0,4209	0,3494	0,3620	0,8224	0,4997	0,4366	0,4606
Utility (A=1)	0,0906	0,0809	0,0888	0,0937	0,1151	0,1014	0,1079	0,1117	0,1199	0,0853	0,0699	0,0742	0,1274	0,1071	0,0948	0,1082
Utility (A=3)	0,0769	0,0414	0,0336	0,0275	0,0942	0,0442	0,0412	0,0269	0,0955	0,0192	-0,0191	-0,0200	0,1025	0,0378	0,0103	-0,0033
Utility (A=5)	0,0631	0,0020	-0,0217	-0,0387	0,0733	-0,0131	-0,0255	-0,0579	0,0710	-0,0469	-0,1080	-0,1142	0,0777	-0,0316	-0,0743	-0,1148

Table 4.22: Descriptive statistics, Sharpe ratios and Utilities for bulk carrier semi-annual (6-month holding period - operating strategy 1)

Vessel type/size class	Handymax bulk carriers				Panamax bulk carriers				Capesize bulk carriers			
Contract type	6 consecutive trip charters of 1 month duration				6 consecutive voyages of 1 month duration				6 consecutive voyages of 1 month duration			
Vessel age	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO
Average return	12,62%	13,48%	14,92%	16,63%	11,30%	11,44%	12,79%	13,94%	13,56%	14,44%	14,39%	17,88%
Standard Deviation (Risk)	15,92%	26,56%	28,90%	32,77%	17,42%	28,79%	33,74%	35,57%	17,38%	29,84%	32,83%	38,32%
Sample Variance	2,54%	7,05%	8,35%	10,74%	3,04%	8,29%	11,39%	12,65%	3,02%	8,90%	10,78%	14,68%
Kurtosis	-0,3243	2,2577	1,7690	1,8275	0,0452	1,4676	2,1313	1,6583	-0,7926	1,2974	1,5009	0,9688
Skewness	-0,1755	-0,1178	-0,2500	0,1210	0,1577	-0,1233	0,4283	0,2995	-0,0636	-0,0567	0,2973	0,3386
Range	75,31%	155,15%	167,69%	184,07%	86,75%	167,16%	188,07%	193,88%	72,00%	172,59%	194,28%	213,94%
Minimum	-27,48%	-63,64%	-68,43%	-72,83%	-30,87%	-68,57%	-73,17%	-77,96%	-23,97%	-69,13%	-72,82%	-76,85%
Maximum	47,83%	91,51%	99,26%	111,24%	55,87%	98,60%	114,90%	115,92%	48,03%	103,46%	121,46%	137,09%
Observations	108	108	108	108	108	108	108	108	108	108	108	108
Sharpe ratio	0,7285	0,4694	0,4811	0,4764	0,5901	0,3619	0,3489	0,3635	0,7221	0,4500	0,4074	0,4400
Utility (A=1)	0,1135	0,0996	0,1075	0,1126	0,0978	0,0729	0,0710	0,0762	0,1205	0,0999	0,0900	0,1054
Utility (A=3)	0,0881	0,0290	0,0239	0,0052	0,0675	-0,0100	-0,0429	-0,0503	0,0903	0,0109	-0,0177	-0,0415
Utility (A=5)	0,0628	-0,0415	-0,0596	-0,1022	0,0371	-0,0928	-0,1567	-0,1768	0,0602	-0,0782	-0,1255	-0,1883

Table 4.23: Descriptive statistics, Sharpe ratios and Utilities for bulk carrier semi-annual returns (6-month holding period - operating strategy 2)

Contract type	6 consecutive voyages of 1 month duration																
Vessel type/size class	"MR" Product tankers			Panamax "coated" tankers		Aframax tankers				Suezmax tankers			VLCCs			
Vessel age	NB	5YO	10YO	NB	5YO	NB	5YO	10YO	15YO	NB	5YO	10YO	NB	5YO	10YO	15YO
Average return	5,62%	4,78%	2,95%	5,73%	5,55%	8,34%	7,16%	7,66%	15,64%	9,93%	7,82%	12,14%	7,78%	7,23%	8,09%	19,21%
Standard Deviation (Risk)	11,26%	16,23%	18,35%	10,63%	19,24%	13,26%	16,15%	18,59%	34,78%	12,73%	14,64%	25,29%	13,80%	16,55%	19,66%	28,90%
Sample Variance	1,27%	2,64%	3,37%	1,13%	3,70%	1,76%	2,61%	3,46%	12,10%	1,62%	2,14%	6,40%	1,90%	2,74%	3,87%	8,35%
Kurtosis	-0,1443	0,2343	-0,0798	-0,4082	7,9432	-0,0578	0,2738	-0,5278	2,7301	-0,3860	0,0188	0,9873	-0,1190	0,2183	0,5342	0,3905
Skewness	-0,4824	-0,1601	-0,2508	-0,2762	-1,5617	-0,5384	0,0301	-0,1489	1,2570	-0,1198	-0,1191	1,0606	0,2180	-0,2128	0,0112	0,4628
Range	46,92%	75,59%	87,23%	45,47%	146,68%	58,94%	78,58%	80,85%	190,10%	55,71%	70,27%	119,22%	64,70%	83,75%	107,23%	161,25%
Minimum	-21,55%	-33,48%	-43,04%	-18,65%	-101,74%	-25,44%	-35,63%	-36,21%	-46,94%	-18,60%	-27,79%	-27,33%	-19,34%	-39,59%	-44,52%	-53,20%
Maximum	25,37%	42,11%	44,19%	26,82%	44,94%	33,50%	42,94%	44,64%	143,17%	37,11%	42,48%	91,90%	45,36%	44,16%	62,71%	108,05%
Observations	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108
Sharpe ratio	0,4091	0,2315	0,1051	0,4432	0,2357	0,5526	0,3804	0,3573	0,4205	0,7002	0,4644	0,4397	0,4900	0,3755	0,3598	0,6296
Utility (A=1)	0,0499	0,0346	0,0126	0,0516	0,0370	0,0746	0,0586	0,0593	0,0959	0,0912	0,0675	0,0894	0,0683	0,0586	0,0616	0,1503
Utility (A=3)	0,0372	0,0082	-0,0211	0,0403	-0,0000	0,0571	0,0325	0,0247	-0,0251	0,0750	0,0460	0,0254	0,0492	0,0312	0,0229	0,0668
Utility (A=5)	0,0245	-0,0181	-0,0547	0,0290	-0,0370	0,0395	0,0064	-0,0098	-0,1461	0,0588	0,0246	-0,0386	0,0302	0,0038	-0,0157	-0,0167

Table 4.24: Descriptive statistics, Sharpe ratios and Utilities for tanker semi-annual returns (6-month holding period - operating strategy 2 only)

When bulk carriers operate under a 6-month time charter contract, risk increases with the increase in vessels' age and so does in most cases their average return. Only the average return on newly built Panamaxes was found to be higher than the average returns on the respective second hand vessels as well as the average returns on 10-year old Panamaxes and Capesizes were found to be lower than the average returns on the respective 5-year old vessels. Similarly, when bulk carriers operate under 6 consecutive voyage contracts (trip charter contracts for Handymaxes) of 1 month duration, both risk and average return increase with the increase in the vessels' age with only the average return on 10-year old Capesizes being slightly lower than the average return on the respective 5-year old ones.

On the other hand, when "MR" product and Panamax "Coated" tankers operate under 6 consecutive voyage contracts of 1 month duration their risk increases and their average returns decrease with the increase in their age. Regarding the rest tanker sub-markets (Aframax, Suezmax and VLCC), while their risk increases with the increase in the vessels' age, their average returns firstly decrease and then increase (check table 4.22).

Moreover, risk is higher for larger vessels for both tankers and bulk carriers as well as for both operating strategies (with respect to bulk carriers). In the dry bulk sector, only 10-year old Capesizes were found not to follow this pattern for both operating strategies as well as the newly built ones when they operate under 6 consecutive voyage contracts of 1 month duration (their risk is lower than the risk of the respective Panamaxes). Regarding the exceptions in the wet bulk sector, newly built "MR" Product tankers, newly built Aframax tankers, 5-year old Aframax tankers, 15-year old Aframax tankers and 10-year old Suezmax tankers were found to be riskier than newly built Panamax "Coated" tankers, newly built Suezmax tankers, 5-year old Suezmax tankers, 15-year old VLCCs and 10-year old VLCCs respectively.

Furthermore, bulk carriers were found to be less risky when they operate under a 6-month time charter contract since, generally speaking, time chartering can be considered as a physical hedging strategy in shipping. Additionally, a comparison between the two sectors revealed that bulk carriers are riskier than tankers when both operate under 6-consecutive voyage contracts (trip charter contracts for Handymaxes) of 1 month duration.

The coefficient of skewness indicates that the distribution of the returns on all bulk carriers and tankers deviate from normality and therefore, the respective risks are overestimated or underestimated. The coefficient of kurtosis indicates underestimation of the likelihood of returns which are closer to the average return (negative excess kurtosis) for all newly built tankers as well as for the 10-year old "MR" Product and Aframax tankers and newly built Handymax and Capesize bulk carriers (for both operating strategies). For the rest of the vessels it indicates underestimation of the likelihood of extreme returns, either positive or negative (positive excess kurtosis). Moreover, the minimum and maximum statistic measures indicate the highest and lowest, respectively, monthly returns observed for all vessels during the period of assessment. Especially for bulk carriers, the minimum and maximum reported returns during the period of assessment were found to be higher when the vessels operate under 6 consecutive voyage contracts (trip charter contracts for Handymaxes) of 1 month duration. In addition, the maximum and minimum observed returns for tankers were generally lower than the ones of bulk carriers with the only exception being 15-year old Aframax tankers which yielded the highest maximum return during the period of assessment.

In addition, as it is evident in tables 4.22, 4.23 and 4.24, the Sharpe ratios indicate again that all newly built bulk carriers (for both operating strategies) and tankers are better investment alternatives than any of the respective second hand vessels except for 15-year old VLCCs the Sharpe ratio of which was found to be higher than the one of the respective newly built vessels. As regards the Sharpe ratios of second hand vessels, they do not follow a specific pattern. The ranking of vessels of different age for each sub-market in the two sectors based on Sharpe ratios are the following:

- Newly built/5-year old/15-year old/10-year old for Handysize bulk carriers that operate under a 6-month time charter contract
- Newly built/10-year old/5-year old/15-year old and newly built/10-year old/15-year old/5-year old for Handymax bulk carriers that operate under a 6-month time charter contract and 6 consecutive trip charter contracts of 1 month duration respectively
- Newly built/5-year old/15-year old/10-year old and newly built/15-year old/5-year old/10-year old for Panamax bulk carriers that operate under a 6-month time charter contract and 6 consecutive voyage contracts of 1 month duration respectively
- Newly built/5-year old/15-year old/10-year old and newly built/5-year old/15-year old/10-year old for Capesize bulk carriers that operate under a 6-month time charter contract and 6 consecutive voyage contracts of 1 month duration respectively
- Newly built/5-year old/(10-year old) for "MR" Product and Panamax "Coated" tankers that operate under 6 consecutive voyage contracts of 1 month duration
- Newly built/15-year old/5-year old/10-year old for Aframax tankers that operate under 6 consecutive voyage contracts of 1 month duration
- Newly built/5-year old/10-year old for Suezmax tankers that operate under 6 consecutive voyage contracts of 1 month duration and
- 15-year old/ Newly built/5-year old/10-year old for VLCCs that operate under 6 consecutive voyage contracts of 1 month duration

What is more, the Sharpe ratios of all bulk carriers were found to be higher when the vessels operate under a 6-month time charter contract, apart from the ones of 15-year old Panamaxes.

A comparison of the Sharp ratios across different vessel sizes resulted in specific rankings per vessel age for each sector. More specifically, newly built bulk carriers can be ranked as Capesize/Handymax/Panamax/(Handysize) for both operating strategies while second hand bulk carriers can be ranked as Handymax/Capesize/(Handysize)/Panamax for both operating strategies as well with the only exception being 10-year old vessels that operate under 6-month time charter contracts for which the respective ranking was found to be Handymax/Handysize/Capesize/Panamax. In the wet bulk sector the respective rankings were found to be Suezmax/Aframax/VLCC/Panamax “Coated”/“MR” Product for newly built and 5-year old vessels, Suezmax/VLCC/Aframax/“MR” Product for 10-year old vessels and VLCC/Aframax for 15-year old vessels.

Last but not least, the ranking of bulk carriers and tankers according to the investors’ utilities differs from the ranking provided by the Sharpe ratios (except for Panamax bulk carriers and “MR” Product and Panamax “Coated” tankers) as well as for investors with different risk preferences (except for “MR” Product and Panamax “Coated” tankers). Concerning the different operating strategies for bulk carriers, the utilities of the risk-averse investors deteriorate when the vessels operate under 6 consecutive voyage contracts (trip charter contracts for Handymaxes) of 1 month duration simply because the risk (expressed in variance terms) is higher. That is, when the risk increases the risk penalty for risk-averse investors, is greater. For instance, the ranking of Capesizes which operate under a 6-month time charter contract is newly built/15-year old/5-year old/10-year old for an investor with a degree of risk aversion equal to 1 and newly built/5-year old/10-year old/15-year old for investors with a degree of risk aversion equal to 3 or 5. This is also the ranking for both investors when the respective Capesizes operate under 6 consecutive voyage contracts of 1 month duration but, as it is evident in tables 4.20 and 4.21, the investors’ utilities are lower in this case.

The ranking of all bulk carriers for both operating strategies, according to Sharpe ratio and the utilities of investors with different risk preferences can be obtained from tables 4.22 and 4.23. Similarly, the ranking of tankers that operate under 6 consecutive voyage contracts of 1 month duration based on the same criteria can be obtained from table 4.24.

4.3.3 Annual returns

Contract type	1-year Time charter															
Vessel type/size class	Handysize bulk carriers				Handymax bulk carriers				Panamax bulk carriers				Capesize bulk carriers			
Vessel age	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO
Average return	19,63%	21,54%	25,08%	25,79%	25,57%	27,63%	30,53%	33,58%	26,50%	24,61%	24,01%	24,82%	28,77%	29,77%	28,23%	34,76%
Standard Deviation (Risk)	19,24%	30,06%	35,53%	38,93%	23,74%	35,96%	39,31%	46,09%	24,92%	38,70%	43,92%	46,85%	26,65%	38,85%	43,08%	53,61%
Sample Variance	3,70%	9,04%	12,62%	15,16%	5,64%	12,93%	15,45%	21,24%	6,21%	14,98%	19,29%	21,95%	7,10%	15,09%	18,56%	28,74%
Kurtosis	-0,3115	-0,1571	-0,2925	0,0124	-0,8593	-0,4270	-0,5400	-0,6254	-0,9154	-0,6473	-0,6581	-0,3253	-0,4712	-0,9216	-1,1576	-0,7877
Skewness	-0,3111	-0,5328	-0,3823	0,0864	-0,2075	-0,2396	-0,1996	0,0659	0,0714	-0,0934	0,0928	0,3536	-0,1362	-0,1661	0,1160	0,4247
Range	83,84%	126,83%	142,31%	171,33%	96,14%	142,58%	155,84%	184,28%	99,51%	159,12%	171,54%	204,74%	115,54%	144,37%	155,98%	203,94%
Minimum	-29,06%	-45,21%	-48,65%	-52,55%	-29,68%	-45,77%	-47,66%	-53,87%	-27,57%	-50,53%	-56,67%	-58,69%	-35,61%	-46,84%	-48,94%	-51,18%
Maximum	54,79%	81,62%	93,65%	118,79%	66,46%	96,81%	108,18%	130,40%	71,94%	108,59%	114,87%	146,05%	79,93%	97,53%	107,04%	152,76%
Observations	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
Sharpe ratio	0,8845	0,6298	0,6325	0,5953	0,9669	0,6958	0,7102	0,6719	0,9585	0,5684	0,4871	0,4741	0,9816	0,6989	0,5947	0,5997
Utility (A=1)	0,1778	0,1703	0,1877	0,1821	0,2275	0,2117	0,2280	0,2296	0,2339	0,1712	0,1436	0,1385	0,2522	0,2222	0,1895	0,2039
Utility (A=3)	0,1408	0,0799	0,0615	0,0305	0,1711	0,0824	0,0735	0,0172	0,1718	0,0214	-0,0493	-0,0810	0,1812	0,0712	0,0040	-0,0835
Utility (A=5)	0,1038	-0,0105	-0,0647	-0,1211	0,1148	-0,0469	-0,0811	-0,1952	0,1097	-0,1283	-0,2422	-0,3005	0,1102	-0,0797	-0,1816	-0,3709

Table 4.25: Descriptive statistics, Sharpe ratios and Utilities for bulk carrier annual returns (1-year holding period - operating strategy 1)

Contract type	2 consecutive 6-month Time charters															
Vessel type/size class	Handysize bulk carriers				Handymax bulk carriers				Panamax bulk carriers				Capesize bulk carriers			
Vessel age	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO
Average return	22,02%	24,34%	28,67%	30,50%	28,61%	31,32%	35,10%	39,48%	30,44%	28,88%	28,71%	31,08%	32,68%	34,62%	33,47%	42,48%
Standard Deviation (Risk)	22,64%	33,82%	40,19%	45,16%	27,57%	40,41%	44,77%	52,41%	30,03%	43,41%	49,62%	54,02%	31,60%	45,06%	49,90%	64,02%
Sample Variance	5,13%	11,44%	16,16%	20,39%	7,60%	16,33%	20,04%	27,47%	9,02%	18,84%	24,62%	29,18%	9,99%	20,30%	24,90%	40,98%
Kurtosis	-0,6028	-0,1382	-0,3569	-0,0527	-1,0356	-0,4421	-0,5595	-0,6717	-0,9486	-0,6676	-0,6755	-0,5371	-1,0435	-0,8680	-1,0760	-0,6202
Skewness	-0,2836	-0,5382	-0,3808	0,0995	-0,1954	-0,2881	-0,2452	0,0272	0,0668	-0,1420	0,0680	0,2642	0,0300	-0,1324	0,1332	0,4690
Range	90,30%	145,08%	164,67%	196,09%	103,32%	157,77%	176,54%	203,41%	114,07%	171,81%	195,25%	221,28%	122,01%	170,95%	183,78%	255,21%
Minimum	-31,09%	-54,25%	-58,83%	-60,60%	-31,71%	-54,17%	-58,18%	-63,11%	-29,03%	-55,15%	-62,46%	-63,23%	-32,87%	-52,86%	-53,12%	-56,73%
Maximum	59,20%	90,83%	105,84%	135,49%	71,61%	103,59%	118,35%	140,29%	85,05%	116,66%	132,79%	158,06%	89,14%	118,09%	130,67%	198,48%
Observations	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
Sharpe ratio	0,8569	0,6424	0,6483	0,6177	0,9430	0,7105	0,7256	0,7035	0,9268	0,6053	0,5259	0,5270	0,9514	0,7103	0,6184	0,6227
Utility (A=1)	0,1945	0,1862	0,2059	0,2031	0,2481	0,2316	0,2508	0,2574	0,2593	0,1946	0,1640	0,1649	0,2768	0,2447	0,2102	0,2199
Utility (A=3)	0,1432	0,0718	0,0443	-0,0008	0,1721	0,0683	0,0503	-0,0172	0,1692	0,0062	-0,0823	-0,1269	0,1770	0,0416	-0,0388	-0,1900
Utility (A=5)	0,0920	-0,0426	-0,1172	-0,2047	0,0961	-0,0950	-0,1501	-0,2919	0,0790	-0,1822	-0,3285	-0,4187	0,0771	-0,1614	-0,2878	-0,5998

Table 4.26: Descriptive statistics, Sharpe ratios and Utilities for bulk carrier annual returns (1-year holding period - operating strategy 2)

Vessel type/size class	Handymax bulk carriers				Panamax bulk carriers				Capesize bulk carriers			
Contract type	12 consecutive trip charters of 1 month duration				12 consecutive voyages of 1 month duration				12 consecutive voyages of 1 month duration			
Vessel age	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO
Average return	28,83%	32,33%	36,82%	42,06%	26,62%	28,24%	31,81%	35,28%	32,06%	35,20%	34,97%	45,81%
Standard Deviation (Risk)	30,18%	44,02%	49,10%	57,56%	32,76%	47,53%	55,21%	61,06%	34,83%	49,80%	54,78%	71,35%
Sample Variance	9,11%	19,38%	24,11%	33,13%	10,73%	22,59%	30,49%	37,29%	12,13%	24,80%	30,01%	50,91%
Kurtosis	-1,0011	-0,3811	-0,4905	-0,5953	-0,9871	-0,6591	-0,6425	-0,5451	-1,1472	-0,7696	-1,0054	-0,4714
Skewness	-0,1641	-0,3146	-0,2793	-0,0064	0,0491	-0,1533	0,0715	0,2368	0,0903	-0,1480	0,0859	0,4725
Range	112,26%	171,15%	187,06%	217,14%	122,44%	182,15%	216,00%	241,37%	131,27%	186,67%	198,22%	278,37%
Minimum	-32,77%	-59,84%	-63,21%	-67,13%	-35,85%	-62,07%	-67,69%	-70,29%	-31,53%	-59,01%	-58,93%	-65,09%
Maximum	79,49%	111,31%	123,86%	150,01%	86,59%	120,08%	148,31%	171,08%	99,74%	127,66%	139,29%	213,27%
Observations	102	102	102	102	102	102	102	102	102	102	102	102
Sharpe ratio	0,8689	0,6751	0,6967	0,6854	0,7328	0,5393	0,5289	0,5350	0,8453	0,6545	0,5907	0,6054
Utility (A=1)	0,2428	0,2264	0,2477	0,2550	0,2125	0,1695	0,1657	0,1664	0,2599	0,2281	0,1996	0,2036
Utility (A=3)	0,1517	0,0326	0,0066	-0,0764	0,1052	-0,0564	-0,1392	-0,2065	0,1386	-0,0199	-0,1005	-0,3055
Utility (A=5)	0,0607	-0,1612	-0,2345	-0,4077	-0,0022	-0,2823	-0,4440	-0,5794	0,0173	-0,2679	-0,4005	-0,8146

Table 4.27: Descriptive statistics, Sharpe ratios and Utilities for bulk carrier annual returns (1-year holding period - operating strategy 3)

Contract type	1-year Time charter													
Vessel type/size class	"MR" Product tankers			Panamax "coated" tankers	Aframax tankers			Suezmax tankers			VLCCs			
Vessel age	NB	5YO	10YO	NB	NB	5YO	10YO	NB	5YO	10YO	NB	5YO	10YO	15YO
Average return	11,95%	9,72%	6,89%	12,46%	14,86%	12,03%	10,34%	16,17%	11,86%	19,13%	14,86%	13,42%	12,72%	29,36%
Standard Deviation (Risk)	16,67%	21,85%	26,20%	16,51%	19,39%	22,62%	25,51%	17,76%	20,53%	39,78%	20,66%	22,45%	25,81%	42,12%
Sample Variance	2,78%	4,77%	6,86%	2,73%	3,76%	5,12%	6,51%	3,15%	4,22%	15,83%	4,27%	5,04%	6,66%	17,74%
Kurtosis	-0,3514	0,3171	-0,2573	-0,6772	0,0755	0,2551	0,0090	-0,2814	0,3942	1,2251	-0,2784	0,2088	0,1306	-0,3041
Skewness	-0,8899	-0,9510	-0,3842	-0,5944	-0,4159	-0,0900	-0,0084	-0,3366	-0,3323	1,1933	0,0998	-0,2294	-0,0467	0,4238
Range	59,08%	97,71%	113,30%	65,57%	83,56%	108,02%	113,02%	72,99%	98,85%	186,88%	84,25%	101,74%	111,91%	174,02%
Minimum	-26,14%	-46,34%	-52,17%	-23,29%	-29,95%	-40,71%	-43,45%	-21,97%	-39,03%	-40,96%	-26,53%	-40,91%	-44,44%	-52,02%
Maximum	32,94%	51,37%	61,12%	42,28%	53,61%	67,31%	69,57%	51,02%	59,82%	145,91%	57,72%	60,83%	67,47%	122,00%
Observations	102	102	102	102	102	102	102	102	102	102	102	102	102	102
Sharpe ratio	0,5605	0,3255	0,1632	0,5966	0,6319	0,4163	0,3029	0,7632	0,4505	0,4152	0,5930	0,4816	0,3918	0,6351
Utility (A=1)	0,1056	0,0734	0,0345	0,1110	0,1298	0,0947	0,0708	0,1459	0,0975	0,1122	0,1273	0,1090	0,0939	0,2049
Utility (A=3)	0,0779	0,0256	-0,0341	0,0837	0,0922	0,0435	0,0058	0,1143	0,0554	-0,0461	0,0846	0,0586	0,0273	0,0275
Utility (A=5)	0,0501	-0,0221	-0,1027	0,0565	0,0546	-0,0076	-0,0593	0,0828	0,0132	-0,2043	0,0419	0,0082	-0,0393	-0,1499

Table 4.28: Descriptive statistics, Sharpe ratios and Utilities for tanker annual returns (1-year holding period - operating strategy 1)

Contract type	12 consecutive voyages of 1 month duration															
Vessel type/size class	"MR" Product tankers			Panamax		Aframax tankers				Suezmax tankers			VLCCs			
Vessel age	NB	5YO	10YO	NB	5YO	NB	5YO	10YO	15YO	NB	5YO	10YO	NB	5YO	10YO	15YO
Average return	13,23%	11,59%	8,99%	13,77%	14,77%	19,68%	17,49%	18,47%	36,42%	22,80%	18,79%	30,38%	18,71%	17,64%	19,71%	45,00%
Standard Deviation (Risk)	21,68%	28,08%	33,74%	20,18%	25,44%	24,04%	28,22%	33,10%	58,25%	23,41%	25,88%	50,68%	26,24%	28,60%	32,96%	56,47%
Sample Variance	4,70%	7,89%	11,38%	4,07%	6,47%	5,78%	7,96%	10,96%	33,94%	5,48%	6,70%	25,69%	6,88%	8,18%	10,86%	31,89%
Kurtosis	-0,5517	-0,3926	-0,5075	-0,5608	-0,6305	0,1155	-0,0001	-0,0903	1,3251	-0,0028	0,6234	1,2721	-0,1443	0,1484	0,1560	0,4040
Skewness	-0,6715	-0,5388	-0,1036	-0,4018	-0,3431	-0,3567	0,0551	0,0879	0,9507	0,0180	0,1555	1,3130	0,2702	0,1166	0,2680	0,9264
Range	76,89%	119,21%	139,73%	82,50%	102,37%	104,09%	132,72%	144,14%	273,03%	103,04%	130,97%	230,06%	105,33%	129,62%	147,08%	231,19%
Minimum	-32,26%	-51,82%	-58,34%	-28,80%	-39,30%	-36,29%	-47,17%	-50,40%	-61,16%	-26,56%	-43,11%	-46,07%	-31,20%	-48,44%	-51,73%	-41,55%
Maximum	44,63%	67,39%	81,39%	53,70%	63,07%	67,79%	85,55%	93,74%	211,87%	76,48%	87,86%	183,99%	74,14%	81,18%	95,35%	189,64%
Observations	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
Sharpe ratio	0,4897	0,3198	0,1892	0,5530	0,4780	0,7099	0,5274	0,4792	0,5803	0,8624	0,6253	0,5478	0,6136	0,5254	0,5189	0,7507
Utility (A=1)	0,1088	0,0765	0,0330	0,1174	0,1154	0,1679	0,1351	0,1300	0,1945	0,2006	0,1544	0,1753	0,1527	0,1355	0,1428	0,2906
Utility (A=3)	0,0618	-0,0024	-0,0808	0,0766	0,0507	0,1101	0,0555	0,0204	-0,1448	0,1458	0,0875	-0,0816	0,0839	0,0537	0,0342	-0,0283
Utility (A=5)	0,0148	-0,0813	-0,1946	0,0359	-0,0140	0,0523	-0,0242	-0,0892	-0,4842	0,0910	0,0205	-0,3384	0,0150	-0,0282	-0,0744	-0,3472

Table 4.29: Descriptive statistics, Sharpe ratios and Utilities for tanker annual returns (1-year holding period - operating strategy 3)
***** There is no operating strategy 3 for a 1-year holding period for tankers.**

According to tables 4.25 - 4.27, in all operating strategies for bulk carriers, risk increases with the increase in the vessels' age and so does, in most cases, their average return. More specifically, Handysizes and Handymaxes follow this pattern for all operating strategies, whereas Capesizes follow it with the exception of the respective 10-year old vessels the average return on which was found to be lower than the average return on the 5-year old ones. On the other hand, the average return on Panamaxes was found to be in line with this pattern only when they operate under 12 consecutive voyage contracts of 1 month duration. In the other two operating strategies, their average return decreases with the increase in their age with the only exception being 15-year old Panamaxes the average return on which was found to be higher than the average return on the respective 5-year old ones when they operate under a 1-year time charter contract and the highest one when they operate under 2 consecutive 6-month time charter contracts.

In the wet bulk sector, as it is evident in tables 4.28 and 4.29, risk increases with the increase in the vessels' age for all tankers and for both operating strategies while their respective average returns decrease, except for 10-year old Suezmaxes and 15-year old VLCCs for both operating strategies as well as 10-year old VLCCs, 15-

year old Aframaxes and 5-year old Panamax “Coated” tankers when they operate under 12 consecutive voyage contracts of 1 month duration, the average returns on which were found to be higher than the average returns on the respective newly built vessels. In addition, the average return on 10-year old Aframaxes was found to be higher than the average return on the respective 5-year old ones.

Moreover, bulk carriers’ risk was found to be higher for larger vessels in all operating strategies, except for 10-year old Capesizes the risk of which was found to be slightly lower than the risk of the 10-year old Panamaxes when both operate under a 1-year time charter contract or 12 consecutive contracts of 1 month duration.

Similarly, tankers’ risk was found to be higher for larger vessels though several were the exceptions in both operating strategies. More specifically, Panamax “Coated” tankers were found to be less risky than “MR” Product tankers for all vessels’ ages, 5-year old “MR” Product tankers riskier than 5-year old Suezmaxes and 10-year old “MR” product tanker riskier than the respective Aframaxes and VLCCs. Additionally, when tankers operate under a 1-year time charter contract the risk of the newly built Aframaxes was found to be higher than the risk of newly built Suezmaxes, the risk of 5-year old Aframaxes higher than the risk of both 5-year old Suezmaxes and VLCCs and the risk of 10-year old Suezmaxes higher than the risk of 10-year old VLCCs. Similarly, when tankers operate under 12 consecutive voyage contracts of 1 month duration, newly built and 5-year old Aframaxes are again riskier than the respective Suezmaxes but less risky than the respective VLCCs. Furthermore, 10-year old VLCCs are less risky than the 10-year old Aframaxes and Suezmaxes and the 15-year old VLCCs are less risky than the 15-year old Aframaxes.

In addition, by comparing the different operating strategies we observe that the risk of the vessels of all ages and sizes for both bulk carriers and tankers increases with the decrease in the contract durations (a series of which is required to cover the holding period of 1 year) and so do their average returns. That is, contracts of longer duration can be considered as hedging strategies. Moreover, bulk carriers were found to be riskier than tankers for both operating strategies.

The coefficient of skewness indicates that the distribution of the returns on all bulk carriers and tankers for all operating strategies deviate from normality and therefore, the respective risks are overestimated or underestimated. However, several are the cases for which it indicates slight or insignificant skewness. Additionally, the coefficient of kurtosis indicates underestimation of the likelihood of returns which are closer to the average return (negative excess kurtosis) for all bulk carriers, “MR” product tankers, Panamax “Coated” tankers, newly built Suezmaxes and newly built VLCCs in all operating strategies and underestimation of the likelihood of extreme returns, either positive or negative (positive excess kurtosis), for almost all the other tankers. Moreover, the minimum and maximum statistic measures indicate the highest and lowest, respectively, monthly returns observed for all vessels during the period of assessment which are first of all higher when the vessels operate under consecutive contracts of shorter duration and secondly higher in the dry bulk sector than in the wet bulk one.

Furthermore, the Sharpe ratios indicate once again that the newly built bulk carriers and tankers of all sizes are the best investment alternatives compared to the respective second hand vessels for all operating strategies with the only exception being the 15-year old VLCCs the Sharpe ratio of which was found to be higher than the one of the respective newly built vessels. Apart from this, the Sharpe ratios of second hand tankers decrease with the increase in the vessels' age thus resulting in the general ranking newly built/5-year old/10-year old for all tanker sub-markets in both operating strategies, except VLCCs for all operating strategies and Aframaxes when they operate under 2 consecutive voyage contracts of 1 month duration , the rankings of which are 15-year old/newly built/5-year old/10-year old and newly built/15-year old /5-year old/10-year old respectively. On the other hand the Sharpe ratios of the second hand bulk carriers change in a different way for each vessel size and in some cases for each of the operating strategies thus resulting in the following rankings:

- Newly built/10-year old/5-year old/15-year old for Handysize bulk carriers that operate under a 1-year time charter contract or 2 consecutive 6-month time charter contracts
- Newly built/10-year old/5-year old/15-year old for Handymax bulk carriers that operate under a 1-year time charter contract or 2 consecutive 6-month time charter contracts and newly built/10-year old/15-year old/5-year old when they operate under 12 consecutive trip charter contracts
- Newly built/5-year old/10-year old/15-year old for Panamax bulk carriers that operate under a 1-year time charter contract and newly built/5-year old/15-year old/10-year old when they operate under 2 consecutive 6-month time charter contracts or 12 consecutive voyage contracts and
- Newly built/5-year old/15-year old/10-year old for Capesize bulk carriers for all operating strategies

What is more, in the bulk sector Sharp ratios indicate that the best operating strategy for newly built vessels is the 1-year time charter whereas for all the second hand ones the 2 consecutive 6-month time charters, except for 10 and 15-year old Panamaxes the Sharp ratios of which were found to be higher when they operate under 12 consecutive voyage contracts of 1 month duration. As regards the wet bulk sector, Sharpe ratios are generally higher for "MR" Product and Panamax "Coated" tankers when they operate under a 1-year time charter contract whereas for the rest of the tankers Sharpe ratios were found to be higher when they operate in the spot market.

By comparing the Sharp ratios across different vessel sizes in both sectors for each of the operating strategies, specific rankings can be obtained per vessel age as well. All these rankings are clearly distinguishable in tables 4.25 – 4.29. For instance, when 5-year old bulk carriers operate under a 1-year time charter contract or 12 consecutive voyage contracts (12 consecutive trip charter contracts for Handymaxes) the generated ranking is Capesize/Handymax/(Handysize)/Panamax, whereas when they operate under 2 consecutive 6-month time charter contracts or 12 consecutive voyage contracts (12 consecutive trip charter contracts for Handymaxes) the respective ranking is Handymax/Capesize/Handysize/Panamax.

Last but not least, the investors' utilities produce different rankings for the vessels compared to the ones produced by Sharpe ratios as well as for investors with different risk preferences. Again, the utilities of the investors deteriorate as risk increases or to put it differently, when the vessels operate under consecutive contracts of shorter duration. For instance, the ranking of Suezmax tankers which operate under a 1-year time charter contract is newly built/10-year old/5-year old for an investor with a degree of risk aversion equal to 1 and newly built/5-year old/10-year old/ for an investor with a degree of risk aversion equal to 3. This is also the ranking for both investors when the respective Suezmaxes operate under 12 consecutive voyage contracts of 1 month duration but, as it is evident in tables 4.26 and 4.27, the utilities in the second case are lower compared to the ones in the first case.

The ranking of all bulk carriers and tankers for all operating strategies, according to Sharpe ratio and the utilities of investors with different risk preferences can be obtained from tables 4.25 and 4.29.

4.3.4 3-year-end returns

Contract type	3-year Time charter															
Vessel type/size class	Handysize bulk carriers				Handymax bulk carriers				Panamax bulk carriers				Capesize bulk carriers			
Vessel age	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO
Average return	57,33%	54,79%	58,11%	52,53%	69,73%	63,83%	67,39%	68,82%	70,78%	47,77%	43,10%	34,99%	79,94%	71,89%	60,66%	67,35%
Standard Deviation (Risk)	35,87%	56,73%	64,87%	67,36%	41,28%	65,03%	68,07%	74,43%	41,64%	54,00%	68,55%	69,77%	42,86%	66,02%	62,13%	67,79%
Sample Variance	12,87%	32,19%	42,08%	45,38%	17,04%	42,29%	46,34%	55,41%	17,34%	29,17%	46,99%	48,67%	18,37%	43,59%	38,60%	45,96%
Kurtosis	-1,6360	-1,7095	-1,7139	-1,4894	-1,1151	-1,5909	-1,4593	-1,5363	-1,3049	-1,2809	-1,5140	-1,3287	-1,4205	-1,6240	-1,5254	-1,4661
Skewness	-0,2652	-0,1920	-0,1949	-0,0630	0,2963	-0,0201	0,0458	0,0212	0,0446	0,2581	0,0566	0,2002	0,1419	-0,0649	0,1368	0,1111
Range	109,37%	169,30%	192,35%	230,44%	147,17%	195,89%	224,29%	225,53%	149,56%	180,24%	202,27%	221,99%	138,28%	192,48%	203,70%	219,41%
Minimum	1,74%	-25,51%	-29,22%	-54,91%	11,02%	-21,89%	-19,61%	-33,26%	6,17%	-23,30%	-45,09%	-63,96%	19,81%	-17,73%	-19,89%	-25,11%
Maximum	111,10%	143,79%	163,13%	175,53%	158,18%	174,00%	204,67%	192,28%	155,73%	156,94%	157,17%	158,03%	158,10%	174,76%	183,81%	194,30%
Observations	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
Sharpe ratio	1,3596	0,8150	0,7638	0,6528	1,4819	0,8500	0,8644	0,8097	1,4941	0,7261	0,5040	0,3789	1,6655	0,9593	0,8387	0,8673
Utility (A=1)	0,5089	0,3870	0,3706	0,2984	0,6121	0,4269	0,4422	0,4112	0,6211	0,3318	0,1961	0,1066	0,7076	0,5009	0,4136	0,4438
Utility (A=3)	0,3802	0,0651	-0,0502	-0,1554	0,4417	0,0040	-0,0211	-0,1429	0,4476	0,0402	-0,2737	-0,3802	0,5239	0,0651	0,0277	-0,0158
Utility (A=5)	0,2516	-0,2568	-0,4710	-0,6092	0,2712	-0,4190	-0,4845	-0,6969	0,2742	-0,2515	-0,7436	-0,8669	0,3402	-0,3708	-0,3583	-0,4754

Table 4.30: Descriptive statistics, Sharpe ratios and Utilities for bulk carrier 3-year-end returns (3-year holding period - operating strategy 1)

Contract type	3 consecutive 1-year Time charters															
Vessel type/size class	Handysize bulk carriers				Handymax bulk carriers				Panamax bulk carriers				Capesize bulk carriers			
Vessel age	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO
Average return	80,06%	80,65%	91,26%	96,28%	103,97%	103,39%	114,54%	128,19%	104,13%	81,35%	82,62%	88,27%	118,28%	116,90%	110,03%	142,98%
Standard Deviation (Risk)	41,30%	64,86%	76,00%	81,75%	50,11%	79,12%	83,02%	98,80%	48,50%	65,13%	79,80%	84,81%	54,29%	82,44%	80,58%	109,41%
Sample Variance	17,05%	42,07%	57,76%	66,84%	25,11%	62,59%	68,92%	97,61%	23,53%	42,42%	63,68%	71,94%	29,47%	67,96%	64,93%	119,72%
Kurtosis	-1,2024	-1,3794	-1,4123	-1,4027	-0,7579	-1,1478	-0,8997	-1,0408	-0,7531	-0,4736	-0,9398	-0,4675	-0,2920	-0,9238	-0,6777	-0,8300
Skewness	-0,5496	-0,3599	-0,3750	-0,2865	-0,5558	-0,4625	-0,3935	-0,2397	-0,4731	-0,1357	-0,0262	0,1748	-0,6245	-0,5648	-0,4644	-0,1054
Range	127,82%	202,67%	226,08%	259,47%	192,10%	262,81%	315,73%	352,78%	182,86%	262,21%	294,30%	349,61%	226,06%	273,51%	307,88%	390,54%
Minimum	3,40%	-34,51%	-37,15%	-37,94%	2,36%	-35,19%	-36,12%	-42,76%	5,73%	-36,38%	-48,43%	-48,98%	4,89%	-38,79%	-41,54%	-48,36%
Maximum	131,22%	168,16%	188,93%	221,53%	194,46%	227,61%	279,61%	310,02%	188,59%	225,84%	245,88%	300,63%	230,95%	234,72%	266,34%	342,18%
Observations	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
Sharpe ratio	1,7316	1,1116	1,0882	1,0730	1,9042	1,1987	1,2766	1,2109	1,9705	1,1177	0,9282	0,9398	2,0211	1,3143	1,2593	1,2286
Utility (A=1)	0,7154	0,5962	0,6238	0,6286	0,9142	0,7210	0,8008	0,7939	0,9237	0,6014	0,5078	0,5230	1,0355	0,8292	0,7756	0,8312
Utility (A=3)	0,5448	0,1755	0,0462	-0,0398	0,6631	0,0950	0,1116	-0,1823	0,6884	0,1772	-0,1290	-0,1964	0,7407	0,1496	0,1263	-0,3659
Utility (A=5)	0,3743	-0,2452	-0,5314	-0,7082	0,4120	-0,5309	-0,5776	-1,1584	0,4531	-0,2470	-0,7657	-0,9157	0,4460	-0,5300	-0,5230	-1,5631

Table 4.31: Descriptive statistics, Sharpe ratios and Utilities for bulk carrier 3-year-end returns (3-year holding period - operating strategy 2)

Contract type	6 consecutive 6-month Time charters															
Vessel type/size class	Handysize bulk carriers				Handymax bulk carriers				Panamax bulk carriers				Capesize bulk carriers			
Vessel age	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO
Average return	87,71%	89,33%	102,47%	111,11%	112,31%	113,11%	125,93%	143,55%	115,11%	93,73%	96,35%	106,54%	131,23%	132,56%	125,32%	166,61%
Standard Deviation (Risk)	45,17%	69,54%	82,40%	90,59%	54,11%	84,72%	89,46%	105,75%	52,87%	70,86%	87,14%	93,59%	60,97%	92,27%	89,62%	126,84%
Sample Variance	20,41%	48,36%	67,89%	82,07%	29,28%	71,78%	80,03%	111,82%	27,95%	50,21%	75,94%	87,60%	37,17%	85,13%	80,32%	160,87%
Kurtosis	-1,0990	-1,3461	-1,3859	-1,4068	-0,7709	-1,1680	-0,9426	-1,0393	-0,6590	-0,7501	-1,1380	-0,9275	-0,2672	-0,8966	-0,7600	-0,8667
Skewness	-0,6326	-0,4024	-0,4037	-0,3031	-0,6413	-0,4933	-0,4312	-0,3018	-0,5927	-0,3109	-0,1950	-0,1232	-0,7238	-0,5220	-0,4722	-0,0511
Range	146,81%	233,37%	250,66%	273,20%	202,58%	278,13%	338,82%	356,40%	197,79%	260,90%	293,72%	339,87%	250,83%	314,67%	332,20%	448,33%
Minimum	-5,95%	-41,63%	-45,54%	-45,97%	0,26%	-41,52%	-43,02%	-48,72%	-0,21%	-43,56%	-57,97%	-57,60%	-7,28%	-46,15%	-48,87%	-51,66%
Maximum	140,86%	191,73%	205,12%	227,23%	202,84%	236,61%	295,80%	307,68%	197,58%	217,33%	235,74%	282,27%	243,55%	268,52%	283,33%	396,68%
Observations	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
Sharpe ratio	1,7522	1,1615	1,1398	1,1320	1,9173	1,2341	1,3121	1,2766	2,0155	1,2020	1,0075	1,0469	2,0121	1,3440	1,3029	1,2461
Utility (A=1)	0,7751	0,6515	0,6853	0,7007	0,9766	0,7722	0,8592	0,8764	1,0113	0,6862	0,5838	0,6274	1,1264	0,9000	0,8516	0,8617
Utility (A=3)	0,5710	0,1679	0,0063	-0,1199	0,6838	0,0544	0,0589	-0,2418	0,7319	0,1841	-0,1756	-0,2486	0,7547	0,0487	0,0484	-0,7470
Utility (A=5)	0,3669	-0,3158	-0,6726	-0,9406	0,3910	-0,6634	-0,7415	-1,3601	0,4524	-0,3180	-0,9349	-1,1246	0,3830	-0,8026	-0,7548	-2,3557

Table 4.32: Descriptive statistics, Sharpe ratios and Utilities for bulk carrier 3-year-end returns (3-year holding period - operating strategy 3)

Vessel type/size class	Handymax bulk carriers				Panamax bulk carriers				Capesize bulk carriers			
Contract type	36 consecutive trip charters of 1 month duration				36 consecutive voyages of 1 month duration				36 consecutive voyages of 1 month duration			
Vessel age	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO	NB	5YO	10YO	15YO
Average return	110,91%	113,04%	128,51%	147,45%	100,22%	90,61%	103,63%	116,67%	126,29%	130,46%	125,76%	169,17%
Standard Deviation (Risk)	60,26%	91,16%	99,03%	118,48%	59,47%	82,32%	98,70%	109,21%	68,95%	101,62%	98,21%	140,22%
Sample Variance	36,31%	83,10%	98,07%	140,38%	35,36%	67,76%	97,43%	119,26%	47,55%	103,27%	96,45%	196,61%
Kurtosis	-0,9070	-1,2660	-1,0820	-1,1621	-0,9427	-0,9782	-1,2130	-0,9948	-0,5618	-1,0549	-0,8951	-0,8806
Skewness	-0,6091	-0,4297	-0,3529	-0,1954	-0,4974	-0,1781	-0,1183	-0,0097	-0,6445	-0,3816	-0,3891	0,0677
Range	211,30%	287,34%	364,45%	399,85%	206,35%	297,58%	333,78%	396,85%	265,59%	344,42%	347,01%	491,97%
Minimum	-7,88%	-48,31%	-51,13%	-57,34%	-23,25%	-57,75%	-65,20%	-66,30%	-22,57%	-58,64%	-60,48%	-62,92%
Maximum	203,42%	239,03%	313,32%	342,50%	183,09%	239,83%	268,58%	330,55%	243,03%	285,78%	286,53%	429,05%
Observations	78	78	78	78	78	78	78	78	78	78	78	78
Sharpe ratio	1,6986	1,1462	1,2113	1,1723	1,5414	0,9967	0,9632	0,9900	1,7074	1,1997	1,1934	1,1454
Utility (A=1)	0,9276	0,7149	0,7948	0,7726	0,8254	0,5672	0,5491	0,5703	1,0251	0,7883	0,7753	0,7086
Utility (A=3)	0,5644	-0,1161	-0,1859	-0,6312	0,4717	-0,1104	-0,4251	-0,6223	0,5497	-0,2444	-0,1892	-1,2576
Utility (A=5)	0,2013	-0,9472	-1,1666	-2,0350	0,1181	-0,7880	-1,3994	-1,8149	0,0742	-1,2770	-1,1538	-3,2237

Table 4.33: Descriptive statistics, Sharpe ratios and Utilities for bulk carrier 3-year-end returns (3-year holding period - operating strategy 4)

Contract type	3-year Time charter				
Vessel type/size class	"MR" Product tankers	Panamax "coated" tankers	Aframax tankers	Suezmax tankers	VLCCs
Vessel age	NB	NB	NB	NB	15YO
Average return	39,21%	51,39%	45,46%	49,78%	47,56%
Standard Deviation (Risk)	40,49%	46,10%	43,53%	38,42%	47,08%
Sample Variance	16,39%	21,26%	18,95%	14,76%	22,16%
Kurtosis	-1,5477	-1,4442	-1,4487	-1,5442	-1,5509
Skewness	-0,2291	-0,3668	-0,0037	-0,3462	-0,0213
Range	113,45%	136,36%	134,13%	110,85%	130,13%
Minimum	-19,70%	-26,81%	-19,88%	-12,00%	-16,72%
Maximum	93,75%	109,55%	114,25%	98,85%	113,41%
Observations	78	78	78	78	78
Sharpe ratio	0,7570	0,9291	0,8477	1,0730	0,8285
Utility (A=1)	0,3101	0,4076	0,3598	0,4240	0,3648
Utility (A=3)	0,1462	0,1951	0,1703	0,2764	0,1432
Utility (A=5)	-0,0178	-0,0175	-0,0192	0,1288	-0,0785

Table 4.34: Descriptive statistics, Sharpe ratios and Utilities for tanker 3-year-end returns (3-year holding period - operating strategy 1)

Contract type	3 consecutive 1-year time charters														
Vessel type/size class	"MR" Product tankers			Panamax "coated" tankers	Aframax tankers			Suezmax tankers			VLCCs			
Vessel age	NB	5YO	10YO	NB	NB	5YO	10YO	NB	5YO	10YO	NB	5YO	10YO	15YO
Average return	48,09%	40,97%	37,23%	51,39%	56,30%	48,17%	41,26%	62,67%	51,34%	92,43%	60,55%	50,50%	49,32%	89,25%
Standard Deviation (Risk)	48,03%	62,61%	69,98%	46,10%	51,60%	65,81%	65,09%	47,22%	55,89%	108,39%	54,24%	56,97%	64,99%	103,78%
Sample Variance	23,07%	39,20%	48,97%	21,26%	26,63%	43,31%	42,36%	22,29%	31,23%	117,47%	29,42%	32,46%	42,24%	107,70%
Kurtosis	-1,5205	-1,5119	-1,6072	-1,4442	-1,4521	-1,3924	-1,5263	-1,4674	-1,3999	-1,2948	-1,4795	-1,5224	-1,4417	-0,7600
Skewness	-0,3565	-0,0317	-0,0784	-0,3668	-0,0584	0,2305	0,1629	-0,2760	-0,0266	0,3669	0,0121	0,0574	0,1444	0,7519
Range	136,77%	201,21%	203,23%	136,36%	156,43%	211,09%	193,53%	143,93%	179,04%	364,08%	166,03%	178,63%	209,93%	381,72%
Minimum	-25,92%	-44,45%	-59,90%	-26,81%	-26,14%	-40,42%	-45,78%	-15,68%	-33,71%	-41,57%	-19,74%	-35,47%	-46,17%	-36,02%
Maximum	110,84%	156,76%	143,33%	109,55%	130,29%	170,67%	147,75%	128,25%	145,33%	322,50%	146,29%	143,15%	163,76%	345,70%
Observations	78	78	78	78	78	78	78	78	78	78	78	78	78	78
Sharpe ratio	0,8231	0,5177	0,4098	0,9291	0,9252	0,6020	0,5024	1,1462	0,7656	0,7739	0,9586	0,7363	0,6272	0,7776
Utility (A=1)	0,3655	0,2137	0,1275	0,4076	0,4298	0,2652	0,2007	0,5153	0,3573	0,3369	0,4584	0,3427	0,2820	0,3540
Utility (A=3)	0,1348	-0,1784	-0,3623	0,1951	0,1636	-0,1679	-0,2229	0,2923	0,0449	-0,8378	0,1642	0,0182	-0,1405	-0,7230
Utility (A=5)	-0,0959	-0,5704	-0,8520	-0,0175	-0,1027	-0,6009	-0,6465	0,0694	-0,2674	-2,0125	-0,1299	-0,3064	-0,5629	-1,7999

Table 4.35: Descriptive statistics, Sharpe ratios and Utilities for tanker 3-year-end returns (3-year holding period - operating strategy 2)

Contract type	36 consecutive voyages of 1 month duration															
Vessel type/size class	"MR" Product tankers			Panamax "coated" tankers		Aframax tankers				Suezmax tankers			VLCCs			
Vessel age	NB	5YO	10YO	NB	5YO	NB	5YO	10YO	15YO	NB	5YO	10YO	NB	5YO	10YO	15YO
Average return	53,73%	49,62%	49,67%	56,83%	63,22%	72,94%	67,34%	72,14%	131,07%	85,95%	75,93%	135,38%	73,43%	65,57%	74,65%	149,03%
Standard Deviation (Risk)	62,85%	81,38%	92,74%	56,87%	80,62%	65,15%	82,95%	91,52%	132,70%	61,39%	72,09%	143,50%	66,47%	71,67%	83,02%	151,74%
Sample Variance	39,50%	66,23%	86,00%	32,34%	64,99%	42,44%	68,81%	83,76%	176,08%	37,69%	51,97%	205,92%	44,18%	51,37%	68,93%	230,26%
Kurtosis	-1,5457	-1,4827	-1,6305	-1,5188	-1,3113	-1,4688	-1,3582	-1,5532	-0,7501	-1,5106	-1,4644	-1,3091	-1,4818	-1,4963	-1,4534	-1,0673
Skewness	-0,2029	0,0936	0,0241	-0,1809	0,1756	0,0603	0,3197	0,2063	0,5633	-0,0904	0,0909	0,4089	0,1346	0,1931	0,2209	0,7161
Range	176,61%	254,90%	261,94%	165,46%	260,46%	190,96%	258,12%	264,76%	491,28%	181,46%	222,64%	465,39%	195,27%	216,89%	256,11%	485,06%
Minimum	-38,29%	-56,54%	-71,10%	-30,67%	-42,39%	-25,95%	-41,47%	-45,87%	-56,69%	-12,79%	-31,33%	-36,26%	-25,77%	-40,71%	-48,38%	-12,29%
Maximum	138,32%	198,36%	190,85%	134,78%	218,07%	165,01%	216,65%	218,88%	434,59%	168,67%	191,30%	429,13%	169,51%	176,18%	207,73%	472,76%
Observations	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
Sharpe ratio	0,7188	0,5045	0,4434	0,8488	0,6781	0,9884	0,7087	0,6947	0,9233	1,2606	0,9346	0,8838	0,9760	0,7956	0,7961	0,9258
Utility (A=1)	0,3398	0,1650	0,0667	0,4066	0,3072	0,5172	0,3294	0,3026	0,4303	0,6710	0,4994	0,3242	0,5134	0,3989	0,4018	0,3390
Utility (A=3)	-0,0552	-0,4973	-0,7933	0,0831	-0,3427	0,0928	-0,3587	-0,5350	-1,3305	0,2941	-0,0203	-1,7349	0,0715	-0,1148	-0,2874	-1,9636
Utility (A=5)	-0,4502	-1,1597	-1,6533	-0,2403	-0,9925	-0,3315	-1,0468	-1,3726	-3,0914	-0,0828	-0,5400	-3,7941	-0,3703	-0,6284	-0,9767	-4,2663

Table 4.36: Descriptive statistics, Sharpe ratios and Utilities for tanker 3-year-end returns (3-year holding period - operating strategy 4)

***** There is no operating strategy 3 for a 3-year holding period for tankers**

According to tables 4.30 - 4.33, bulk carriers' risk increases with the increase in the vessels' age for all operating strategies with the only exception being 10-year old Capesizes the risk of which was found to be slightly lower than the risk of the respective 5-year old ones. As regards their average returns, these were generally found to decrease with the increase in the vessels' age when the vessels operate under a 3-year time charter contract and increase in all other operating strategies. However, in the first case, the average return on 10-year old Handysizes was found to be higher than the average return on newly built ones as well as the average returns on 10-year old Handymaxes, 15-year old Handymaxes and 15-year old Capesizes were found to be higher than the average returns on the respective younger second hand vessels. In the second case the exceptions are the 10-year old Capesizes, the average return on which was found to be lower than the average returns on the 5-year old ones and the newly built Panamaxes the average return on which was found to be higher than the average returns on all the respective second hand vessels when they operate under 3 consecutive 1-year time charter contracts or 6 consecutive 6-month time charter contracts. Similarly, the average return on newly built Handymaxes was found to be higher than the average return on 5-year old ones and the average return on newly built Capesizes higher than the average returns on the respective 5 and 10-year old vessels, when they operate under 3 consecutive 1-year time charter contracts.

In the wet bulk sector, as it is evident in tables 4.35 and 4.36, risk increases with the increase in the vessels' age for all tankers and for both operating strategies, except for 10-year old Aframaxes the risk of which was found to be slightly lower that the risk of 5-year old ones when they operate under 3 consecutive 1-year time charter contracts. On the contrary, the average returns decrease with the increase in the vessels' age except for the oldest vessels of each size class category, especially when they operate in the spot market, the average returns on which are even higher that the average returns on the newly built ones.

Moreover, bulk carriers' risk was generally found to be higher for larger vessels for all operating strategies, though several are the exceptions. Firstly, all Panamaxes (newly built and second hand) were found to be less risky than the respective Handymaxes for all operating strategies apart from newly built and 10-year old ones when they operate under a 3-year time charter contract. Secondly, when the vessels operate under a 3-year time charter contract the risk of 10-year old Capesizes was found to be lower than the risk of all other bulk carriers and the risk of the 15-year old Capesizes lower than the risk of the respective Handymaxes and Panamaxes. Finally, 10-year old Capesizes were also found to be less risky than the respective Handymaxes for the rest operating strategies as well as less risky than the 10-year old Panamaxes when both operate under 36 consecutive voyage contracts of 1 month duration. As regards the wet bulk sector, risk was found to increase with the increase in the vessels' size. However there were a lot of remarkable exceptions as it is evident in tables 4.34 – 4.36.

Similar to the previous scenarios, a comparison between the different operating strategies revealed that the risk of the vessels of all ages and sizes for both bulk carriers and tankers increases when they operate under consecutive freight contracts of shorter duration and so do their average returns. That is, the higher average returns generated in unhedged strategies come with a significant increase in the undertaken risk. In addition, bulk carriers were found to be riskier than tankers for all operating strategies.

The coefficient of skewness indicates that the distribution of the returns of all bulk carriers and tankers for all operating strategies deviate from normality and therefore, the respective risks are overestimated or underestimated. Additionally, the coefficient of kurtosis indicates underestimation of the likelihood of returns which are closer to the average return (negative excess kurtosis) for all bulk carriers and so does for tankers but to a slightly greater extent. Moreover, the minimum and maximum statistic measures indicate the highest and lowest, respectively, monthly returns observed for all vessels during the period of assessment which are again higher when the vessels operate under consecutive contracts of shorter duration. What is more, the highest and lowest returns observed in the dry bulk sector were even higher and lower respectively than the ones observed in the wet bulk sector.

Moreover, Sharpe ratios indicate once again that newly built bulk carriers and tankers of all sizes are the best investment alternatives compared to the respective second hand vessels for all operating strategies. Additionally, in the dry bulk sector the ranking of the vessels according to their age within each size class category is the same for all operating strategies except for Handymaxes, Panamaxes and Capesize when these operate under a 3 year time charter contract. More specifically, the ranking of Handysizes is newly built/5-year old/10-year old/15-year old for all operating strategies (the Sharpe ratio decreases with the increase in Handysizes' age), whereas for the rest three bulk carriers (Handymaxes, Panamaxes, Capesizes) the rankings are newly built/10-year old/5-year old/15-year old, newly built/5-year old/10-year old/15-year old, newly built/5-year old/15-year old/10-year old respectively when they operate under a 3-year time charter contract and newly built/10-year old/15-year old/5-year old, newly built/5-year old/15-year old/10-year old, newly built/5-year old/10-year old/15-year old respectively for the rest operating strategies. Similarly, in the wet bulk sector Sharpe ratio decreases with the increase in the vessels' age only for "MR" Product and Panamax tankers whereas the respective rankings for the Aframaxes, Suezmaxes and VLCCs are newly built/5-year old/10-year old, newly built/10-year old/5-year old, newly built/15-year old/5-year old/10-year old respectively when they operate under 3 consecutive 1-year time charter contracts and newly built/15-year old/5-year old/10-year old, newly built/5-year old/10-year old, newly built/15-year old/10-year old/5-year old respectively when they operate under 36 consecutive voyage contracts of 1 month duration.

What is more, in both sectors, when the vessels operate under 36 consecutive voyage contracts (36 consecutive trip charter contracts for Handymaxes), the respective Sharp ratios are lower than the ones generated in all other operating strategies. In addition to this, the Sharp ratios of bulk carries increase when they operate under consecutive time charter contracts of shorter duration thereby concluding that the employment of the vessels under 6 consecutive 6-month time charter contracts is the best operating strategy for all bulk carriers when the holding period is set to 3 years. The only exception is newly built Capesizes for which the best operating strategy is the 3 consecutive 1-year time charters. On the contrary, the best operating strategy for tankers was found to be the 36 consecutive voyages of 1 month duration with the only exceptions being newly built and 5-year old "MR" Product tankers as well as newly built Panamax "Coated" and Suezmax tankers the Sharpe ratio of which was found to be higher when the operate under 3 consecutive 1-year time charter contracts.

Furthermore, by comparing the Sharp ratios across different vessel sizes in both sectors for each of the operating strategies, specific rankings can be obtained per vessel age. All these rankings are clearly distinguishable in tables 4.30 – 4.36. For example, when newly built tankers operate under a 3-year time charter contract the generated ranking is Suezmax/Panamax "Coated"/Aframax/VLCC/"MR" Product whereas when they operate under 3 consecutive 1-year time charter contracts or 36 consecutive voyages of 1 month duration the respective rankings are Suezmax/ VLCC /Panamax "Coated"/Aframax/ "MR" Product and Suezmax/ Aframax / VLCC /Panamax "Coated" /"MR" Product.

Last but not least, the investors' utilities produce different rankings for some vessels compared to the ones produced by Sharpe ratios as well as different rankings for investors with different risk preferences. In addition, as in the previous two cases, they produce different rankings for different operating strategies for some vessels as well as they deteriorate when the vessels operate under consecutive contracts of shorter duration. These rankings are quite a lot to be presented so they can easily be obtained from tables 4.30 – 4.36. For instance, the ranking of VLCCs which operate under a 3-consecutive 1-year time charter contracts is newly built/15-year old/5-year old/10-year old for an investor with a degree of risk aversion equal to 1 and newly built/5-year old/10-year old/15-yaear old for an investor with a degree of risk aversion equal to 3. For the second investor this ranking is retained when the VLCCs operate under 36 consecutive voyage contracts of 1 month duration but his/her utility deteriorates whereas for the first investor not only the utility deteriorates but also the ranking of VLCCs changes to newly built /10-year old/5-year old/15-year old.

The ranking of all bulk carriers and tankers for all operating strategies, according to Sharpe ratio and the utilities of investors with different risk preferences can be obtained from tables 4.30 and 4.36.

Chapter 5 Portfolio risk management

5.1 Portfolio selection problem

Investors in all sectors of the economy have to deal with the uncertainty that characterizes the outcomes of their investment decisions. More specifically, at the time of the investment decision, the returns on the available investment alternatives over a specified holding period are unknown and cannot be precisely predicted. Therefore, investors have difficulty in defining which of them to select. The standard investment advice would have been to place their given amount of wealth only to the ones from which they expect the highest possible gains, constructing in this way a portfolio only from these. However, investors are not only interested in higher gains but also in more certain gains which means that at the time of the investment decision they have to balance, against each other, two conflicting objectives.

In view of this, let's say conflicting situation, Harry Markowitz (1952) suggested that investors should not treat each investment alternative in isolation but collectively, thus selecting not only one of them but several. This means that, the investors' portfolios should comprise of multiple securities or assets with different risk-reward characteristics. In this case, the overall risk can be reduced. That is, "*Diversification reduces risk*", the basic premise of the Modern Portfolio theory.

Based on the random walk hypothesis, the Modern portfolio theory is simply a mathematical model for risk reduction through diversification. It treats the one-period returns on various securities as random variables thus making them capable of being assigned expected values, standard deviations and correlations. The expected returns and standard deviations of the these securities are the only inputs for the measurement of the portfolio's expected return and standard deviation while the correlations play the most important role in the diversification mechanism. More specifically, the expected return on the portfolio is equal to the weighted average of the expected returns on its component securities and as long as these expected returns on individual securities are not perfectly and positively correlated, the portfolio's standard deviation is less than the weighted average of the standard deviations of the securities.

5.2 Portfolio's risk and return

If a portfolio comprises of a number of risky securities each one of which has a specific weight in it, the expected return is given by the following formula:

$$E(r_p) = \sum_{i=1}^{N} w_i E(r_i) \qquad (5.1)$$

Where,

N = the number of securities

w_i = the weight of security i in the portfolio, i.e. the proportion of the investor's wealth invested in security i

$E(r_p)$ = the expected return on the portfolio and

$E(r_i)$ = the expected return on security i (for historical data this is the average return on security i calculated for a specific sample)

Additionally, the sum of the security weights should be equal to 1, i.e. $\sum_{i=1}^{N} w_i = 1$ (based on the assumption that investors have a given amount of wealth available to invest in risky securities)

The portfolio's risk is given by its variance or standard deviation. The variance of the portfolio can be calculated according to the following formula:

$$\sigma_p^2 = \sum_{i=1}^{N} \sum_{j=1}^{N} w_i w_j Cov(r_i, r_j) \quad (5.2)$$

(Double summation: the formula includes both variances and covariances)

Where

σ_p^2 = the portfolio's variance

w_i, w_j = the weights of security i and j respectively in the portfolio, i.e. the proportions of the investor's wealth invested in each one of securities i and j and

$Cov(r_i, r_j)$ = the covariance between the return on security i and the return on security j

The covariance is a statistical measure which describes the relationship between these two variables and more specifically their relative movement.

- Positive covariance (large positive value) means that the returns on securities i and j move in the same direction (e.g. both of them are higher than average at the same time)
- Negative covariance (large negative value) means that the returns on securities i and j move in the opposite direction (e.g. the returns on security i are higher than average while and the returns on security j are lower than average)
- Low or zero covariance indicates little or no relationship between the returns on securities i and j.

The covariance between the returns on securities i and j is given by the following formula:

$$Cov(r_i, r_j) = \rho_{ij} \sigma_i \sigma_j \quad (5.3)$$

Where,

ρ_{ij} = the correlation coefficient between the returns on securities i and j

σ_i = the standard deviation of the returns on security i

σ_j = the standard deviation of the returns on security j

Whether the covariance between the returns on the securities i and j is positive, negative or zero, depends on the correlation coefficient since $-1 \leq \rho \leq 1$.

If $\rho=1$, the correlation between the returns on securities i and j is perfect positive

If $\rho=-1$, the correlation between the returns on securities i and j is perfect negative

If -1<ρ<1, the correlation between the returns on securities i and j is "normal" and

If ρ = 0, there is no correlation between the returns on securities i and j

The following figure illustrates differently correlated returns on two securities i and j.

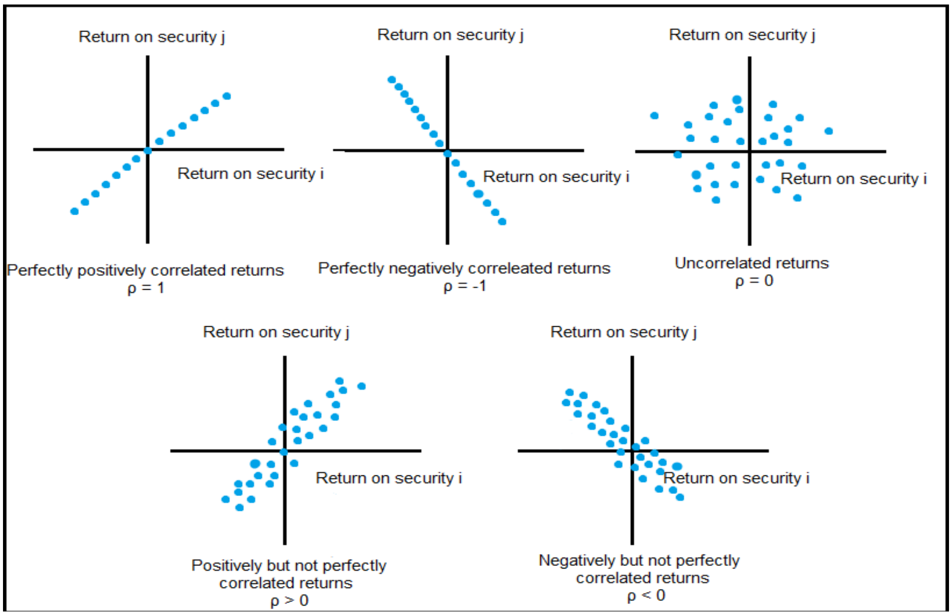


Figure 5.1: Correlation between the returns on two securities i and j

The portfolio's standard deviation is simply the square root of its variance:

$$\sigma_p = \sqrt{\sigma_p{}^2} \qquad (5.4)$$

5.3 Illustration of how diversification reduces risk

As we mentioned in section 5.1 of this chapter, Markowitz argued that investors should diversify by investing not only in one investment alternative but in several, since in this way risk can be reduced. In addition, the more diversified a portfolio becomes the greater the risk reduction is. The following figure illustrates this argument.

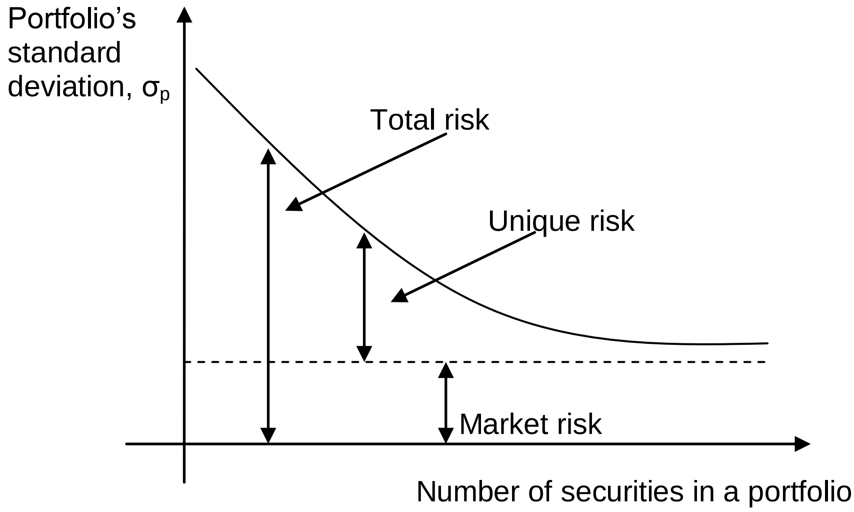


Figure 5.2: Diversification and risk reduction

More specifically, figure 5.2 shows that by increasing the number of securities in a portfolio we do manage to reduce risk, though not eliminate it completely, even after extensive diversification. In fact, the diversification results in the unique risk's elimination, i.e. the risk which is associated with the component securities. The unique risk is also known as diversifiable or unsystematic risk. What remains, is the market or systematic risk, which is attributable to economy-wide factors that not only affect the individual securities but also the economy as a whole. This risk cannot be eliminated.

Consider for example a portfolio that comprises of N securities as described by Brealey, Myers and Allen (2008). Assume also that the securities are equally weighted in the portfolio (w = 1/N). The following table is the variance-covariance matrix, a tool which helps us calculate the portfolio's variance.

	Security 1	**Security 2**	**…**	**Security N**
Security 1	$(1/N)^2$xAv.Var.	$(1/N)^2$xAv.Cov.	**…**	$(1/N)^2$xAv.Cov.
Security 2	$(1/N)^2$xAv.Cov.	$(1/N)^2$xAv.Var.	**…**	$(1/N)^2$xAv.Cov.
…	**…**	**…**	$(1/N)^2$xAv.Var.	**…**
Security N	$(1/N)^2$xAv.Cov.	$(1/N)^2$xAv.Cov.	**…**	$(1/N)^2$xAv.Var.

Table 5.1: Variance – Covariance matrix of a portfolio that comprises of N securities

As can be seen, the portfolio's variance is the sum of N variances (diagonal) and N^2-N covariances. Mathematically this can be expresses as follows:

$$\text{Portfolio variance} = N\left(\frac{1}{N}\right)^2 Av.Var. + (N^2 - N)\left(\frac{1}{N}\right)^2 Av.Cov. =$$

$$= \left(\frac{1}{N}\right) Av.Var. + \left(1 - \frac{1}{N}\right) Av.Cov.$$

As the number of securities in the portfolio increase to infinite, Portfolios variance becomes equal to the Average covariance. That is the market risk.

5.4 The two-asset portfolio

Suppose that a portfolio comprises of two securities or assets with different risk-return profiles. Asset A has a higher expected return [$E(r_A)$] and a higher standard deviation (σ_A), whereas asset B has a lower expected return [$E(r_B)$] and a lower standard deviation (σ_B).

In this case, the Expected return on this portfolio is:

$$E(r_p) = w_A E(r_A) + w_B E(r_B) \qquad (5.5)$$

where $w_A + w_B = 1$

And the portfolio's variance and standard deviation is:

$$\sigma_p^2 = w_A^2 \sigma_A^2 + w_B^2 \sigma_B^2 + 2 w_A w_B \rho_{A,B} \sigma_A \sigma_B \qquad (5.6)$$

and $\sigma_p = \sqrt{\sigma_p^2}$ respectively

Both assets can be plotted in terms of their risk-return characteristics in a system of axes in which the Y-axis corresponds to the expected return and the X-axis to the standard deviation.

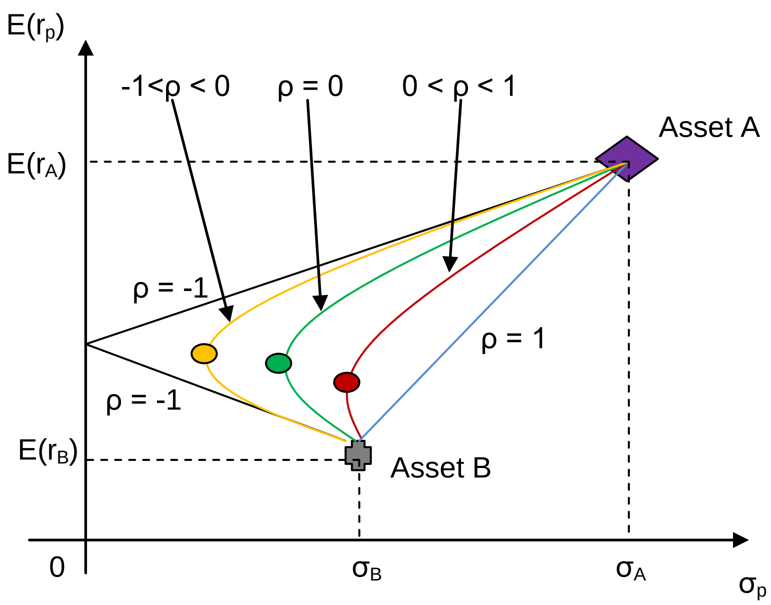


Figure 5.3: The effect of correlation

The colored curves in figure 5.3 represent the opportunity or feasible set for different values of the correlation coefficient. The opportunity or feasible set can be defined as all possible combinations of portfolio's expected return and standard deviation that can be constructed by these two assets. Every point on a curve corresponds to a different portfolio and every portfolio corresponds to a different mix of assets A and B (different weights). Investors can select any of these portfolios based on their risk tolerance. More risk tolerant investors select portfolios with a higher weight for asset A and conversely more risk-averse investors select portfolios with a higher weight for asset B. The most risk-averse investor will chose the portfolio with the minimum variance, the one represented by the colored dot on each curve. The part of a curve from the minimum variance portfolio to asset A is the efficient set or efficient frontier, i.e. all the portfolios that offer the higher expected return for different levels of risk and lower risk for different levels of expected return. No points under or above the curves are feasible.

As far as the effect of correlation is concerned, if $\rho_{A,B} = 1$, the portfolios variance is:

$$\sigma_p{}^2 = w_A{}^2\sigma_A{}^2 + w_B{}^2\sigma_B{}^2 + 2w_A w_B \rho_{A,B}\sigma_A\sigma_B \overset{\rho_{A,B}=1}{\Leftrightarrow}$$

$$\sigma_p{}^2 = w_A{}^2\sigma_A{}^2 + w_B{}^2\sigma_B{}^2 + 2w_A w_B \sigma_A\sigma_B \Leftrightarrow$$

$$\sigma_p{}^2 = (w_A\sigma_A + w_B\sigma_B)^2$$

And therefore its standard deviation is:

$$\sigma_p = \sqrt{\sigma_p{}^2} \Leftrightarrow$$

$$\sigma_p = w_A\sigma_A + w_B\sigma_B \tag{5.7}$$

That is, when the returns on the two assets are positively and perfectly correlated, the portfolio's standard deviation is equal to the weighted average of the standard deviations of these assets and therefore, there are no benefits from diversification.

On the other hand, as the correlation coefficient decreases we observe that for a given level of Expected return the portfolio's standard deviation decreases or for a given level of risk (standard deviation) the portfolio's Expected return increases. Hence, the closer the value of the correlation coefficient to -1, the greater the benefits from diversification. In case the correlation coefficient is equal to -1 (perfect negative correlation) the benefits from diversification are the maximum that can be achieved.

5.5 Multiple-asset portfolio and risk preference

If a portfolio comprises of more than two assets, let's say N, the feasible set is the enclosed area (including the boundaries) depicted in figure 5.4 and represents all portfolios that can be constructed from these N assets.

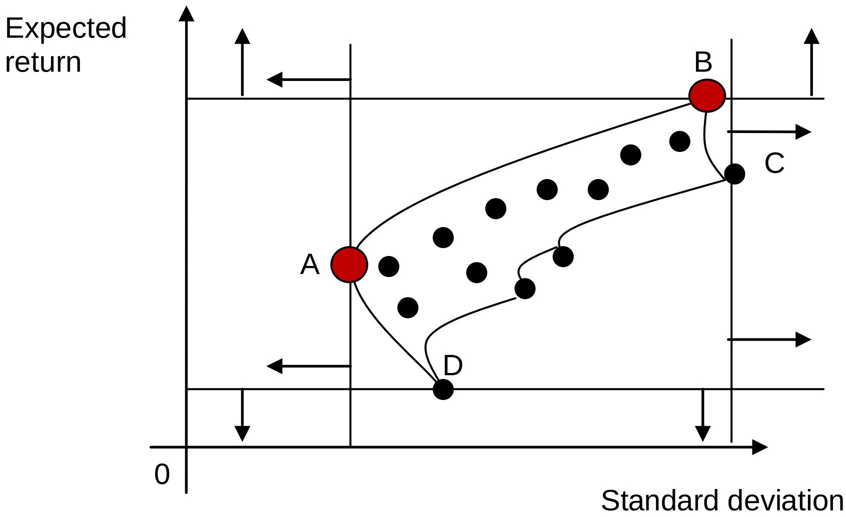


Figure 5.4: Efficient frontier

If we drag a vertical line to left, we will see that no other portfolio offers less risk than portfolio A (minimum variance) and if we drag it to the right, we will see that no other portfolio offers more risk than portfolio C. Similarly, if we drag a horizontal line up we will see that no other portfolio offers higher expected return than portfolio B and if we drag it down we will see that no other portfolio offers less expected return than portfolio D.

Therefore, there are no other portfolios that offer higher expected return for different levels of risk and no other portfolios that offer minimum risk for different levels of expected return, except for the ones that lie on the boundary between A and B. This boundary is the efficient frontier or efficient set. All portfolios that lie directly on the efficient set are efficient portfolios whereas all portfolios that lie below it are inefficient portfolios. Finally, portfolios above the efficient set are unobtainable.

Every rational investor who seeks the maximum possible expected return for the lowest possible risk selects an optimum portfolio that lies on the efficient set based on his/her risk preference (investors are considered risk averse). More specifically each investor selects the portfolio that maximizes his/her utility. This is the one that lies at the point where the respective utility curve is tangent to the efficient set. Figure 5.5 illustrates the selection of the portfolio that maximizes the utilities of three investors with different risk preference:

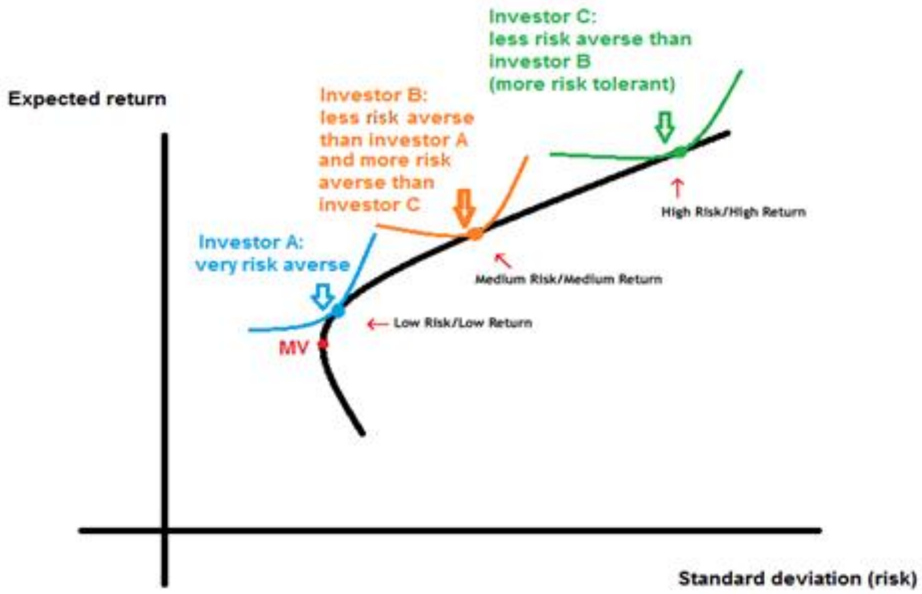


Figure 5.5: Portfolio selection by means of utility curves for investors with different risk preferences

5.6 Efficient frontier calculation

Given the fact that the multiple-asset portfolio's expected return and variance can be calculated by means of formulas 5.1 – 5.2, the efficient frontier can be mathematically expressed and created by means of excels' solver as follows:

For a predefined level of expected return, find the portfolio with the minimum variance (risk).

$$\text{Minimize} \sum_{i=1}^{N}\sum_{j=1}^{N} w_i w_j Cov(r_i,r_j)$$

Subject to:

$$\sum_{i=1}^{N} w_i E(r_i) \geq \text{desired level of expected return}$$

$$\sum_{i=1}^{N} w_i = 1$$

$$w_i \geq 0$$

Or

For a predefined level of variance (risk), find the portfolio with the maximum expected return.

$$\text{Maximize} \sum_{i=1}^{N} w_i E(r_i)$$

Subject to:

$$\sum_{i=1}^{N}\sum_{j=1}^{N} w_i w_j \mathrm{Cov}(r_i, r_j) \leq \text{desired variance (level of risk)}$$

$$\sum_{i=1}^{N} w_i = 1$$

$$w_i \geq 0$$

5.7 Application in shipping

Having established the theoretical basis for the construction of efficient portfolios, we now apply it to shipping. The components of the shipping portfolio will be all the vessels we described in section 3.2.1 of chapter 3.

5.7.1 The two-ship portfolio

The aim of this section is to evaluate the risk-return profile of a portfolio which consists of two vessels and illustrate the benefit of diversifying in shipping. For this reason we selected a 10 year old Capesize bulk carrier and a 5 year old “MR” Product tanker, which have different (high – low respectively) risk-return profiles.

Figure 5.6 illustrates the movement of the monthly returns of these two vessels as well as their average level for the period of time between January 2002 and May 2011.

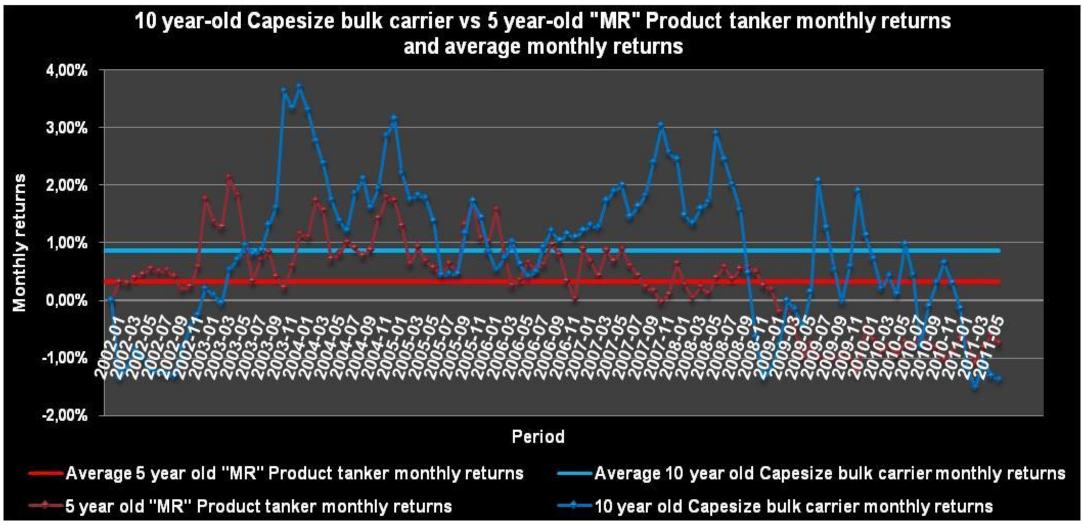


Figure 5.6: 10 year-old Capesize bulk carrier and 5 year-old “MR” Product tanker monthly returns and average monthly returns (1/2002 – 05/2011).

The relative higher risk-return profile of the 10 year old Capesize bulk carrier compared to the one of the 5 year old “MR” Product tanker is noticeable in the higher average level of its monthly returns and their higher dispersion from this average level throughout the whole period of assessment.

Assuming that the weights w_C and w_{MR} of these vessels in a two ship portfolio are equal (50%-50%), the expected return of this portfolio, $E(r_p)$, is given by the weighted average of their expected returns. Since we are based on historical data, the expected returns of the individual vessels are their respective mean monthly returns, r_C and r_{MR}, which were found to be 0.86% for the 5-year old Capesize and 0.33% for the 5-year old “MR” Product tanker. Therefore,

$$E(r_p) = (w_C \text{ x } r_C) + (W_{MR} \text{ x } r_{MR}) = (0.50 \text{ x } 0.0086) + (0.50 \text{ x } 0.0033) =$$

$$= 0.00430 + 0.00165 = 0.00595 \text{ or } 0.595\%$$

Furthermore, as we can see in figure 5.6, the returns on these two vessels do not move exactly together as well as for some small intervals within the period of assessment the move in opposite directions.

The correlation coefficient between the monthly returns of these two vessels is given in the following correlation matrix:

	10 year-old Capesize bulk carrier	**5 year-old “MR” Product tanker**
10 year-old Capesize bulk carrier	1	
5 year-old “MR” Product tanker	0.3746	1

As we can see, $0 < \rho_{10YO\ C,\ 5YO\ MR} < 1$ which means that the monthly returns on the vessels are positively but not perfectly correlated and therefore there will be diversification benefits if we include them in a two ship portfolio.

The two ship portfolio's risk is calculated by means of the following variance-covariance matrix:

	5 year-old Capesize bulk carrier	**5 year-old "MR" Product tanker**
5 year-old Capesize bulk carrier	$W_C^2 \times \sigma_C^2$ $0.50^2 \times 0.0126^2$ **0.00003970**	$W_C \times W_{MR} \times \sigma_{C,MR}$ $W_C \times W_{MR} \times \rho_{C,MR} \times \sigma_C \times \sigma_{MR}$ 0.50 x 0.50 x 0.3746 x 0.0126 x 0.0080 **0.00000945**
5 year-old "MR" Product tanker	$W_{MR} \times W_C \times \sigma_{MR,C}$ $W_{MR} \times W_C \times \rho_{MR,C} \times \sigma_{MR} \times \sigma_C$ 0.50 x 0.50 x 0.3746 x 0.0080 x 0.0126 **0.00000945**	$W_{MR}^2 \times \sigma_{MR}^2$ $0.50^2 \times 0.0080^2$ **0.00001602**

Therefore, the variance of this two ship portfolio is:

$$\sigma^2 = W_C^2 \times \sigma_C^2 + W_{MR}^2 \times \sigma_{MR}^2 + 2 \times W_C \times W_{MR} \times \rho_{C,MR} \times \sigma_C \times \sigma_{MR} =$$

$$= 0.00003970 + 0.00001602 + (2 \times 0.00000945) =$$

$$= 0.00007462 \text{ or } 0.007462\%$$

…and its standard deviation is:

$$\sigma=\sqrt{\sigma^2}= \sqrt{0{,}00007462}=0.00864 \text{ or } 0.864\%$$

Had the vessels been perfectly positively correlated, the portfolios standard deviation whould have been equal to the weighted average of the standard deviations of the monthly returns of the individual vessels, or more specifically, by means of formula (5.7):

$$(W_C \times \sigma_C) + (W_{MR} \times \sigma_{MR}) = (0.50 \times 0.0126) + 0.50 \times 0.0080) =$$

$$= 0.0063 + 0.0040 = 0.0103 \text{ or } 1.03\% > 0.864\%$$

The fact that the standard deviation of the two ship portfolio these two vessels form is less than the weighted average of the standard deviations of their individual monthly returns, is the benefit of diversification. Should the monthly returns of the individual vessels were not only imperfectly correlated but also negatively correlated, these benefits would have been even greater. In addition, the diversification opportunities are generaly greater in shipping portfolios that consist of more that two vessels as described in the next section of this chapter.

5.7.2 The multiple-ship portfolio

Due to the volatility in vessels' prices and daily earnings, investors are exposed to substantial risks when the place their wealth in the shipping market. Therefore, in seek of the maximum return for the lowest possible risk, they would prefer to diversify by acquiring several vessels of different type, size and age as well as by employing these vessels under different freight contracts.

As described in chapter 3, for the purpose of this paper, we considered 4 scenarios of vessels' purchase, operation and sale which differ in the investment or holding period. Moreover, for each holding period, we assumed that the vessels can operate under either a freight contract of the same duration or under a series of a specific freight contract of shorter duration (if applicable).

If the holding period is set to 1 month, all vessels operate under voyage contracts (trip charter contracts for Handymax bulk carriers) of 1 month duration and therefore shipping investors can diversify only by acquiring several vessels of different type, size and age.

On the other hand, if the holding period is set to 6 months, 1 year or 3 years, vessels can operate under time charter contracts of the same duration, consecutive time charter contracts of shorter duration (not applicable when the holding period is set to 6 months), or consecutive voyages of 1 month duration. Hence, shipping investors can also diversify by selecting different operating strategies.

In this section we will estimate and present the efficient shipping portfolios for all the above mentioned cases.

- **Efficient shipping portfolios based on monthly returns**

Table 5.2 is the correlation matrix for the monthly returns on all vessels of all types, sizes and ages. As we can see, better diversification opportunities lie between vessels of different type and especially between tankers and bulk carriers which differ in size and age. More specifically, the greater this size and age difference, the lower the correlation between the monthly returns on the respective vessels. As regards the size difference, this is due to the fact that each sector is affected by different factors since the vessels engage in the trade of different commodities as well as to the fact that smaller vessels are more versatile than larger ones in terms of the routes they serve. As a result their daily earnings and prices do not move together and this is transmitted to their returns. In addition good diversification opportunities lie between large and small vessels in the wet bulk sector which can be attributed to the fact that smaller tankers engage in oil products transportation, while larger ones in crude oil transportation. Therefore, vessel prices and daily earnings, being again affected by different factors, do not move together which in turn affects differently their returns. On the other hand, the returns on all bulk carriers are more correlated with each other because of the high degree of substitution among them in terms of the cargoes they carry and the routes they serve (Alizadeh and Nomikos, 2009).

With respect to different vessel ages we observe that the returns on newly built and second hand tankers are highly correlated due to the fact that their prices were moving together throughout the whole period of assessment. On the contrary, the returns on newly built and second hand bulk carriers are less (but still highly) correlated. During the period of assessment the dry bulk sector was booming and as a result the bulk carrier second hand prices increased sharply while newbuilding ones increased less and more smoothly. That is also why the returns on all second hand bulk carriers are highly correlated with each other and so are the monthly returns on all newly built bulk carriers.

	NB HM BC	5YO HM BC	10YO HM BC	15YO HM BC	NB P BC	5YO P BC	10YO P BC	15YO P BC	NB C BC	5YO C BC	10YO C BC	15YO C BC	NB MR P T	5YO MR P T	10YO MR P T	NB P T	5YO P T	NB A T	5YO A T	10YO A T	15YO A T	NB S T	5YO S T	10YO S T	NB VLCC	5YO VLCC	10YO VLCC	15YO VLCC
NB HM BC	1																											
5YO HM BC	0,84050	1																										
10YO HM BC	0,87427	0,97028	1																									
15YO HM BC	0,82046	0,98168	0,96369	1																								
NB P BC	0,97710	0,85604	0,87886	0,83172	1																							
5YO P BC	0,90964	0,94888	0,95765	0,94116	0,93766	1																						
10YO P BC	0,83167	0,96367	0,94128	0,95961	0,88274	0,96535	1																					
15YO P BC	0,84099	0,96753	0,95324	0,96909	0,88484	0,97524	0,98801	1																				
NB C BC	0,93909	0,84373	0,83768	0,81664	0,95872	0,89980	0,86986	0,85821	1																			
5YO C BC	0,75068	0,89900	0,86043	0,88355	0,81101	0,88635	0,93120	0,90962	0,87213	1																		
10YO C BC	0,81677	0,91061	0,88775	0,89782	0,86004	0,91632	0,94229	0,92912	0,91310	0,97236	1																	
15YO C BC	0,75973	0,89430	0,88142	0,88519	0,80761	0,89699	0,92881	0,91646	0,85816	0,96683	0,97473	1																
NB MR P T	0,29942	0,43165	0,30925	0,45882	0,28317	0,36119	0,42438	0,41813	0,37582	0,40877	0,44797	0,36449	1															
5YO MR P T	0,20749	0,36690	0,22242	0,38805	0,20210	0,27621	0,36098	0,34283	0,30544	0,37031	0,37457	0,29260	0,97201	1														
10YO MR P T	0,24226	0,45135	0,31052	0,47287	0,23793	0,34404	0,43191	0,42054	0,33397	0,43467	0,43306	0,36138	0,95808	0,97325	1													
NB P T	0,23535	0,37545	0,27168	0,37923	0,21565	0,30115	0,35393	0,34690	0,30879	0,35391	0,39356	0,32854	0,91089	0,88205	0,88170	1												
5YO P T	0,09767	0,23144	0,10717	0,22333	0,08670	0,14435	0,21215	0,19332	0,20342	0,25285	0,26193	0,19966	0,84710	0,87358	0,84953	0,95555	1											
NB A T	0,32087	0,48713	0,36019	0,47573	0,34286	0,42769	0,48900	0,47329	0,43520	0,48568	0,50175	0,45203	0,83456	0,82576	0,79620	0,78484	0,74170	1										
5YO A T	0,22641	0,39893	0,25685	0,37741	0,26892	0,33843	0,41299	0,38856	0,36252	0,42742	0,42208	0,37533	0,76727	0,79758	0,75824	0,70949	0,71015	0,96817	1									
10YO A T	0,22369	0,45332	0,31202	0,42749	0,27736	0,37980	0,46158	0,43835	0,35782	0,47535	0,44805	0,42432	0,72421	0,76223	0,74639	0,68499	0,67725	0,94475	0,97731	1								
15YO A T	0,14907	0,39579	0,25500	0,39953	0,19631	0,31216	0,42158	0,38742	0,28991	0,43203	0,41621	0,38834	0,78925	0,80904	0,77410	0,72202	0,69789	0,94992	0,95209	0,94619	1							
NB S T	0,40048	0,55913	0,46049	0,52425	0,43091	0,52624	0,55334	0,55657	0,48909	0,54048	0,54626	0,53165	0,67678	0,66050	0,66774	0,66789	0,62482	0,90510	0,88041	0,89919	0,81974	1						
5YO S T	0,35847	0,49574	0,40975	0,46577	0,38478	0,48000	0,49248	0,50229	0,45246	0,48943	0,50401	0,49966	0,60460	0,58846	0,58897	0,60723	0,57473	0,86560	0,84954	0,86473	0,77402	0,97397	1					
10YO S T	0,27062	0,54428	0,42332	0,51267	0,33430	0,47222	0,54664	0,53842	0,39337	0,55406	0,50678	0,52383	0,60017	0,62909	0,66712	0,57863	0,56596	0,81487	0,83867	0,90369	0,80339	0,92485	0,88928	1				
NB VLCC	0,42913	0,58632	0,48524	0,55745	0,45360	0,53708	0,58562	0,57140	0,50607	0,56399	0,56643	0,54895	0,67631	0,68048	0,69335	0,66820	0,63733	0,84347	0,81717	0,83622	0,76829	0,90481	0,84639	0,86989	1			
5YO VLCC	0,40657	0,55668	0,45975	0,52407	0,43528	0,51821	0,55951	0,54520	0,49539	0,55729	0,55644	0,53847	0,62207	0,63775	0,65022	0,62354	0,60823	0,81398	0,80618	0,82823	0,74016	0,89334	0,86153	0,86761	0,98323	1		
10YO VLCC	0,31109	0,51589	0,41166	0,48463	0,34861	0,45889	0,52070	0,50235	0,40743	0,52096	0,50810	0,50499	0,60108	0,62728	0,64494	0,61611	0,60886	0,80038	0,80370	0,83924	0,75787	0,87823	0,84531	0,88611	0,97027	0,98873	1	
15YO VLCC	0,23504	0,39619	0,30872	0,35421	0,27583	0,36977	0,41162	0,38924	0,33206	0,41556	0,40175	0,41990	0,47257	0,50739	0,50713	0,50960	0,53185	0,72287	0,75037	0,79045	0,68958	0,82009	0,81371	0,83295	0,89858	0,93585	0,94966	1

Table 5.2: Correlation matrix for monthly returns on the vessels under assessment

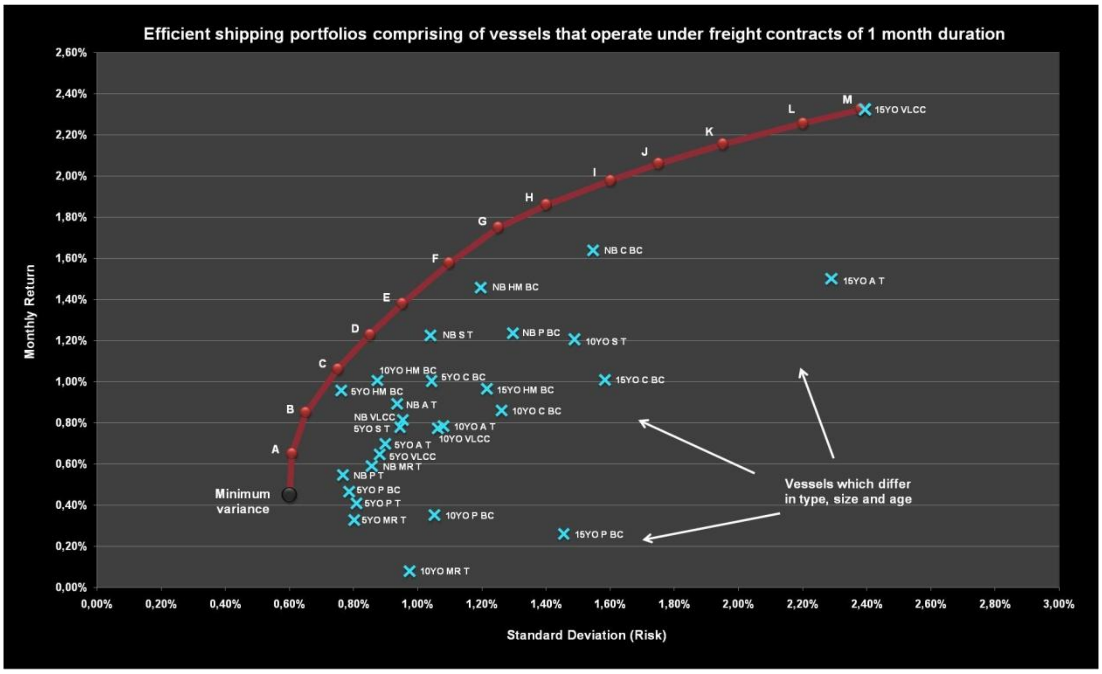


Figure 5.7: Efficient frontier based on monthly returns

	NB HM BC	5YO HM BC	5YO P BC	NB C BC	5YO MR P T	NB P T	5YO P T	5YO A T	NB S T	15YO VLCC	Monthly return	SD	VAR
MV	0,00%	2,21%	49,70%	0,00%	0,15%	0,00%	47,94%	0,00%	0,00%	0,00%	0,45%	0,60%	0,0036%
A	0,00%	42,31%	13,57%	0,00%	0,00%	0,00%	44,12%	0,00%	0,00%	0,00%	0,65%	0,61%	0,0037%
B	4,28%	59,51%	0,00%	0,00%	0,00%	0,22%	25,75%	3,01%	7,24%	0,00%	0,85%	0,65%	0,0042%
C	17,55%	42,15%	0,00%	0,00%	0,00%	14,14%	0,00%	0,00%	25,87%	0,30%	1,06%	0,75%	0,0056%
D	29,75%	30,67%	0,00%	0,00%	0,00%	3,51%	0,00%	0,00%	32,40%	3,67%	1,23%	0,85%	0,0072%
E	42,01%	21,05%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	26,76%	10,18%	1,38%	0,95%	0,0090%
F	62,05%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	19,10%	18,85%	1,58%	1,10%	0,0120%
G	66,37%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	33,63%	1,75%	1,25%	0,0156%
H	53,57%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	46,43%	1,86%	1,40%	0,0196%
I	21,95%	0,00%	0,00%	22,85%	0,00%	0,00%	0,00%	0,00%	0,00%	55,20%	1,98%	1,60%	0,0256%
J	0,00%	0,00%	0,00%	38,70%	0,00%	0,00%	0,00%	0,00%	0,00%	61,30%	2,06%	1,75%	0,0306%
K	0,00%	0,00%	0,00%	24,86%	0,00%	0,00%	0,00%	0,00%	0,00%	75,14%	2,15%	1,95%	0,0380%
L	0,00%	0,00%	0,00%	9,95%	0,00%	0,00%	0,00%	0,00%	0,00%	90,05%	2,26%	2,20%	0,0484%
M	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	100,00%	2,32%	2,38%	0,0567%

Table 5.3: Optimal vessel weightings based on monthly returns

In this case the investors' holding period is set to 1 month and therefore diversification can be achieved only by selecting vessels of different type, size and age. As table 5.3 shows, the minimum variance portfolio comprises of 2.21% 5-year old Handymax bulk carriers, 49.70% 5-year old Panamax bulk carriers, 0.15% 5-year old "MR" Product tankers and 47.94% 5-year old Panamax "Coated" tankers, all operating under freight contracts of 1 month duration. As we increase the desire return, the more risky newly built Handymax bulk carriers and Suezmax tankers are included in the efficient portfolios and the proportions of the less risky ones decrease. Furthermore, we can see that there are always vessels of both types in the efficient portfolios because better diversification opportunities lie between vessels of different type. These opportunities are especially higher when the vessels differ not only in type but also in size and age. That is why the portfolios which are closer to the minimum variance portfolio and have relative low expected return and risk include newly built Handymax bulk carriers and 15-year old VLCCs. Finally the portfolios which offer higher expected return comprise of newly built Capesize bulk carriers and 15-year old VLCCs. No 10 or other 15-year old vessels are included in the efficient portfolios.

- **Efficient shipping portfolios based on semi-annual returns**

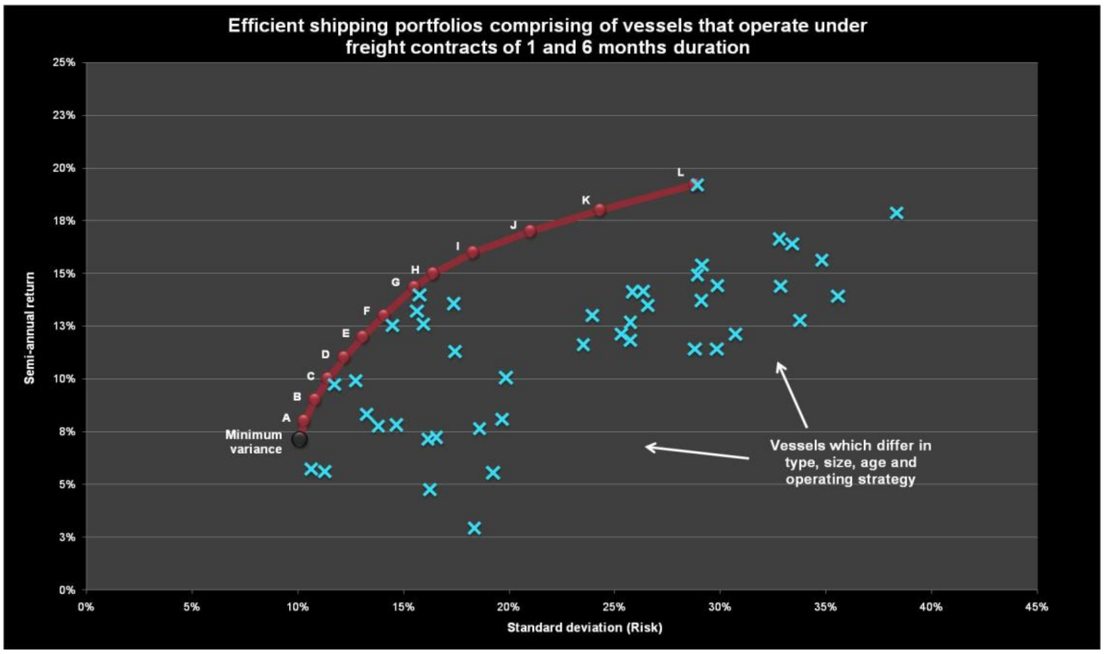


Figure 5.8: Efficient frontier based on semi-annual returns

	NB HS BC 6M TC	NB HM BC 6M TC	NB C BC 6M TC	NB P T 6X1M SP	NB S T 6X1M SP	15YO VLCC 6X1M SP	Semi-annual return	SD	VAR
MV	34,95%	0,00%	0,00%	65,05%	0,00%	0,00%	7,13%	10,12%	1,02%
A	56,55%	0,00%	0,00%	43,45%	0,00%	0,00%	8,00%	10,30%	1,06%
B	62,06%	0,00%	0,00%	19,38%	18,56%	0,00%	9,00%	10,81%	1,17%
C	58,32%	5,84%	1,66%	0,99%	33,18%	0,00%	10,00%	11,44%	1,31%
D	42,83%	13,41%	15,21%	0,00%	26,59%	1,96%	11,00%	12,20%	1,49%
E	31,65%	18,03%	27,62%	0,00%	16,92%	5,78%	12,00%	13,08%	1,71%
F	20,55%	22,51%	40,07%	0,00%	7,24%	9,63%	13,00%	14,07%	1,98%
G	0,00%	28,96%	56,50%	0,00%	0,00%	14,54%	14,33%	15,51%	2,41%
H	0,00%	6,43%	72,31%	0,00%	0,00%	21,25%	15,00%	16,40%	2,69%
I	0,00%	0,00%	61,38%	0,00%	0,00%	38,62%	16,00%	18,29%	3,35%
J	0,00%	0,00%	42,26%	0,00%	0,00%	57,74%	17,00%	21,02%	4,42%
K	0,00%	0,00%	23,14%	0,00%	0,00%	76,86%	18,00%	24,31%	5,91%
L	0,00%	0,00%	0,00%	0,00%	0,00%	100,00%	19,21%	28,77%	8,27%

Table 5.4: Optimal vessel weightings based on semi-annual returns

In this case investors can also diversify by selecting either to employ the bulk carriers under freight contracts of 1 month duration or 6 months duration. The tankers can only operate on the spot market. The minimum variance portfolio comprises of 34.95% newly built Handysize bulk carriers operating under 6-month time charter contracts and 65.05% newly built Suezmax tanker operating under consecutive voyage contracts of 1 month duration. As we increase the desired return newly built Handymax and Capesize bulk carriers operating under 6-month time charter contracts are included in the efficient portfolios while the portfolios which offer even higher expected returns comprise again of newly built Capesize bulk carriers and 15-year old VLCCs operating under 6-month time charter contracts and consecutive voyage contracts of 1 month duration respectively. Apart from the 15-year old VLCCs no other second hand vessels are included in the efficient portfolios. In addition no bulk carriers operating under monthly freight contracts are included in them.

- **Efficient shipping portfolios based on annual returns**

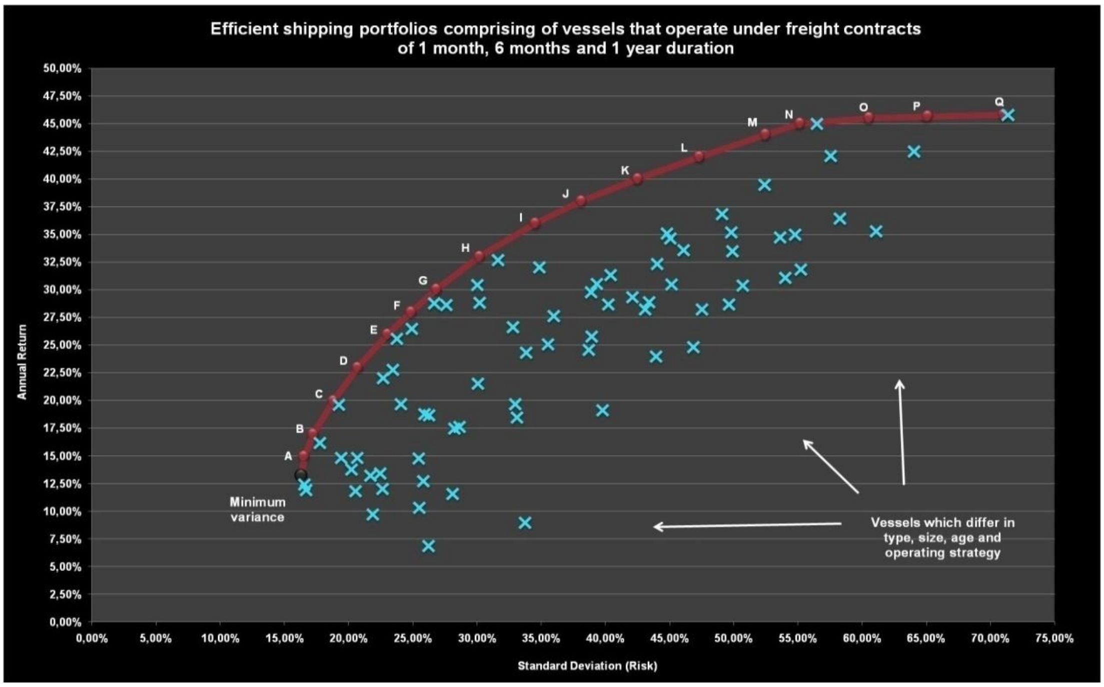


Figure 5.9: Efficient frontier based on annual returns

	NB HS BC 1Y TC	NB HM BC 1Y TC	NB C BC 2X6M TC	NB C BC 1Y TC	15YO C BC 12X1M SP	NB MR H T 1Y TC	NB P T 1Y TC	NB S T 12X1M SP	NB S T 1Y TC	15YO VLCC 12X1M SP	15YO VLCC 1Y TC	Annual return	SD	VAR
MV	12,72%	0,00%	0,00%	0,00%	0,00%	25,32%	61,95%	0,00%	0,00%	0,00%	0,00%	13,24%	16,30%	2,66%
A	35,44%	0,00%	0,00%	0,00%	0,00%	0,00%	64,56%	0,00%	0,00%	0,00%	0,00%	15,00%	16,51%	2,73%
B	51,89%	0,00%	0,00%	0,00%	0,00%	0,00%	33,02%	0,00%	13,11%	0,00%	1,98%	17,00%	17,22%	2,97%
C	56,41%	0,00%	0,00%	12,49%	0,00%	0,00%	11,10%	0,00%	14,55%	0,00%	5,46%	20,00%	18,83%	3,54%
D	54,92%	0,00%	0,00%	24,24%	0,00%	0,00%	0,00%	13,28%	0,00%	0,00%	7,56%	23,00%	20,70%	4,28%
E	16,41%	17,21%	0,00%	42,93%	0,00%	0,00%	0,00%	13,05%	0,00%	0,00%	10,40%	26,00%	23,04%	5,31%
F	0,00%	26,54%	0,00%	52,45%	0,00%	0,00%	0,00%	8,77%	0,00%	3,40%	8,83%	28,00%	24,86%	6,18%
G	0,00%	28,69%	0,00%	57,64%	0,00%	0,00%	0,00%	0,00%	0,00%	13,66%	0,00%	30,07%	26,83%	7,20%
H	0,00%	0,00%	11,25%	65,39%	0,00%	0,00%	0,00%	0,00%	0,00%	23,35%	0,00%	33,00%	30,17%	9,10%
I	0,00%	0,00%	66,64%	4,85%	0,00%	0,00%	0,00%	0,00%	0,00%	28,50%	0,00%	36,00%	34,52%	11,92%
J	0,00%	0,00%	56,81%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	43,19%	0,00%	38,00%	38,08%	14,50%
K	0,00%	0,00%	40,89%	0,00%	4,63%	0,00%	0,00%	0,00%	0,00%	54,48%	0,00%	40,00%	42,48%	18,04%
L	0,00%	0,00%	25,07%	0,00%	10,86%	0,00%	0,00%	0,00%	0,00%	64,07%	0,00%	42,00%	47,31%	22,38%
M	0,00%	0,00%	9,24%	0,00%	17,09%	0,00%	0,00%	0,00%	0,00%	73,67%	0,00%	44,00%	52,45%	27,51%
N	0,00%	0,00%	1,34%	0,00%	20,20%	0,00%	0,00%	0,00%	0,00%	78,46%	0,00%	45,00%	55,11%	30,37%
O	0,00%	0,00%	0,00%	0,00%	61,78%	0,00%	0,00%	0,00%	0,00%	38,22%	0,00%	45,50%	60,49%	36,59%
P	0,00%	0,00%	0,00%	0,00%	80,41%	0,00%	0,00%	0,00%	0,00%	19,58%	0,00%	45,65%	65,04%	42,30%
Q	0,00%	0,00%	0,00%	0,00%	100,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	45,81%	71,00%	50,41%

Table 5.5: Optimal vessel weightings based on annual returns

Investors now have more diversification options, since they can select different operating strategies for both vessel types. The minimum variance portfolio comprises of 12.72% newly built Handysize bulk carriers, 25.32% newly built “MR” Product tankers and 61.95% newly built Panamax “Coated” tankers all operating under 1-year time charter contracts. As the desired return increases, the component vessels are also newly built Capesize bulk carriers and 15-year old VLCCs operating under 1-year time charter contracts (among others) which then shift to consecutive 6 month time charter contracts and consecutive voyage contracts of 1 month duration respectively. For even higher expected returns, the newly built Capesize bulk carriers are replaced 15-year old Capesize bulk carriers operating in the spot market. No 5 and 10-year old vessels are included in the efficient shipping portfolios.

- **Efficient shipping portfolios based on 3-year end returns**

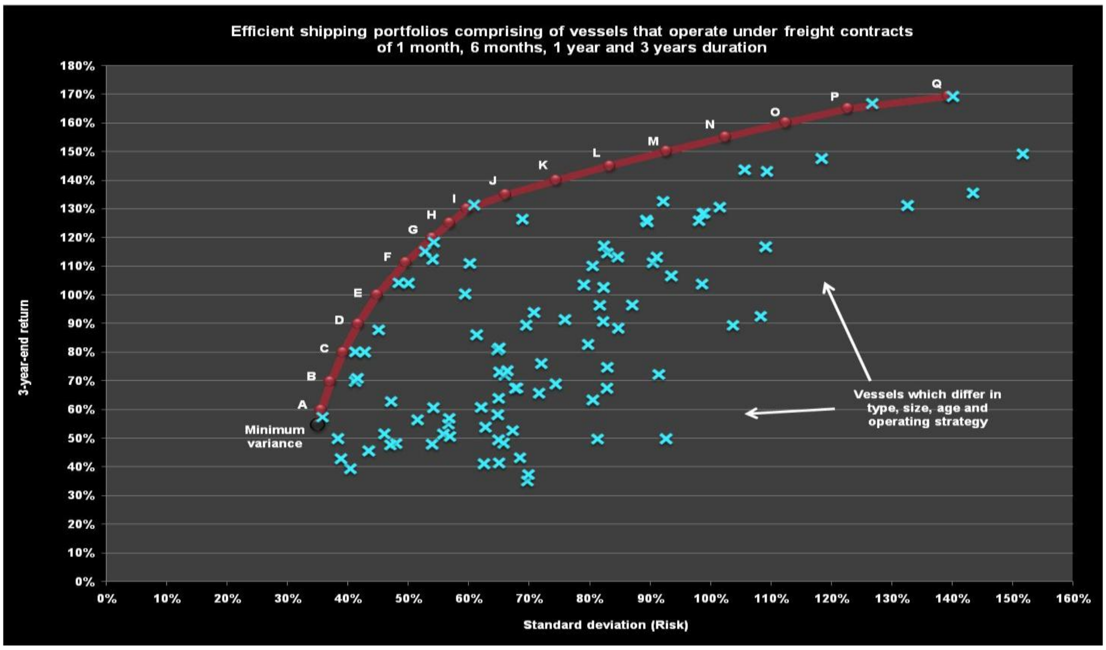


Figure 5.10: Efficient frontier based on 3-year end returns

	NB HS BC 3X1Y TC	NB HS BC 3Y TC	NB P BC 6X6M TC	NB P BC 3Y TC	NB C BC 6X6M TC	NB C BC 3X1Y TC	NB C BC 3Y TC	15YO C BC 36X 1M SP	15YO C BC 6X6M TC	NB P T 3Y TC	NB S T 3Y TC	3-year end returns	SD	VAR
MV	0,00%	70,71%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	7,29%	22,00%	54,60%	35,09%	12,31%
A	0,00%	77,48%	0,00%	0,00%	0,00%	6,38%	0,00%	0,00%	0,00%	0,00%	16,14%	60,00%	35,62%	12,69%
B	0,00%	79,21%	0,00%	0,00%	0,00%	20,79%	0,00%	0,00%	0,00%	0,00%	0,00%	70,00%	37,16%	13,81%
C	17,21%	31,14%	0,00%	26,78%	0,00%	24,86%	0,00%	0,00%	0,00%	0,00%	0,00%	80,00%	39,24%	15,40%
D	16,98%	0,00%	0,00%	45,88%	0,00%	37,14%	0,00%	0,00%	0,00%	0,00%	0,00%	90,00%	41,74%	17,42%
E	0,00%	0,00%	12,92%	34,02%	0,00%	48,59%	4,47%	0,00%	0,00%	0,00%	0,00%	100,00%	44,86%	20,12%
F	0,00%	0,00%	34,73%	0,00%	4,13%	44,60%	16,54%	0,00%	0,00%	0,00%	0,00%	111,37%	49,62%	24,62%
G	0,00%	0,00%	23,02%	0,00%	36,35%	34,74%	5,89%	0,00%	0,00%	0,00%	0,00%	120,00%	54,05%	29,22%
H	0,00%	0,00%	15,65%	0,00%	55,72%	28,64%	0,00%	0,00%	0,00%	0,00%	0,00%	125,00%	56,84%	32,30%
I	0,00%	0,00%	0,00%	0,00%	90,50%	9,50%	0,00%	0,00%	0,00%	0,00%	0,00%	130,00%	59,80%	35,76%
J	0,00%	0,00%	0,00%	0,00%	89,34%	0,00%	0,00%	0,00%	10,66%	0,00%	0,00%	135,00%	66,18%	43,80%
K	0,00%	0,00%	0,00%	0,00%	75,21%	0,00%	0,00%	0,00%	24,79%	0,00%	0,00%	140,00%	74,43%	55,40%
L	0,00%	0,00%	0,00%	0,00%	61,08%	0,00%	0,00%	0,00%	38,92%	0,00%	0,00%	145,00%	83,35%	69,47%
M	0,00%	0,00%	0,00%	0,00%	46,95%	0,00%	0,00%	0,00%	53,05%	0,00%	0,00%	150,00%	92,75%	86,02%
N	0,00%	0,00%	0,00%	0,00%	32,81%	0,00%	0,00%	0,00%	67,18%	0,00%	0,00%	155,00%	102,50%	105,06%
O	0,00%	0,00%	0,00%	0,00%	18,68%	0,00%	0,00%	0,00%	81,32%	0,00%	0,00%	160,00%	112,50%	126,57%
P	0,00%	0,00%	0,00%	0,00%	4,55%	0,00%	0,00%	0,00%	95,45%	0,00%	0,00%	165,00%	122,70%	150,56%
Q	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	100,00%	0,00%	0,00%	0,00%	169,17%	139,32%	194,09%

Table 5.6: Optimal vessel weightings based on 3-year end returns

The last assessed case, is also the one in which diversification can be achieved by selecting vessels of different type, size and age and freight contracts of all durations. The vessels that form the minimum variance portfolio are 70.71% newly built Handysize bulk carriers, 7.29% newly built Panamax "Coated" tankers and 22.00% newly built Suezmax tankers all operating under 3-year time charter contracts. As the desired return increases the already component vessels as well as the new entries shift to consecutive freight contracts of shorter durations. Moreover, portfolios with even higher desired return comprise of newly built and 15-year old Capesize bulk carriers operating under consecutive 6 month time charter contracts. The efficient portfolio which offers the highest expected return comprises 100% of 15-year old Capesize bulk carriers operating in the spot market. No other vessels operating in the spot market are included in the efficient portfolios. Once again, no other 15-year old as well as no 5 and 10-year old vessels are included in the efficient portfolios.

Chapter 6 Portfolio leverage

6.1 The risk free asset

The basic drawback of the Markowitz portfolio theory is the fact that it takes into account only risky securities or assets, while there may be investors who are also interested in risk-free investments.

James Tobin (1958) understood that investors have a full range of investment preferences and introduced the risk free asset, i.e. a hypothetical asset that pays a risk-free rate. As risk free assets are usually considered securities issued by the government, because the probability of its defaulting is extremely low. The most commonly used securities as risk free assets, are the US Treasury bills.

An investor who purchases a risk free asset at the beginning of a holding period knows with certainty what will be its value at the end of the holding period. This means that its standard deviation is zero and therefore it lies on the vertical axis of a portfolio graph. Additionally, the covariance and the correlation between its rate of return and the rate of return of a risky asset or portfolio are zero as well.

Now suppose we combine the risk free asset with a risky asset or portfolio. The expected return of a portfolio that comprises of a risk free asset and a risky portfolio X is the weighted average of their (expected) returns:

$E(r_p) = W_{Rf} x R_f + (1-W_{Rf}) x E(r_X)$ and its variance and standard deviation is:

$\sigma_p^2 = W_{Rf}^2 x \sigma_{Rf}^2 + (1-W_{Rf})^2 x \sigma_X^2 + 2 x W_{Rf} x (1-W_{Rf}) x \rho_{Rf,X} x \sigma_{Rf} \text{ x } \sigma_X = (1-W_{Rf})^2 \text{ x } \sigma_X^2$

Therefore, $\sigma_p = (1-W_{Rf}) \text{ x } \sigma_X$

This means that for a portfolio that contains the risk free asset and a risky asset or portfolio, risk and expected return change linearly and therefore all combinations of portfolio returns and standard deviations can be plotted as a straight line.

6.2 Capital market line

Let's consider the efficient frontier of the following figure and plot some of the efficient (risky) portfolios and the risk free asset (on the vertical axis).

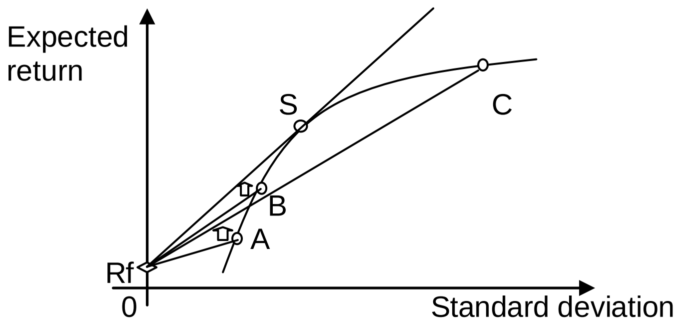


Figure 6.1: Combining efficient (risky) portfolios with the risk free asset

If we invest in the risk free asset and in the efficient portfolio A, we can achieve any point on the line RfA based on the respective weightings W_{Rf} and $(1-W_{Rf})$. Any portfolio that lies on this straight line is superior to any efficient portfolio below A simply because for a given expected return a portfolio that lies on the straight line has lower standard deviation than the one that lies on the efficient frontier. Similarly, we can invest in the risk free asset and in the efficient portfolio B. Again any portfolio that lies on the line RfB is superior to any other below B as well as to any portfolio that lies on the line RfA. In essence, we can combine the risk free asset with every portfolio that lies on the efficient set.

As can be seen, when the efficient portfolio S is selected to be combined with the risk free asset the generated straight line is tangent to the efficient frontier. In fact this line is the higher (with the higher slope) that can be plotted and portfolio S is the best efficient portfolio.

Investors who hold the best efficient portfolio but are interested in higher expected return can either invest on portfolio C or borrow money at the risk free rate and invest the proceeds in the best efficient portfolio. Similarly, investors who are interested in lower risk can sell some of their holdings in the best efficient portfolio and invest the proceeds in the risk free asset (lend). That is both risk and return change linearly and any combination on this line that passes through the risk free rate and the best efficient portfolio dominates everything below it. This line can be considered as the new efficient frontier and is referred to as the Capital Market line (CML).

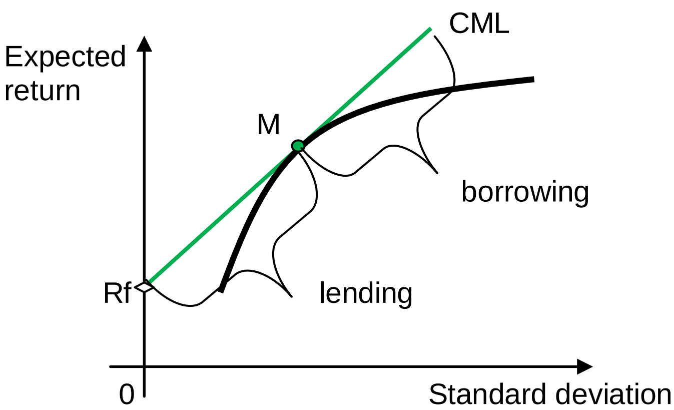


Figure 6.2: CML and portfolio leverage

Given that the best efficient portfolio is by definition the one that offers the maximum expected return for the lowest possible risk compared to all other efficient portfolios that lie on the efficient set, every investor would be willing to invest in it and then borrow or lend at the risk free rate in order to be somewhere on the Capital Market line. This implies that the best efficient portfolio should be the market portfolio (M). That is, unique risk is diversified away and what remains is only the market risk.

While the composition of the market portfolio is independent of the risk preference of each individual investor, his/her relative position on the Capital market is. More risk averse investors prefer to invest more in the risk free asset and therefore be somewhere between Rf and the market portfolio. On the other hand more risk tolerant investors would prefer to borrow money and invest the proceeds in the market portfolio and therefore be somewhere to the right of it. The exact position of each investor on the Capital market line corresponds to the combination of risk free asset and market portfolio that maximizes his/her utility as depicted in the following figure.

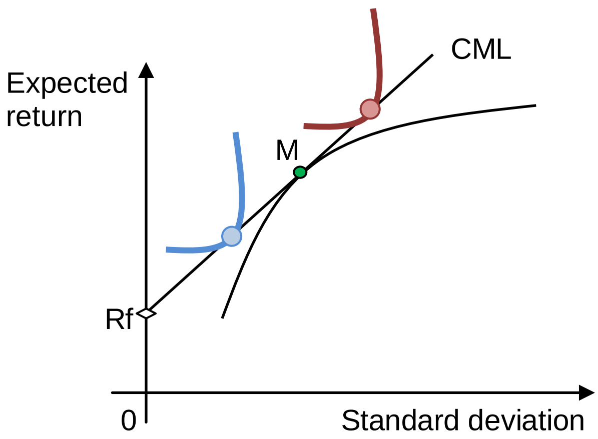


Figure 6.3: CML and risk preference

This is the Tobin's separation theorem. Investors initially decide to invest in the market portfolio and then based on their risk preference they decide where they want to be on the Capital Market line.

6.3 Constructing the Capital Market line

In order to construct the Capital Market line we need first to locate the best efficient/market portfolio on the efficient set. This can be easily done by means of Sharpe ratio, which was explained in section 4.4.2 of chapter 4. More specifically, we calculate the Sharpe ratios of all the (selected) efficient portfolios and the one with the highest Sharpe ratio is the Market portfolio.

Recall that the Sharpe ratio's formula is the following:

$$SR_x = \frac{r_x - R_f}{Stdev_x} \quad <=>$$

$$SR_i = \frac{E(r_{pi}) - R_f}{\sigma_{pi}} \qquad (6.1)$$

Where SRi is the Sharpe ratio of the efficient (risky) portfolio i that lies on the efficient set, $E(r_{pi})$ its expected return, σ_{pi} its standard deviation (risk) and Rf the risk free rate of return.

The Sharpe ratio of the market portfolio will be the slope of the Capital Market line. Therefore, given that the Capital Market line passes through the point on the vertical axis that corresponds to the risk free rate of return we can mathematically express it as follows:

$$CML = E(r_c) = R_f + \sigma_C \frac{E(r_M) - R_f}{\sigma_M} \qquad (6.2)$$

Where

$E(r_C)$ = the expected return of the combination between the risk free asset and the market portfolio

σ_c = the standard deviation of the combination between the risk free asset and the market portfolio

$E(r_M)$ = the expected return on the market portfolio

σ_M = the standard deviation of the market portfolio

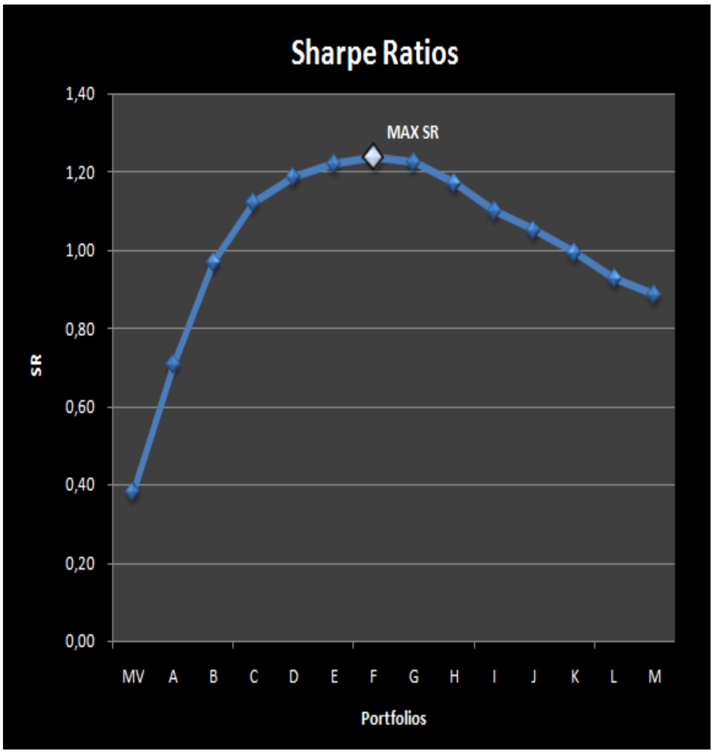
Rf = the risk free rate of return and

$\frac{E(r_M) - R_f}{\sigma_M}$ = the slope of the Capital market line

6.4 Capital Market line in shipping

The following figures illustrate the process required to find the shipping market portfolio and generate the respective Capital market line for each holding period.

- ***Holding period of 1 month***



		RF	0,22%
Portfolio	Monthly returns	SD	SR
MV	0,45%	0,60%	0,3819
A	0,65%	0,61%	0,7063
B	0,85%	0,65%	0,9663
C	1,06%	0,75%	1,1196
D	1,23%	0,85%	1,1857
E	1,38%	0,95%	1,2183
F	1,58%	1,10%	1,2354
G	1,75%	1,25%	1,2225
H	1,86%	1,40%	1,1707
I	1,98%	1,60%	1,0977
J	2,06%	1,75%	1,0503
K	2,15%	1,95%	0,9912
L	2,26%	2,20%	0,9250
M	2,32%	2,38%	0,8833

Figure 6.4: Highest Sharpe ratio – monthly figures

- The average annual US treasury bills' rate divided by 12 was taken as a proxy for the monthly risk free rate.
- Portfolio F is the one with the highest Sharpe ratio and therefore is considered the shipping Market portfolio with the risk-return characteristics presented in figure 6.4.

- The shipping Market portfolio's components are:
  - ✓ 62.05% newly built Handymax bulk carriers operating under trip charter contracts of 1 month duration
  - ✓ 19.10% newly built Suezmax tankers operating under voyage contracts of 1 month duration and
  - ✓ 18.85% 15-year old VLCCs operating under voyage contracts of 1 month duration

Having found the highest Sharpe ratio (1.2354) which is the slope of the capital market line and knowing the risk free rate of return (0.22%) we end up by means of formula (6.2) to the following Capital market line equation:

$$CML = E(r_c) = 0.0022 + \ 1.2354\sigma_C$$

The Capital Market line is plotted as follows:

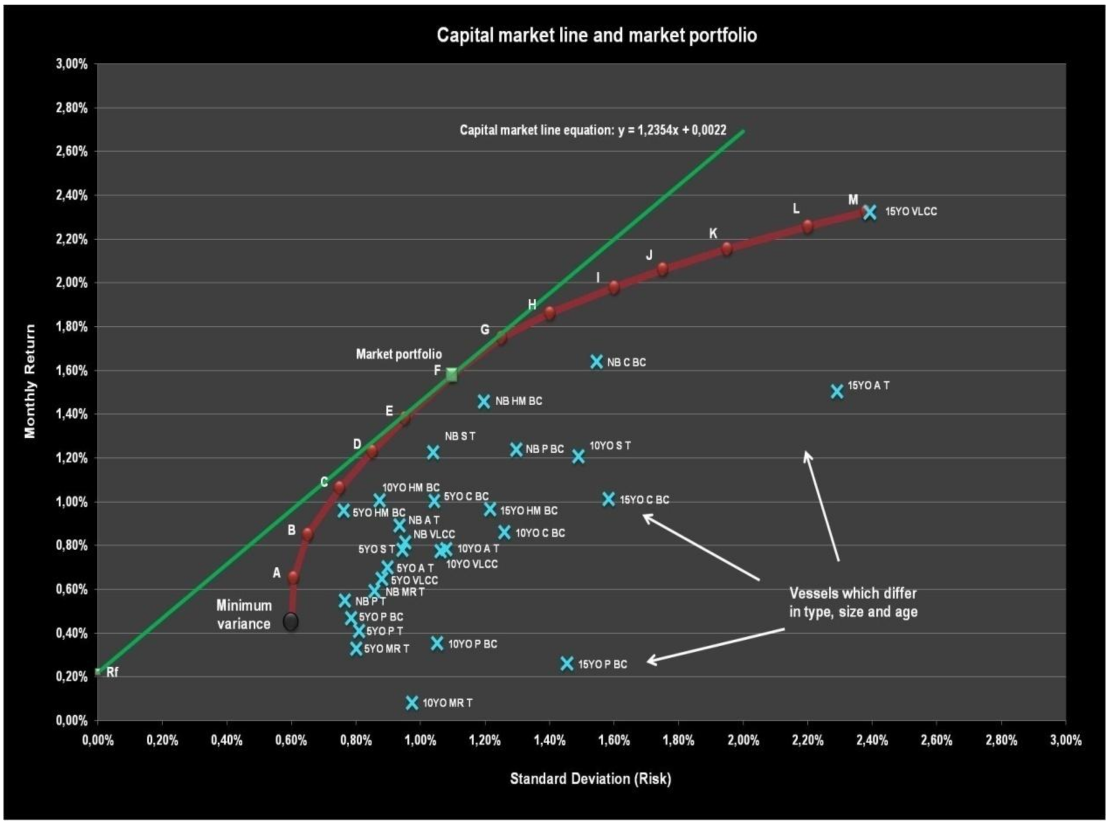
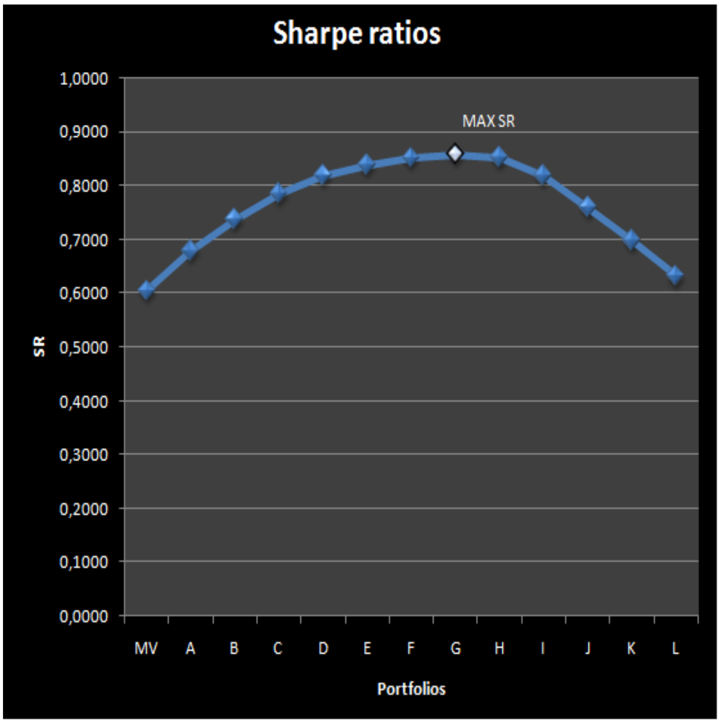


Figure 6.5: CML and shipping Market portfolio – monthly figures

- ***Holding period of 6 months***



		Rf	1,02%
	Semi-annual return	SD	SR
MV	7,13%	10,12%	0,6046
A	8,00%	10,30%	0,6782
B	9,00%	10,81%	0,7385
C	10,00%	11,44%	0,7853
D	11,00%	12,20%	0,8186
E	12,00%	13,08%	0,8395
F	13,00%	14,07%	0,8517
G	14,33%	15,51%	0,8584
H	15,00%	16,40%	0,8527
I	16,00%	18,29%	0,8192
J	17,00%	21,02%	0,7605
K	18,00%	24,31%	0,6987
L	19,21%	28,77%	0,6325

Figure 6.6: Highest Sharpe ratio – semi-annual figures

- The risk free rate taken was the average 6-month US treasury bills' rate.
- Portfolio G is the one with the highest Sharpe ratio and therefore is considered the shipping Market portfolio with the risk-return characteristics presented in figure 6.6.
- The shipping Market portfolio's components are:
  - ✓ 28.96% newly built Handymax bulk carriers operating under 6-month time charter contracts
  - ✓ 56.50% newly built Capesize bulk carriers operating under 6-month time charter contracts and
  - ✓ 14.54% 15-year old VLCCs operating under voyage contracts of 1 month duration

Having found the highest Sharpe ratio (0.8584) which is the slope of the capital market line and knowing the risk free rate of return (1.02%) we end up by means of formula 6.2 to the following Capital market line equation:

$$CML = E(r_c) = 0.0102 + 0.8584\sigma_C$$

The Capital Market line is plotted as follows:

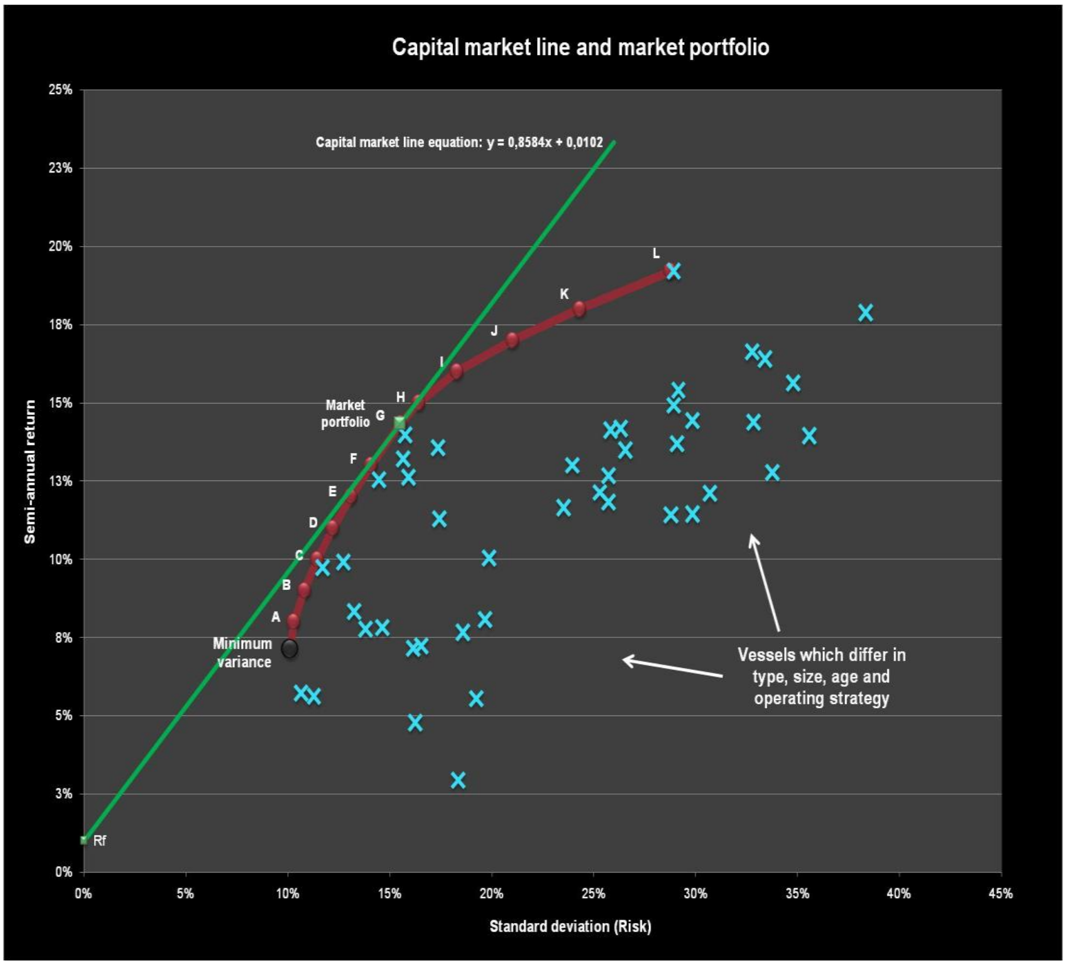
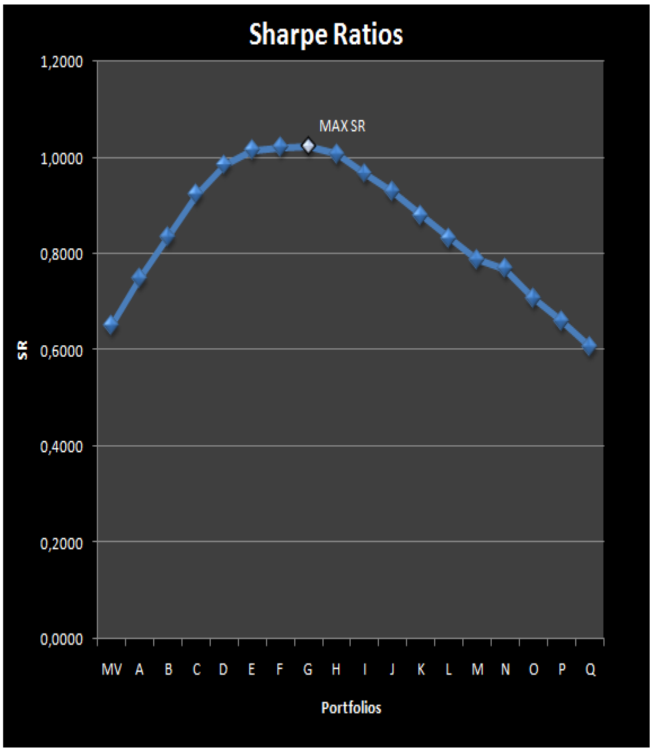


Figure 6.7: CML and shipping Market portfolio – semi-annual figures

- ***Holding period of 1 year***



		Rf	2,61%
	Annual	SD	SR
MV	13,24%	16,30%	0,6522
A	15,00%	16,51%	0,7504
B	17,00%	17,22%	0,8354
C	20,00%	18,83%	0,9236
D	23,00%	20,70%	0,9850
E	26,00%	23,04%	1,0153
F	28,00%	24,86%	1,0213
G	30,07%	26,83%	1,0235
H	33,00%	30,17%	1,0074
I	36,00%	34,52%	0,9672
J	38,00%	38,08%	0,9292
K	40,00%	42,48%	0,8802
L	42,00%	47,31%	0,8326
M	44,00%	52,45%	0,7892
N	45,00%	55,11%	0,7692
O	45,50%	60,49%	0,7091
P	45,65%	65,04%	0,6617
Q	45,81%	71,00%	0,6084

Figure 6.8: Highest Sharpe ratio – annual figures

- The risk free rate taken was the average annual US treasury bills' rate.
- Portfolio G is the one with the highest Sharpe ratio and therefore is considered the shipping Market portfolio with the risk-return characteristics presented in figure 6.8.
- The shipping Market portfolio's components are:
  - ✓ 28.69% newly built Handymax bulk carriers operating under 1-year time charter contracts
  - ✓ 57.64% newly built Capesize bulk carriers operating under 1-year time charter contracts and
  - ✓ 13.66% 15-year old VLCCs operating under consecutive voyage contracts of 1 month duration.

Having found the highest Sharpe ratio (1.0235) which is the slope of the capital market line and knowing the risk free rate of return (2.61%) we end up by means of formula 6.2 to the following Capital market line equation:

$$CML = E(r_c) = 0.0261 + 1.0235\sigma_C$$

The Capital Market line is plotted as follows:

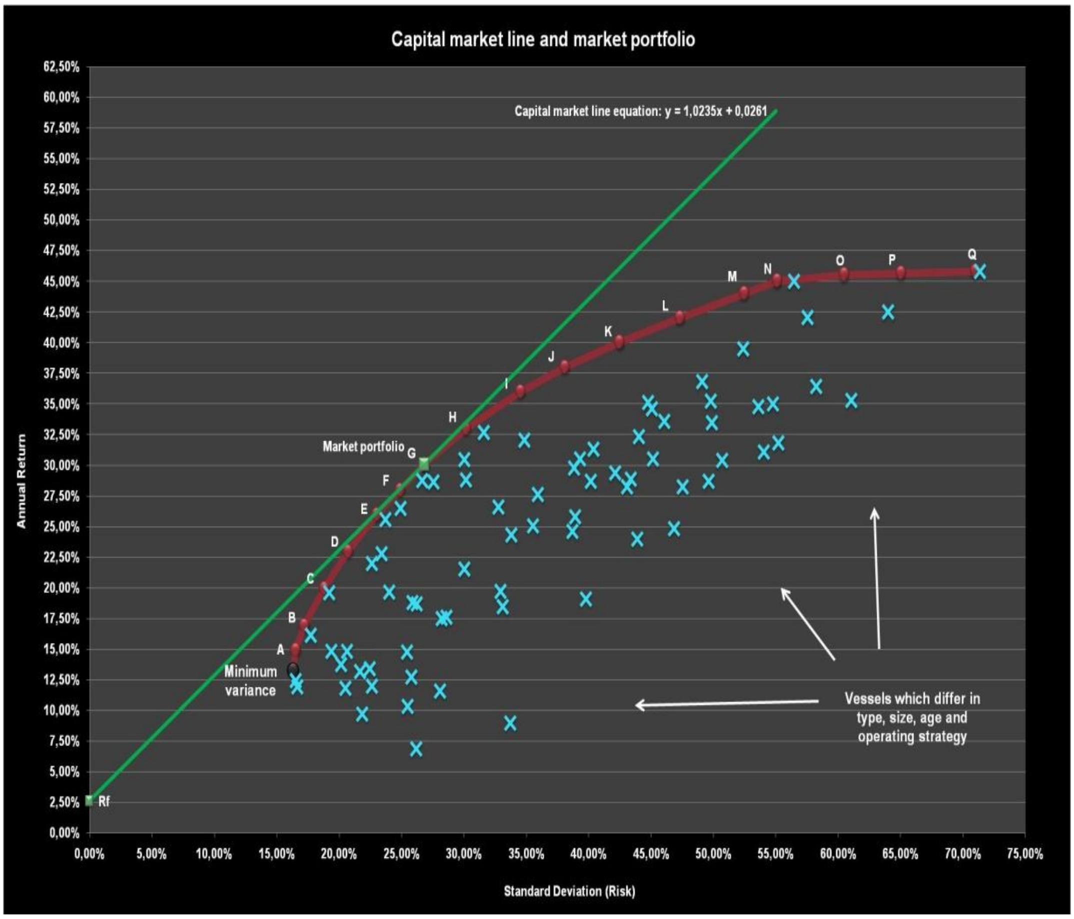
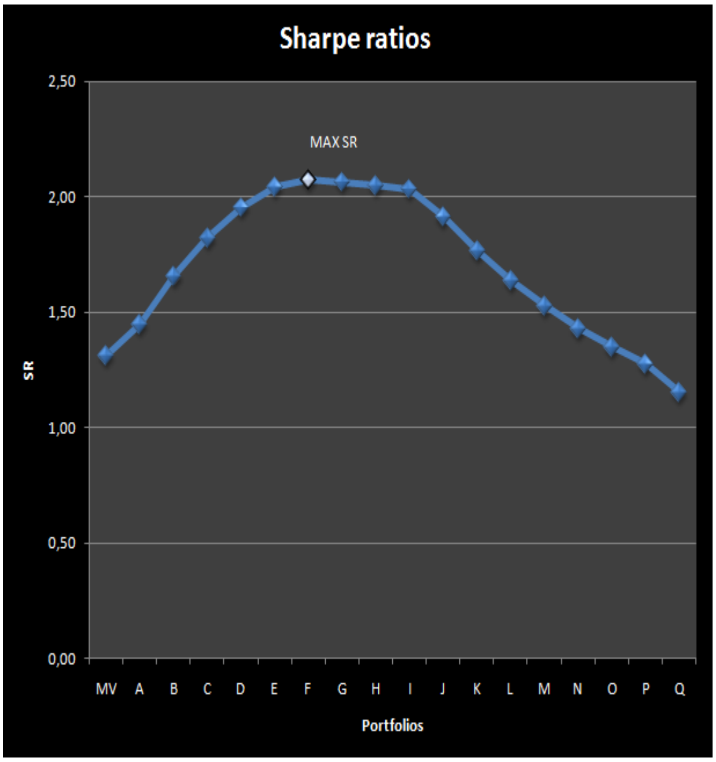


Figure 6.9: CML and shipping Market portfolio – annual figures

- ***Holding period of 3 year***



		Rf	8,56%
	3-year end returns	SD	SR
MV	54,60%	35,09%	1,3123
A	60,00%	35,62%	1,4443
B	70,00%	37,16%	1,6534
C	80,00%	39,24%	1,8207
D	90,00%	41,74%	1,9512
E	100,00%	44,86%	2,0386
F	111,37%	49,62%	2,0721
G	120,00%	54,05%	2,0618
H	125,00%	56,84%	2,0488
I	130,00%	59,80%	2,0309
J	135,00%	66,18%	1,9106
K	140,00%	74,43%	1,7661
L	145,00%	83,35%	1,6370
M	150,00%	92,75%	1,5250
N	155,00%	102,50%	1,4288
O	160,00%	112,50%	1,3462
P	165,00%	122,70%	1,2750
Q	169,17%	139,32%	1,1528

Figure 6.10: Highest Sharpe ratio – 3-year end figures

- The risk free rate taken the average annual US treasury bills' rate multiplied by 3 was taken as a proxy for the 3-year end risk free rate.
- Portfolio F is the one with the highest Sharpe ratio and therefore is considered the shipping Market portfolio with the risk-return characteristics presented in figure 6.8.
- The shipping Market portfolio's components are:
  - ✓ 34.73% newly built Panamax bulk carriers operating under 3-year time charter contracts
  - ✓ 4.13% newly built Capesize bulk carriers operating under consecutive 6-month time charter contracts
  - ✓ 44.60% newly built Capesize bulk carriers operating under consecutive 1-year time charter contracts
  - ✓ 16.54% newly built Capesize bulk carriers operating under 3-year time charter contracts

Having found the highest Sharpe ratio (2.0721) which is the slope of the capital market line and knowing the risk free rate of return (8.56%) we end up by means of formula 6.2 to the following Capital market line equation:

$$CML = E(r_c) = 0.0856 + 2.0721\sigma_C$$

The Capital Market line is plotted as follows:

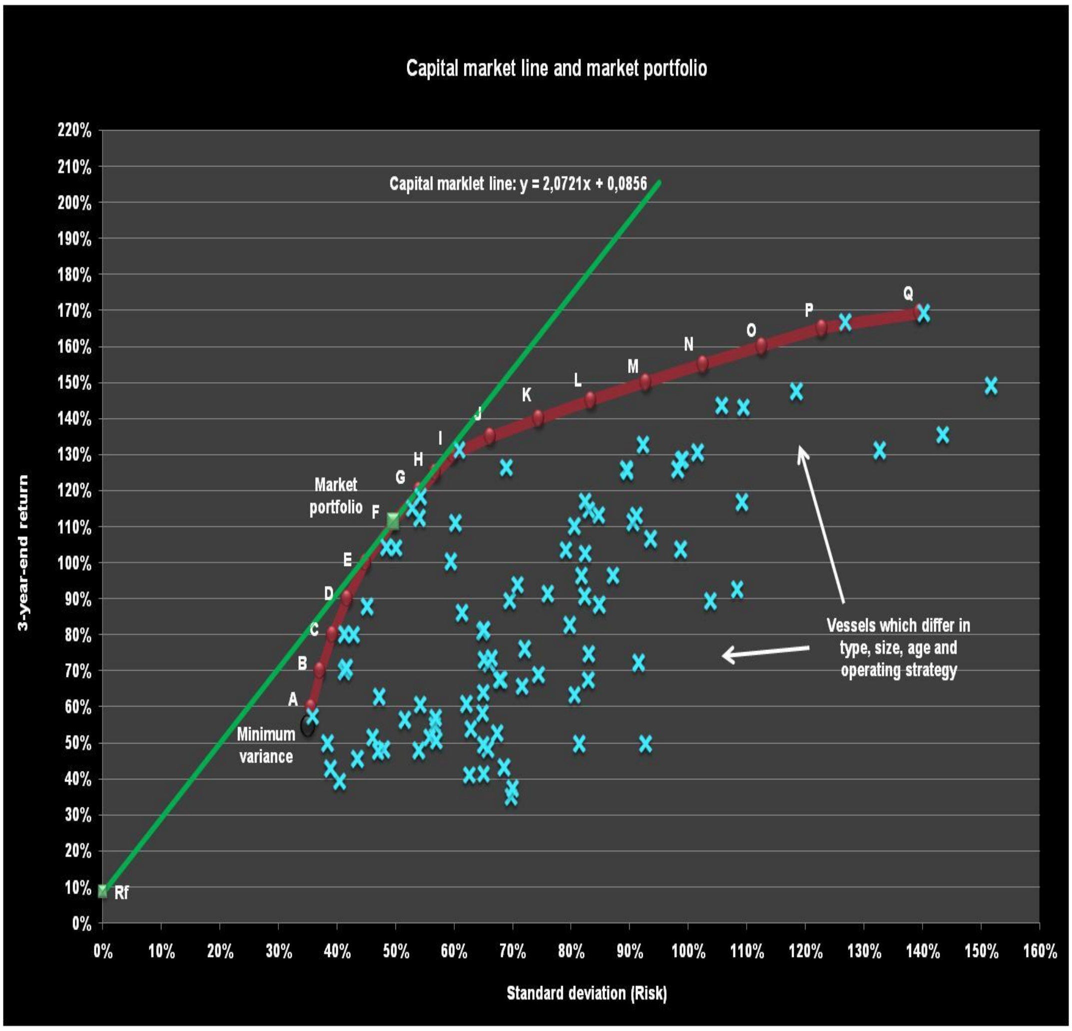


Figure 6.11: CML and shipping Market portfolio – 3-year end figures

By selecting the appropriate combination of risk free asset and market portfolio, shipowners can move along the Capital Market line and therefore achieve better expected return for a given level of risk than the one offered by the portfolios that lie on the efficient set.

Chapter 7 Capital asset pricing model (CAPM)

7.1 Introduction

The Capital Asset Pricing Model (CAPM) was developed in mid 60's by William Sharpe, John Linter and Jan Mossin. It is based on the Markowitz portfolio theory and its key element is the fact that it separates a security's risk into systematic and unsystematic (or specific, or unique) risk. That is,

Total security risk = Systematic risk + Unsystematic risk

Unsystematic risk is the risk associated with the specific security and can be eliminated through diversification while the systematic risk has to do with market related factors that affect all securities in general and cannot be eliminated even after extensive diversification. This means that the risk of a well diversified portfolio, depends on the market related risk of the all the securities included in the portfolio (Brealey, Myers and Allen, 2008) and apparently investors should not expect to be rewarded for unsystematic risk.

7.2 CAPM assumptions

The capital asset pricing model is based on the following assumptions:

- Investment decisions depend on the investments' expected returns and standard deviations (risk)
- Investors select portfolios based on the Markowitz model
- Investors have similar economic view and analyze securities in the same way (Homogenous expectations)
- Investors are price takers
- The investment or holding period is identical for all investors
- There are no transaction and tax costs
- Unlimited borrowing and lending by means of the risk free asset
- Investments are limited to a universe of publicly traded assets

7.3 The market portfolio

In the previous chapter we used the term market portfolio as identical to the best efficient portfolio. The reason for this is that since all investors are interested in portfolios that lie on the efficient set comprised of securities that belong to the same universe for which they share the same information and which they hold for the same period of time, they should all end up holding the risky portfolio that lies at the tangent point of the Capital market line with the efficient set. The market portfolio contains all risky securities in proportion to their market value and is a complete diversified portfolio.

7.4 Beta coefficient

As we mentioned in section 7.1 of this chapter, the risk of a well diversified portfolio depends on the market related risk of the individual securities, i.e. the systematic risk. Beta coefficient is used to measure the systematic risk of each security by measuring the extent to which the returns on a security moves together with the returns on the market portfolio. Beta coefficient can be calculated according to the following formula:

$$\beta_i = \frac{Cov\ (r_i, r_M)}{\sigma(r_M)^2} \quad (7.1)$$

Where,

β_i = the beta coefficient for security i

r_i = the return on security i

r_M = the return on market portfolio

$Cov(r_i, r_M)$ = the covariance between the return on security i and the return on market portfolio and

$\sigma(r_M)^2$ = the variance of the market portfolio

Given this formula, the beta coefficient of the market portfolio is: $\beta_M = 1$.

If the beta coefficient of a security is:

- zero, the returns on this security move independently of the move in the market returns
- positive, the returns on this security move in the same direction with the market returns
- negative, the returns on this security move in the opposite direction of the move in the market returns
- equal to 1, the security is of average riskiness
- greater than 1, the security's riskiness is greater than the overall market
- lower than 1, the security's riskiness is less than the overall market

Securities with negative beta coefficient can be used for hedging purposes.

The beta coefficient of a selected portfolio is the weighted average of the betas of its components.

7.5 CAPM model and security market line

The capital asset pricing model is described by the following formula:

$$SML: E(R_i) = R_f + \beta_i[\left(E(R_M\right) - R_f] \quad (7.2)$$

Where,

$E(R_i)$ = the expected return on security i

R_f = the risk free rate of return

β_i = the beta coefficient of security i

$E(R_M)$ = the expected return on market portfolio and

$[E(R_M) – R_f]$ = the market risk premium

This equation indicates that the risk premium of an individual security is proportional to the market risk premium.

This relationship can also be portrayed graphically as the security market line (SML).

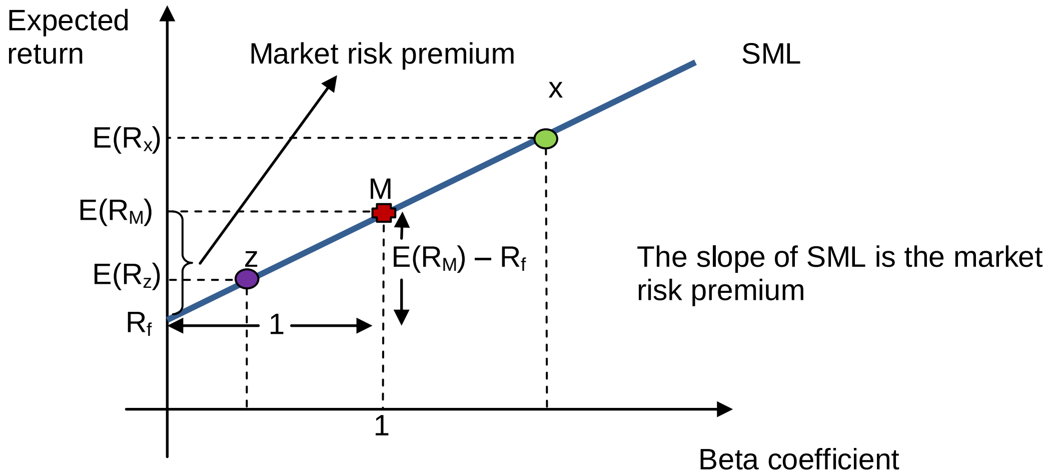


Figure 7.1: Security market line

The security market line provides a benchmark for evaluation of investment performance. Given the risk of an investment, as measured by beta coefficient, it provides the required rate of return that is necessary to compensate investors for both risk and the time value of money (Bodie, Kane and Marcus, 2008). For example security x has a greater risk premium than the market risk premium since its beta is higher than1. On the contrary, security z has a lower risk premium than the market one because its beta is lower than 1. All investment options with the same expected return differ in terms of risk as given by their standard deviations (CML) but their beta coefficient is the same. This means that these investment options correspond to the same point on the SML.

7.6 Security characteristic line

The security characteristic line is given by the following formula:

$$\text{SCL: } R_{i,t}=a_i+\beta_i R_{M,t}+\varepsilon_{i,t} \qquad (7.3)$$

This is the product of the regression we perform between the historical returns on a security and a market index in order to find the beta coefficient of this security.

Where,

$R_{i,t}$ = the return on a security at time t

$R_{M,t}$ = the market return at time t

β_i = the beta coefficient of security i

a_i = the alpha coefficient (the y-intercept in the regression equation)

$e_{i,t}$ = the respective standard error

7.7 Vessel characteristic lines

The following figures correspond to the security characteristic lines of all vessels (except for Handysize bulk carriers) which were produced by means of regression analysis of their monthly returns with the clarksea index. This regression analysis resulted to the estimation of the beta coefficients of all vessels under assessment which are also presented along with the respective coefficient of determination that indicates which percentage of the total risk of the security is market related (systematic risk).

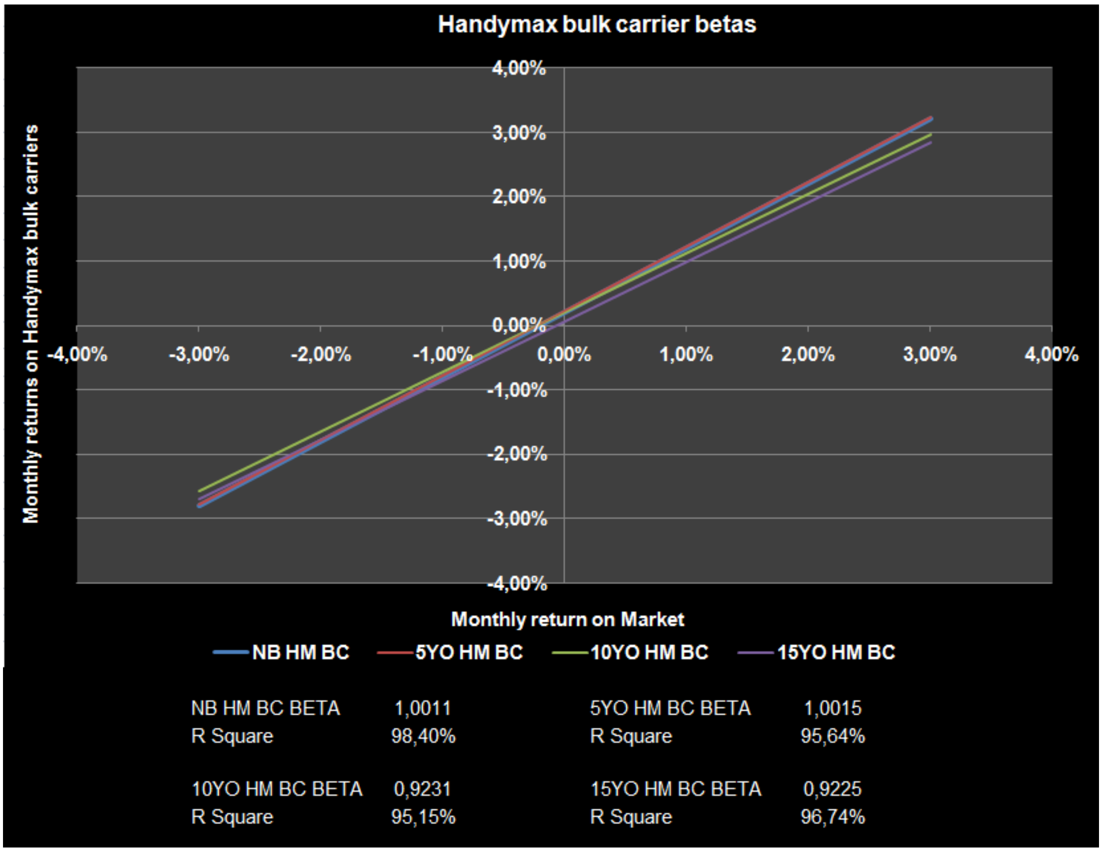


Figure 7.2: Handymax bulk carrier characteristic lines (monthly figures)

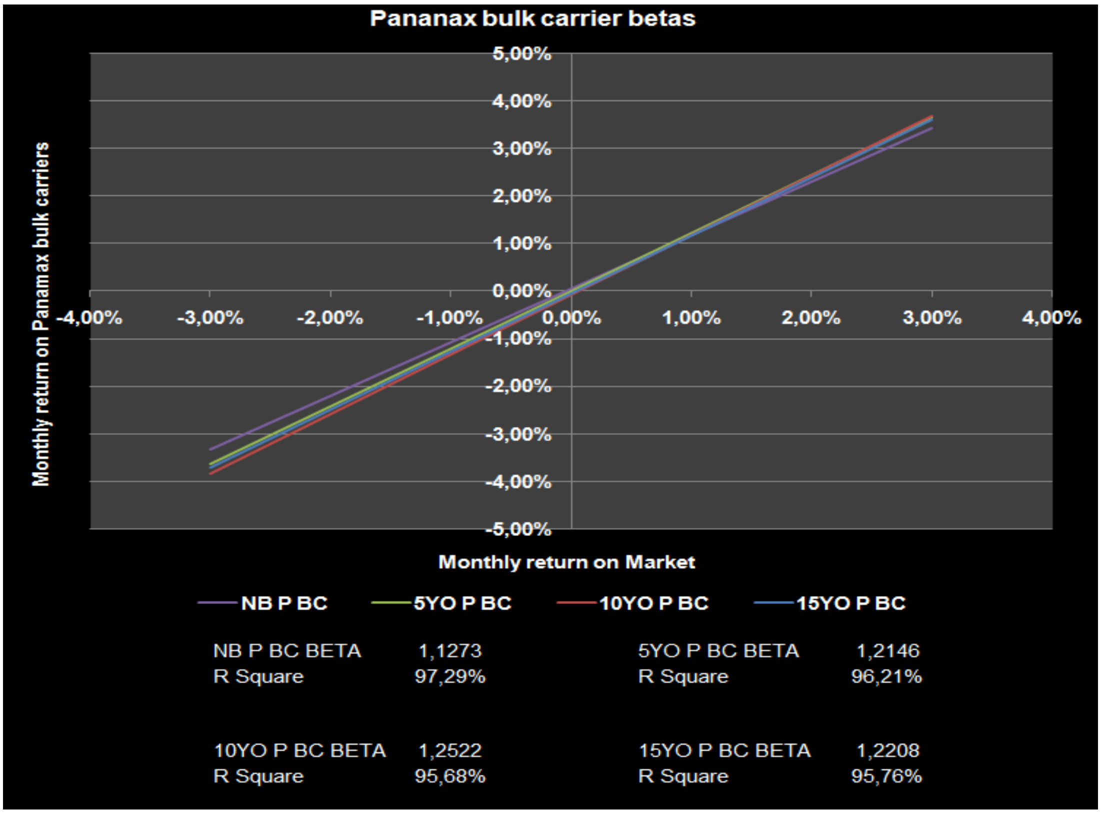


Figure 7.3: Panamax bulk carrier characteristic lines (monthly figures)

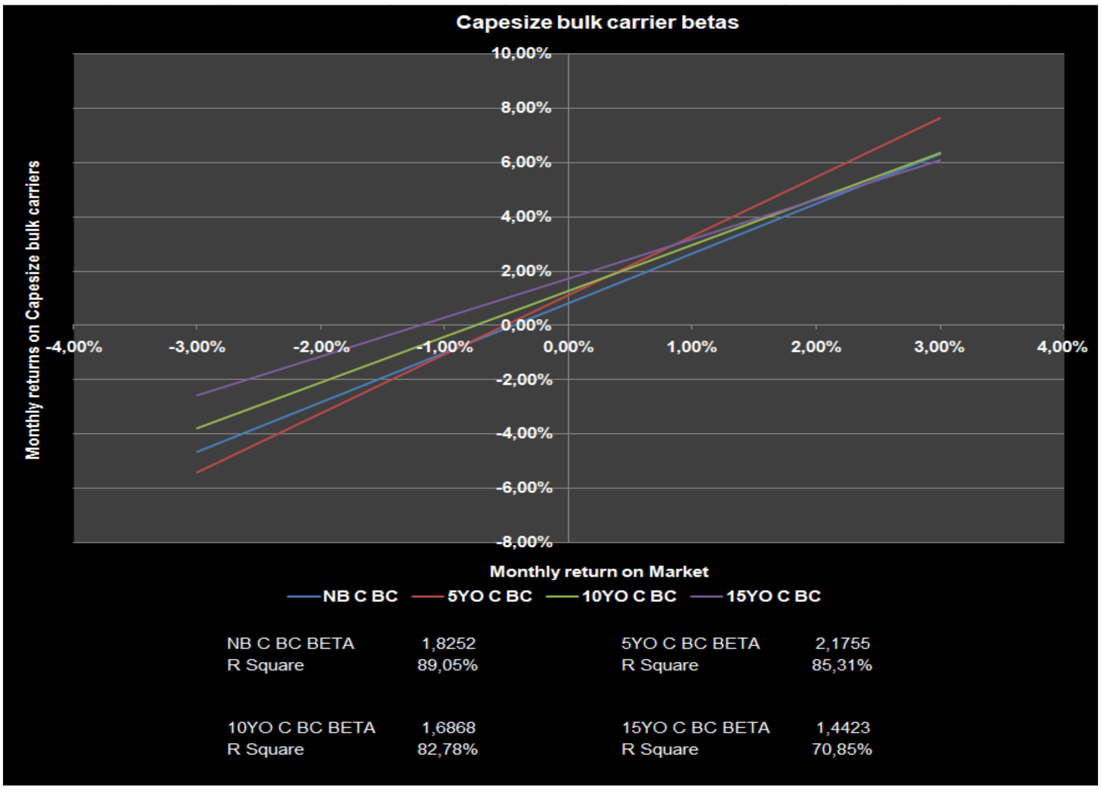


Figure 7.4: Capesize bulk carrier characteristic lines (monthly figures)

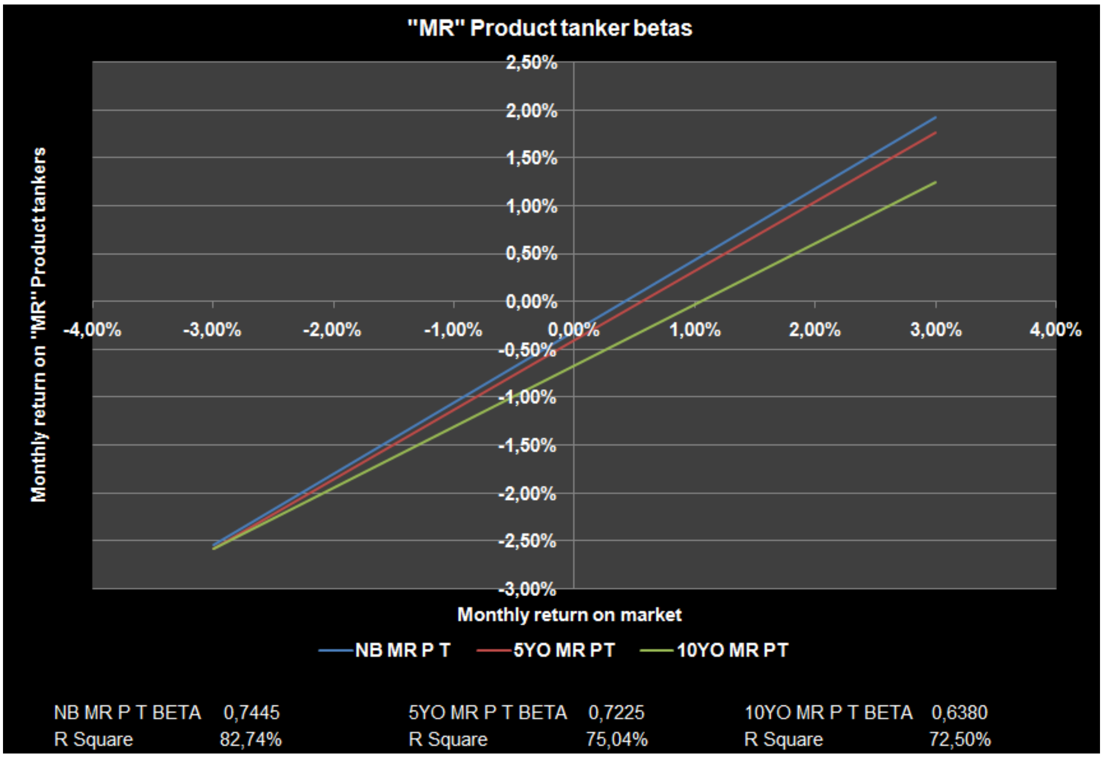


Figure 7.5: "MR" Product tanker characteristic lines (monthly figures)

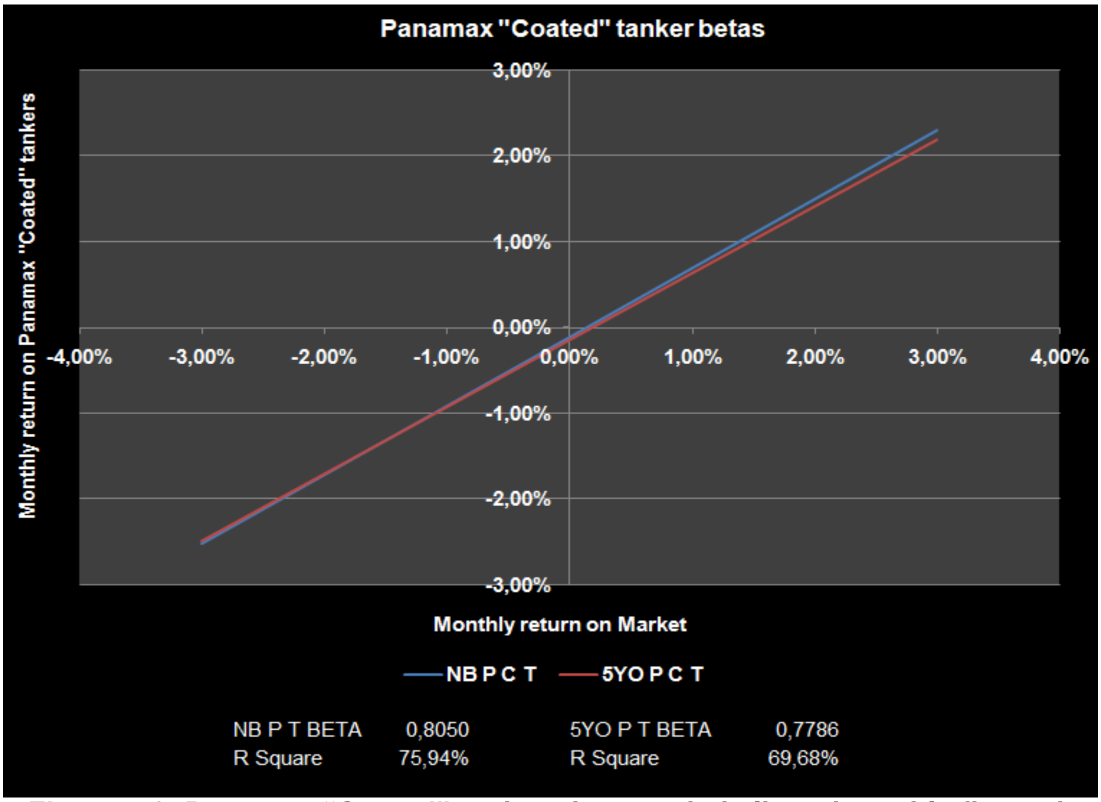


Figure 7.6: Panamax "Coated" tanker characteristic lines (monthly figures)

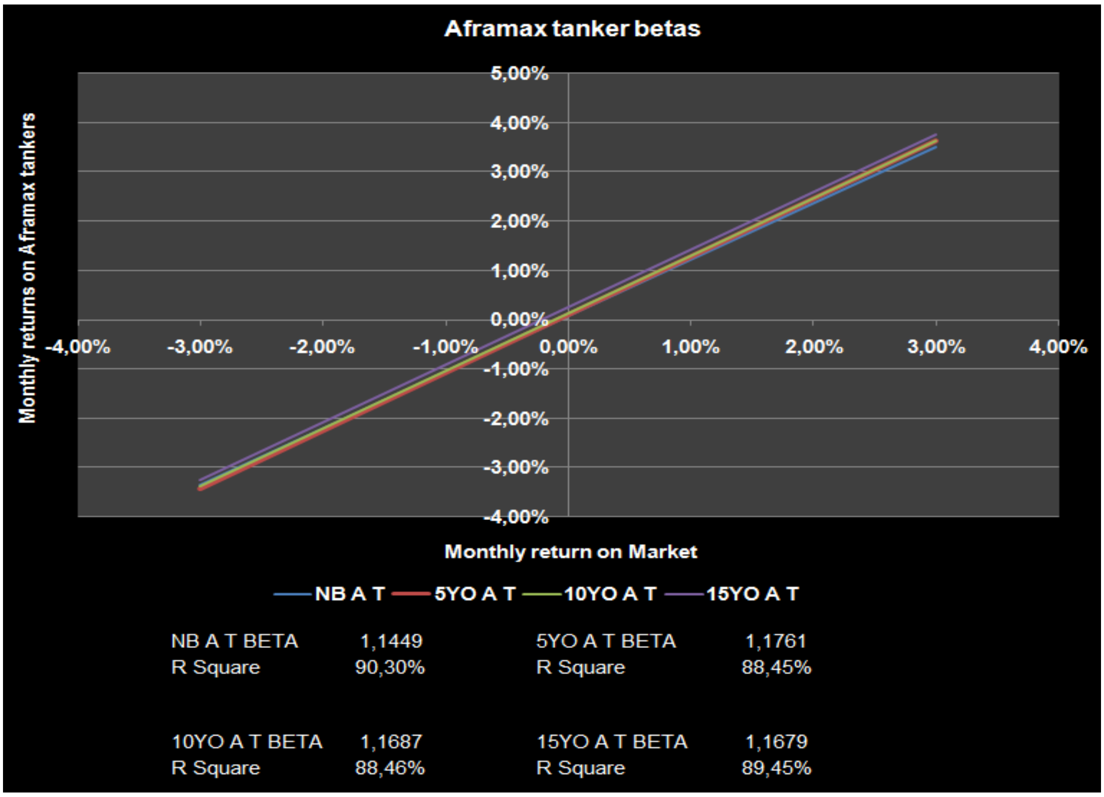


Figure 7.7: Aframax tanker characteristic lines (monthly figures)

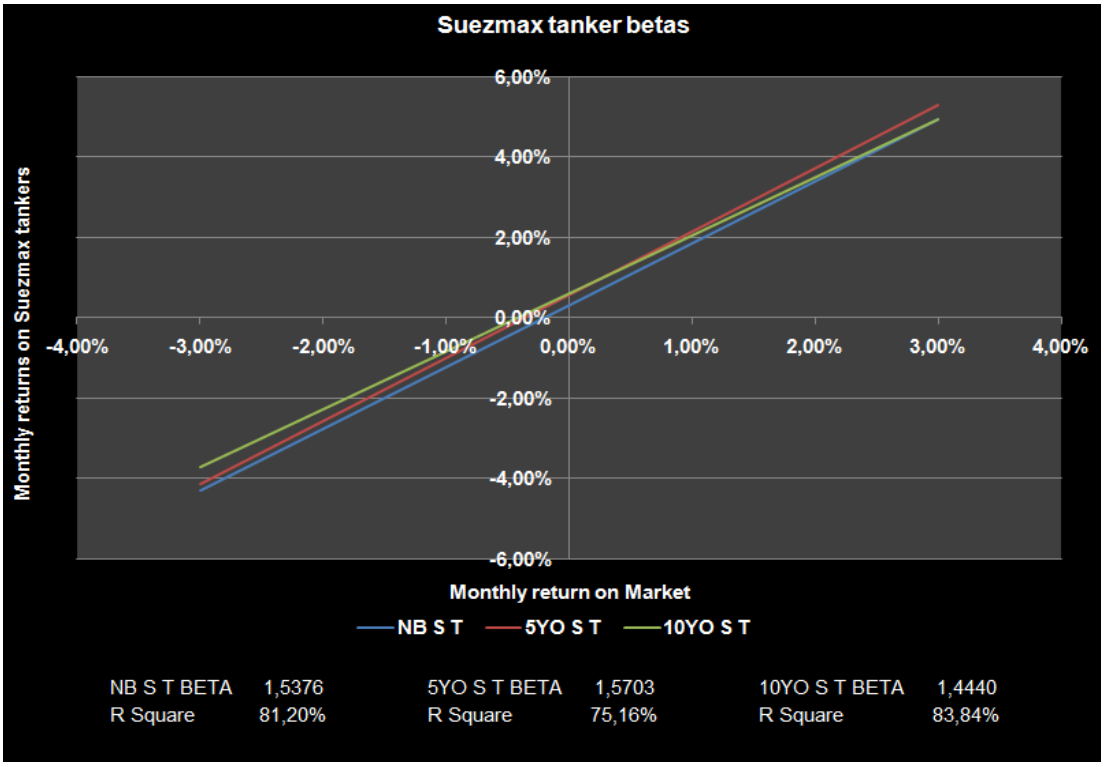


Figure 7.8: Suezmax tanker characteristic lines (monthly figures)

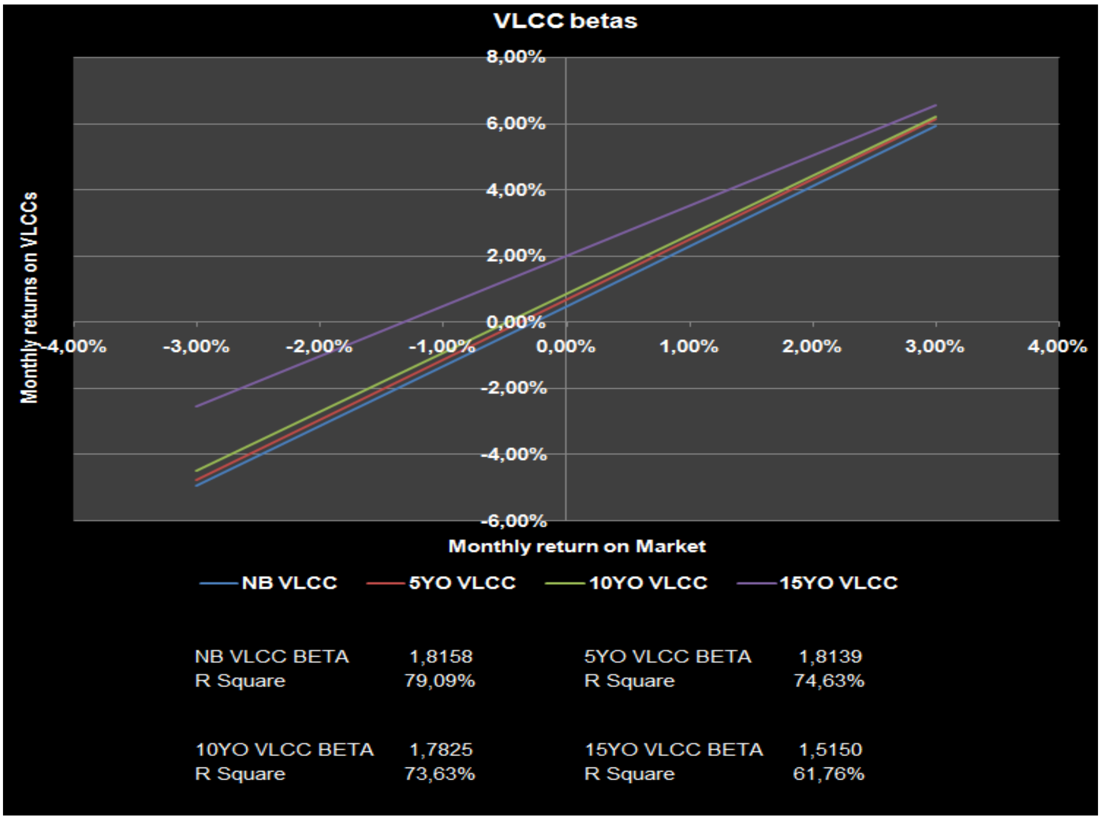


Figure 7.9: VLCC characteristic lines (monthly figures)

Having estimated the beta coefficients of all vessels, we now know how their returns move with respect to the market returns. Since all betas found are positive we can argue that the returns on the vessels move on the same direction with the market returns. That is, for a 1% increase (decrease) in the market returns the average increase (decrease) in the returns of each vessel is β%. For example, for a 1% increase in the market returns the average increase in the returns on 5-year old Capesize bulk carriers (which were found to have the highest beta coefficient), will be 2.18% while the increase in the returns on 10-year old "MR" Product tankers (which were found to have the lowest beta coefficient) will be 0.64%. In addition, the R square provided (coefficient of determination) indicates what percentage of the vessel's total risk corresponds to the systematic risk while the remaining is the unsystematic risk that can be eliminated through diversification. With respect to the two vessels we mentioned above:

	Total risk of the vessel	
	Systematic	Unsystematic
5-year old Capesize bulk carrier	85.31%	14.69%
10-year old "MR" Product tanker	72.50%	27.50%

Moreover, a shipping portfolio's beta can be estimated as the weighted average of the betas of the vessels it contains. Finally, shipping portfolios with betas higher than 1 are preferable when the market is rising or is about to rise while shipping portfolios with a beta lower than 1 are preferable when the market is or is about to be depressed.

7.8 Shipping market line

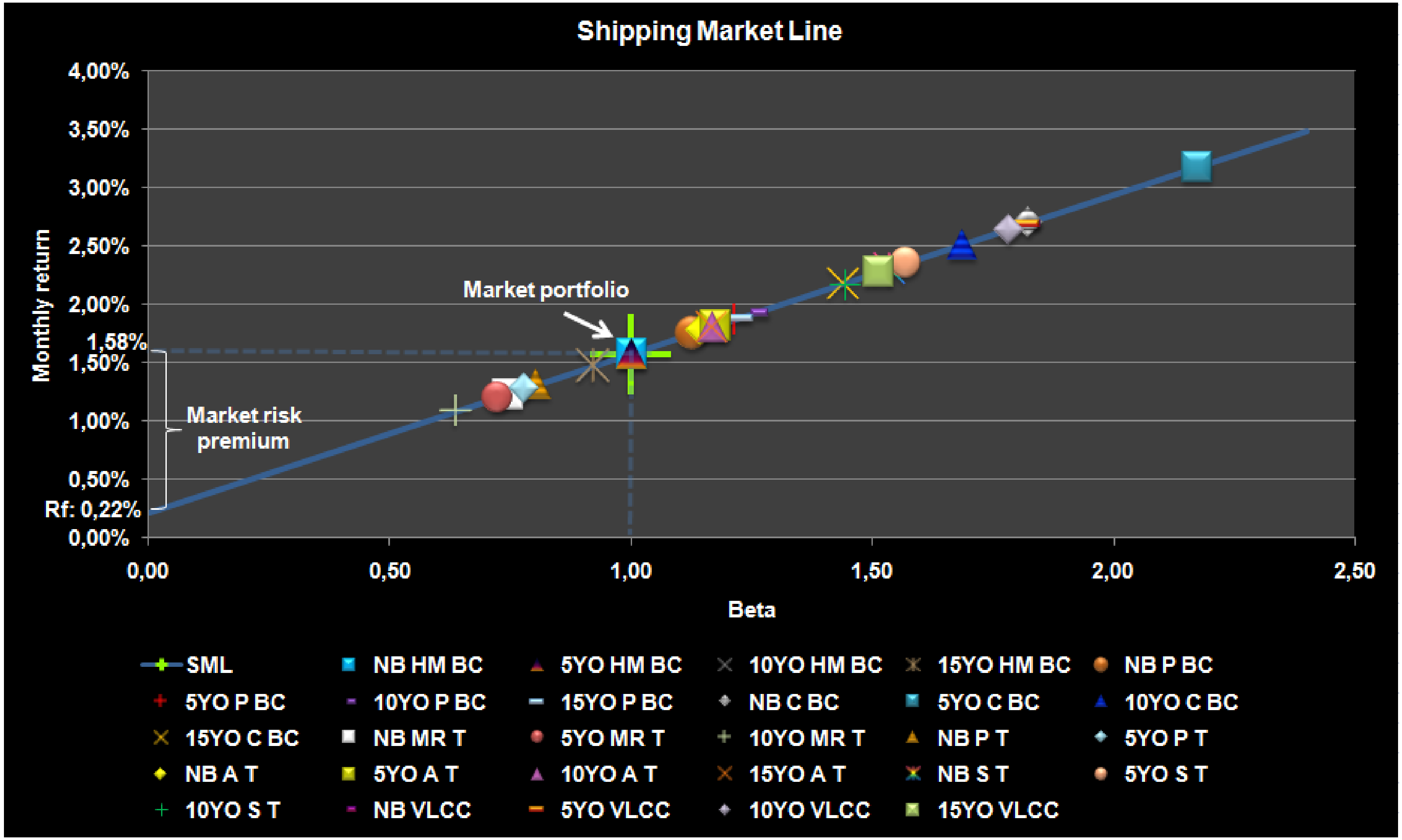


Figure 7.10: Shipping market line (monthly figures)

As we can see, in the figure above, the monthly market risk premium is (1.58% - 0.22=) 1.36%. In addition, the risk premium is higher for all vessels that lie on the shipping market line and are on the right of the market portfolio while it is lower for the ones that are on the left of the market portfolio. This means that vessels, the returns of which are more volatile than the returns on the market, are compensated with the higher risk premium while vessels, the returns of which are less volatile than the market returns, are given lower risk premium. The vessels with the highest and lowest beta coefficients are the 5-year old Capesize bulk carriers and the 10-year old “MR” Product tankers respectively. Their risk premiums can be calculated based on the CAPM model as follows:

$$E(R_{5YO\ C\ BC}) = R_f + \beta_{5YO\ C\ BC}[(E(R_M)-R_f] \iff$$

$$E(R_{5YO\ C\ BC}) - R_f = \beta_{5YO\ C\ BC}[(E(R_M)-R_f] \iff$$

$$\text{5YO C BC risk premium} = \beta_{5YO\ C\ BC}[(E(R_M)-R_f] \iff$$

5YO C BC risk premium = 2.1755 x (1.58-0.22) <=>

5YO C BC risk premium = 2.1755 x 1.36 <=>

5YO C BC risk premium = 2.96% > Market risk premium (1.36%)

and

$$E(R_{10YO\ "MR"\ P\ T}) = R_f + \beta_{10YO\ "MR"\ P\ T}[(E(R_M)-R_f] \iff$$

$$E(R_{10YO\ "MR"\ P\ T}) - R_f = \beta_{10YO\ "MR"\ P\ T}[(E(R_M)-R_f] \iff$$

$$\text{10YO "MR" P T risk premium} = \beta_{10YO\ "MR"\ P\ T}[(E(R_M)-R_f] \iff$$

10YO "MR" P T risk premium = 0.6380 x (1.58-0.22) <=>

10YO "MR" P T risk premium = 0.6380 x 1.36 <=>

10YO "MR" P T risk premium = 0.87% < Market risk premium (1.36%)

The risk premiums of all other vessels can be calculated in the same way.

Conclusion

Despite the various assumptions made and the limitations in terms of data availability, consistency and quality, a clear risk-return profile has been established for each of the vessels under assessment. The estimated Sharp ratios and utility values for investors with different risk preferences provided the bases for the ranking of vessels which differ in age within the sub-markets of each sector as well as the ranking of vessels of each age within each sector. In addition, the Modern portfolio theory has proven to be a useful risk management tool in the shipping industry. Based on the generated risk-return characteristics of the individual vessels, it provided the efficient fleet composition for each investment horizon taking also into account the different available operating strategies. Finally, the successive theory of portfolio leverage and the Capital Asset Pricing Model provided the market portfolios, the measures for systematic and unsystematic risk of the vessels and their risk premiums.

All in all, mathematical models have proven to be applicable in the shipping industry. In essence, they provide reliable information which is required for rational decision making. That is, their suggestions are not binding but they provide the guidelines. They do not replace the traditional way of shipping management but simply enhance it.

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