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Empirical impacts of macroeconomic risk factors on tanker shipping equities.

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Abstract

From a historical point of view tanker freight rates have been volatile. . The tanker shipping segment is the second largest segment within shipping and considered to be the segment with the highest volatility. Shipowners will experience periods abundant of "milk and honey" followed periods where they have to live out of "bread and water". Shipping is a high risk business characterized by stronger impacts from macroeconomic forces and maritime economic theory explains this market behavior by imbalances between supply and demand. This thesis sets out to model how tanker equity values are affected by this supply and demand relationship. Earlier research by Grammenous & Arkoulis (2002) and Mitter & Jensen (2006) have been conducted with different approaches and results. As a dependent variable, we have created a portfolio of 18 tanker shipping companies. The portfolio returns were recalculated monthly and weighted by company specific market capitalization divided by total portfolio market capitalization. To describe the dependent variable, different macroeconomic risk factors are considered as independent variables. The variables that are chosen for our model is based on risk factors depicted in maritime economic literature and macroeconomic literature. To investigate for how independent variables affect the dependent variable a multifactor model approach was applied. The variables that proved to have a significant effect on the dependent variable was: World portfolio stock return, Oil price, exchange rate USD-EUR, VLCC fleet size and selected lags of the series.

The tanker portfolio was proven to have a significant positive relationship with the development of the WTI oil price, VLCC spot rates, tanker fleet size, the MSCI world index and exchange rate of USD. Further the analysis could not detect any significant relationship related to the industrial production in OECD and US or petroleum inventories in the US. The final model ended up with an explanatory power of 39.7% which means that a large part of the changes in the tanker stock portfolio remain unexplained. The results of this thesis are for some relationships in line with earlier studies on risk factors and shipping stock returns, however some relationships differ from earlier studies.

Foreword

One of the most influential people within the tanker shipping industry, Tor Olav Trøim made the following statement about the shipping industry: "*After every storm the sun will smile, the survivors will have open seas and unimagined opportunities*" (Nor Ship 2011). "Heeling in high seas with nothing but dark clouds ahead", may be a suitable maritime reference to describe the last years' tanker market together with the prospect for next coming years. From the Nor Ship Summit (2011), the panel debate stressed that shipping is a highly cyclical market and that the captain that can best predict the weather and manage his ship would be the most likely to survive a storm.

"I'm not afraid of storms, for that is how I'm learning to sail my ship."

(Aeschylus 470 BC)

Aeschylus quote do in many ways describe the motivation behind writing this thesis, we are in many ways interested to study the storm. Together with an assumption that a lesson on how navigate the ship through the high seas can best be done by practical studies of an actual storm.

We would like to thank our advisor, Lisbeth la Cour, for her valuable comments and remarks throughout this process.

Oslo, November 1st 2012.

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1. Introduction

Shipping is widely known to be a highly volatile industry. Understanding and predicting this volatility is important for participants of the industry in making operating and investment decisions. The current crude tanker market is very challenging and is primarily affected by a strong fleet growth and decreasing global demand for transportation of petroleum products, particularly from the OECD countries where the future macroeconomic environment seems to be very uncertain. Both the market imbalance and weaker world economy have resulted in low spot- and period charter earnings, and consequently ship values have declined significantly the last years. The Shipping industry as a whole, but especially the tanker segment within the industry is highly exposed to fluctuations in macroeconomic factors. The world tanker fleet constituted of approximately 38% of the world shipping fleet in 2007 and most of the tanker fleet is used to transport crude oil or oil related products. An increase in for example oil prices may indicate a stronger economic growth, but the effect occurs both in the operating costs as well as in revenue for oil vessels. Different use of hedging strategies amongst the different ship owners adds complexity to the impact of oil prices and makes reliable and stable expectation of impacts of changes in oil price almost impossible. Commodity prices like the oil price cannot be prized from predictions of future cash flow, in contrast to time-discounted expectations of future earnings (stocks) or payments of interest (bonds). This indicates that there might not be a clear relationship between equity returns and the oil price. The presence of measurable relationships between macroeconomic factors and stock returns is a thoroughly debated subject, but without a clear conclusion. Berry, Burmeister, & McElroy (1988) investigates the possibility of such a relationship on a broad basis by applying econometric modeling to a number of stocks in different industries in the United States and tests their relationship with several macroeconomic factors. Berry, Burmeister, & McElroy's (1988) findings do not provide a cohesive result; instead their findings indicate that the impact of macroeconomic variables differs across different industries. Grammenos and Arkoulis (2002) conduct a similar research on shipping equity returns, where they investigate the relationship between shipping stock return and several global macroeconomic risk factors. The specific risk factors are based on Ferson and Harvey's (1994) research, where Grammenos and Arkoulis use the risk factors in a shipping specific environment. In their research, they find several significant relationships between shipping stock returns and risk factors, the specific factors that turned out to be significant were: Oil prices, laid up tonnage and exchange rates.

2. Basic definitions and data

This section offers a brief description of different vessels used for tanker shipping, their different sizes, trading routes and different types of contracts used for transporting liquid bulk. Further on the different costs associated with shipping is grouped and defined. Finally a brief presentation of the data sources we have used for the gathering of data used in the empirical sections is offered.

2.1 Tanker shipping segment

According to Stopford (2009) the shipping market is divided into three major segments; bulk shipping, specialized shipping and liner shipping. Bulk shipping can be divided into dry bulk and liquid bulk transportation where the transportation of bulk liquids by sea requires the use of tankers. This thesis will deal with the relationship between macro factors and tanker equities and we will therefore focus on the basic definitions and theory behind tanker shipping.

The world tanker fleet is defined as all vessels that are dedicated to transporting crude oil or refined oil products. This includes crude oil tankers, product tankers, chemical parcel tankers, liquid gas tankers and combined carriers (OBOs). In 2011 the world tanker fleet constituted of approximately 38 per cent of the world merchant fleet measured in tons deadweight¹. Figure 2.1 illustrates the allocation of the world fleet by ship type.



Figure 2.1 World fleet by ship type, measured in % of total dwt.²

¹ (UNCTAD, 2011)

² (UNCTAD, 2011)

2.1.1 Ships for the liquid bulk trades.

Crude oil tankers

The crude oil tankers is the largest single part of the liquid bulk segment, accounting for approximately 34 per cent of the merchant fleet and 90 per cent of the tanker shipping segment measured in tons deadweight³. Crude oil tankers transport large quantities of unrefined crude oil from ports near oil production sites to refineries. The smaller liquid bulk vessels called product tankers, described in the section below, transport fully refined petrochemicals from refineries to ports near consuming markets. Recent years a category of vessels called shuttle tankers has started to develop. Shuttle tankers are designed to transport crude oil from an offshore oil field to onshore storage facilities and refineries. We will not list the Shuttle tankers in a separate category because of its limited prevalence. In 2008 the shuttle tankers accounted for only 1.4 percent of the tanker shipping segment measured in tons deadweight, consisting of only 45 vessels⁴.

Product tankers

Within the oil tanker segment the product tankers stand out as an independent segment, although they are not clearly defined in statistical terms because of the blurred distinction between crude and product tankers and the fact that product tankers also can be used to transport crude oil. The main difference between the clean products tankers and crude oil tankers are the size of the vessels. While the crude tankers have a significant part of the fleet ranging between 100,000 dwt. and 350,000 dwt., the product tankers have an even distribution of vessels between 10,000 – 80,000 dwt.

Chemical parcel tankers

Vessels carrying small liquid bulk parcels of 2000 – 6000 tons with products such as vegetable oils, lube oils, caustic soda and other special chemicals are called chemical parcel tankers. The chemical parcel tanker segment is a small part of the liquid bulk transportation segment including vessels with capacities from 10,000 dwt. up to 50,000 dwt.

³ (UNCTAD, 2011)

⁴ (Wijnolst & Wergeland, 2009)

Liquid gas tankers

The two main types of liquid gas tankers are Liquid Natural Gas(LNG) carriers and Liquid Petroleum Gas(LPG) carriers. The main difference between the two gas types when it comes to transportation is the fact that LNG needs to be refrigerated down to -163°C. LNG carriers are in most cases specifically designed and built for a specific trade route and they are generally a part of a carefully planned transport process because of the high port handling costs and cost of the liquidation process. The LPG carriers makes up the largest seaborne gas trade because they carry liquefied gasses like propane, butane and isobutene that accounts for the majority share of demand for liquid gas products.

Combined carriers (OBOs)

Vessels that can switch between carrying dry bulk, e.g. ore, grain, coal and liquid bulk such as crude oil is called combined carriers, popular called OBOs (ore-bulk-oil carrier). This gives the ship owners an ability to switch between carrying tanker or bulk products after which market that gives the best payoff and by that maximizing their income. The OBOs also gives the ship owners an opportunity to reduce ballast time and thereby maximizing their utilization by carrying dry and liquid cargoes on alternate legs and may contribute to elasticity in the supply curve.

2.1.2 Fleet segments

Tankers used for liquid bulk trades can be divided into six different size segments. The different size segments are listed in table 2.1. The largest vessels in the world tanker fleet, from 200,000 dwt. and up (VLCCs and ULCCs) typically transport oil on long-haul trades mainly from the Arabian Gulf to Western Europe and the United States via the Cape of Good Hope and Asia. Suezmax tankers from 120,000 to 200,000 dwt. primarily operate in the Atlantic Basin delivering cargo from West Africa, the North Sea, and the former Soviet Union.

Type of ship	Size
Handysize	10,000 - 50,000 dwt.
Panamax	50,000 - 70,000 dwt.
Aframax	70,000 - 100,000 dwt.
Suezmax	100,000 - 200,000 dwt.
VLCC	200,000 - 300,000 dwt.
ULCC	Over 300,000 dwt.

Table 2.1 List of liquid bulk vessel types by size.

Aframax class tankers with displacements from 80,000 to 120,000 dwt. are largely used in the basins of the Black Sea, the North Sea, the Caribbean Sea, the China Sea and the Mediterranean while the smaller Panamax (50,000 – 80,000 dwt.) and Handysize (10,000 – 50,000 dwt.) vessels typically engage in inter coastal or medium to short haul oil trades, in areas of lower crude production or where draft and size restrictions prevent the use of larger vessels. Panamax vessels are in most cases used as product tankers transporting refined petroleum products while the Handysize world fleet contains both liquid parcel vessels and product tankers.

	All	tankers	C	Crude oil Product		Shuttle		
Size Category	No.	Mln. Dwt	No.	Min. Dwt	No.	Min. Dwt	No.	Min. Dwt
Handysize	1761	59,1	102	3,2	1655	55,7	4	157
Panamax	445	29,3	143	9,6	300	19,5	2	146
Aframax	731	75,3	563	58,3	157	15,8	11	1129
Suezmax	348	52,6	318	48,8	2	0,2	28	3594
VLCC	490	143,2	490	143,2				
ULCC	4	1,7	4	1,7				
Total	3779	361,2	1620	264,8	2114	91,2	45	5026

 Table 2.2
 Tanker fleet composition excl. liquid gas tankers: 1/1-2008⁵

2.2 Freight rates and contracts

The following section describes the different ways ship owners revenues are agreed on through the use of different type of contracts. Differences between the different contract types are an important factor for understanding the interaction between freight rates and the revenue earned by the ship owners. The understanding of fixed period contracts like time charters is important when investigating influences from lagged factors in our future analysis. Spot tanker rates are driven by the balance between tanker demand and tanker supply. The relationship between demand and supply and their key influences are described later, in section 3. The spot market for tankers is not a formal institution. It is a worldwide network of personal and professional contacts that carry out of cargo-by-cargo sales and purchases of crude oil and petroleum products transport⁶. When a ship is said to be fixed it means that the ship has been chartered and a freight rate has been agreed upon. The chartering works much in the same way as any other major international hiring agreement. The charterers have cargo they need to transport while the ship owners have vessels for hire. The deal and negotiation over the freight rate, covenants and clauses are arranged by

⁵ (Wijnolst & Wergeland, 2009)

⁶ (Razavi & Fesharaki, 1991)

a shipbroker which puts the deal together⁷.

The spot market, also called the freight market has two main types of transactions, *freight contracts* and *time charters*, that are further divided into different contract types.

Freight contracts

Vessel *freight contract* is established when the charterer buys transport from the ship owner at a fixed price per ton of cargo. The shipper is then responsible for carrying a specific amount of a specific cargo in a specific ship for a negotiated price per ton. There are two main variations of the *freight contracts*, the *voyage charter* and the *contract of affreightment* (COA). While the voyage charter is negotiated and agreed upon for one specific voyage of cargo, the *contract of affreightment* involves several voyages at specific time intervals. For example, the ship owner may reach an agreement with the charterer to supply ten consignments of 200,000 tons of crude from port Aden in Yemen to port Yokohama in Japan at quarterly intervals. The charterer arranges the shipments in a single contract called the *Contract of affreightment*, at an agreed price per ton and leaves the details of each voyage to the ship owner. The ship owner benefits from the deal by being able to plan the use of his ships in the most efficient manner and arrange backhaul cargos which considerably increase ship utilization⁸. Most COAs are carried out in the major dry bulk cargos of iron ore and coal, but COAs are also frequently used in tanker shipping with the majority of contracts in relation with product tankers.

Time charters

Time charter contracts are divided into time charter and bare boat contracts. A time charter contract is an agreement between the ship owner and a charterer to hire the ship, complete with crew, for a specific price per day, month or year. It gives the charterer of the vessel operational control of the vessel, while leaving ownership and management of the vessel to the owner of the vessel. When a vessel is lent out on *a time charter* contract, the ship owner is still responsible for all operational costs like crew, maintenance and repairs, associated with the vessel. The charterer of the vessel is responsible for all voyage costs like bunkers (fuel) costs, port charges and canal dues.

If the charterer wants full operational control over the ship, he will charter a vessel on a bare boat charter.

⁷ (Stopford, 2009)

⁸ (Stopford, 2009)

Under bare boat contracts it is typical that the ship owner is an investor, often a financial institution that purchases a vessel and hands it over to the charterer on a bare boat contract, usually lasting from ten to twenty years. Because the ship owner or investor disclaims the operational responsibility of the vessel it is not required that the ship owner hold maritime skills. Purchase of a vessel purely acts as an investment for the ship owner. Investing in a vessel for chartering out the operational control to a charterer can be compared to a financial lease agreement.

The advantages of a bare boat charter apply for both the investor and the charterer. The charterer gains an advantage by not tying up huge amounts of capital in assets, while the investor may obtain tax benefits. Governments in some countries encourage investment by providing tax incentives such as accelerated depreciation. Companies with high profits but no particular assets of their own can gain tax benefits by investing in a ship and leasing it to a charterer on a financial lease, e.g. a bare boat charter, who operates the ship as his own until the end of the lease⁹. The bare boat charters typically have a lifetime equal to the estimated lifetime of the vessel according to the depreciation scheme.

The use of time charters makes ship owners revenues more or less independent of the freight rates and is therefore hedge against fluctuations in the rates, depending on the length of the contract.

2.3 Ship costs

The cost of running a ship is an important factor for the ship owners and or charterers. The cost of running a ship can determine the optimal size of the ship, trade routes, speed and financing of the ship. There are three main cost categories associated with running a ship. These are capital costs, operating costs and voyage costs.

2.3.1 Capital costs

The *capital costs* for a ship accounts for approximately 40 percent of total costs¹⁰. The *capital costs* of a ship depends a large part on the size and type of the vessel, hence the price of the vessel. The capital value of the ship is the price that the ship is purchased for. The total *capital cost* of the ship becomes the sum of the annual depreciation, interest rate payments on the borrowed money and the required rate of return on the

⁹ (Stopford, 2009) ¹⁰ (Stopford, 2009)

owner's equity¹¹. The annual *capital costs* decrease with a longer vessel lifespan and increase together with an increasing interest rate. The *capital costs* of a ship will also depend on the financial structure of the investment, which depends on the amount of equity that is allocated to the project and how much is borrowed. The ship owner will buy the ship by using some of his own capital and borrowing the remaining from the bank.

2.3.2 Operating costs

Operating costs is the costs connected with the purely operational aspects of the day-to-day running of the vessel, excluding bunkers (fuel) costs that are included in the *voyage costs*. Costs for day-to-day repairs and maintenance are also included in the operating costs, but not major dry dockings that are dealt with separately. *The operating costs* for a ship accounts for approximately 23 percent of total costs.

Summarized, operating costs include:

Crew costs: Include all direct and indirect charges incurred by the crewing of the vessel including crew salaries, social insurance, pensions and other crew related expenses. Crew costs counts for 32 percent of total operating costs.

Stores, supplies and lubricating oils: Expenditures that is necessary to maintain the ship such as ropes, wires, paints, grease, lubricants and spares.

Repairs and maintenance: Repairs of the vessel has to be done when damage occurs. Maintenance includes routine maintenance and extraordinary maintenance that is necessary to stay in class (Maintain the approving by the classification society). Major dry dockings are dealt with separately.

Insurance costs: Accounts for approximately 35 percent of the total operating costs. The two main types of insurance of a vessel is Hull & Machinery (H&M) which protects the owner of the vessel against physical loss or damage, and Protection and Indemnity (P&I) which provides insurance against third party liabilities.

General costs (Management overhead, including administration): The management cost per ship depends on the size of the shipping company and the number of ships that are managed. This cost also includes other miscellaneous costs and agency costs.

¹¹ (Wijnolst & Wergeland, 2009)

2.3.3 Voyage costs

Capital and operating costs occurs irrespective of the sailing of the ship, the voyage costs first come into picture when the ship actually starts sailing¹². The main costs included in this group are bunker (fuel) costs, harbor dues, pilotage, tugs and canal dues.

The fuel used by a tanker ship is called bunkers. The consumption per voyage is determined by the size of the ship. If the ship is traveling fully loaded or in ballast (empty), the speed, the weather, type and quality of fuel and the price of the bunkers fuel which is highly correlated with the world oil price. During the last 25 years the oil prices have fluctuated considerably leading to a profound impact on the shipping industry and contributed to parts of the volatility in costs and revenues.

¹² (Wijnolst & Wergeland, 2009)

3. Modeling markets for tanker shipping

The freight rates in tanker shipping are a result of the demand and supply of transportation of liquid bulk¹³. Demand and supply for liquid bulk transportation is caused by an imbalance between the geographical locations of the oil and gas production, processing and consumption.

This section will first introduce the general relationships between demand and supply for all shipping segments, referred to as the shipping market model by Stopford (2009). Similar models can also be found in earlier literature like the NORBULK and NORTANK model explained by Norman and Wergeland (1981). According to Beenstock and Vergottis (1993) one of the earliest econometric applications to explain and predict shipping freight rates by studying the factors that influence demand and supply was done by Tinbergen (1934). Further on the more specific supply and demand functions of tanker shipping is explained. The demand and supply function for the tanker shipping market is derived from the shipping market model, but includes its own distinctive characteristics. We have developed the tanker shipping model on the basis of the theory around demand and supply for tanker shipping described by Wijnolst and Wergeland (1997).

3.1 The shipping market model

The shipping market model by Stopford (2009) consists of the demand function, the supply function and the freight rate mechanism. The demand side consists of different factors that influence the amounts of goods which require sea transport while the supply side consists of the world merchant fleet which represents the fixed stock of shipping capacity. The supply and demand functions make up a market balance. Any imbalance feeds through into the third part of the model, the freight rate mechanism, which is an adjustment mechanism that links supply and demand. The shipping market model is illustrated in figure 3.1.

¹³ (Stopford, 2009), p.139



Figure 3.1 The shipping market model¹.

3.1.1 The demand for sea transport

Maritime economy is complex and when introducing the theory behind shipping markets one need to simplify the model by singling out those factors that are assumed to be most important. Additional details should not be ignored, but the fact that too much detail can prevent a clear analysis should be embraced. Some of the main driving forces behind shipping demand are according to Wijnolst and Wergeland (1997) energy consumption, the oil price, the business cycle and unexpected political events. The shipping market model depicted by Stopford (2009) points out five influences on demand for sea transport as particularly important, all closely related to the driving forces mentioned by Wijnolst and Wergeland (1997) .The five influences are listed and explained below.

World economy

World economy is the most important single influence on the demand side of the shipping market model. The world economy factor generates the majority of demand for transportation either through import/export of raw materials for use in manufacturing industry or import/export of manufactured products.

Seaborne commodity trades

Description of the seaborne commodity trades falls into two parts: short-term and long-term. The short-term trends are characterized by the seasonality of the commodity trades. Many agricultural commodities,

the oil business and other commodities are subject to seasonal variations. While the agricultural commodities are affected by the annual harvest season, the oil business is affected by the seasonal fluctuations in energy consumption in the Northern Hemisphere. This imbalance in energy consumption leads to more oil being shipped during the autumn and early winter than during spring and summer. The long-term changes in demand is particular influenced by the changes in demand of a particular commodity, changes in the source of the commodity, changes in the location of the processing plants of the commodity and changes in the shippers transport policy.

Average haul and ton miles

Average haul of the trade is the distance effect of voyages. To take account for average haul, it is usual to measure sea transport demand in terms of "ton miles", described as the tonnage of cargo shipped, multiplied by the average distance over which it is transported¹⁴. Amendments in the average haul are usually caused by factors described in the next subsection as "Random shocks". The effect of changes in the average haul on ship demand has been illustrated several times by random shocks that for example have led to the closure of the Suez Canal in 1967 which increased the distance between the Arabian Gulf to Europe by sea, from 6,000 miles to 11,000 miles.

Random shocks

The random shocks part includes partly the political element of the demand function. Random shocks can be weather changes, wars, new resources, significant commodity price changes and other unexpected events. These shocks are unique and often triggered by some particular event. Random shocks can as described in the subsection above have great effect on the demand for sea transport. Examples of random shocks in the recent years are the 1990-1991 Gulf War which resulted in a severe increase in tanker demand because it led to the closure of the Dortyol pipeline and the Venezuelan oil strike I 2002-2003 which reduced Venezuela's oil exports to almost nothing for several months.

Transport costs

Transport costs are a significant factor for the demand for sea transport. Raw materials will only be transported if the cost of transportation is at an acceptable level or some other major benefits are obtained.

¹⁴ (Stopford, 2009),p.146

Transport costs are as shown in Figure 3.1 as an adjustment mechanism in the freight module that adjusts for any imbalance between the supply and demand modules.

3.1.2 The supply of sea transport

In this section the main factors that influence the supply of sea transport is presented. The supply side of the shipping market model consists of the shipping capacity in the world at any given time. The main factor for supply is therefore the amount of vessels trading in the shipping market and their respective size and transport capacity. Merchant ships take on average one year to build, but it might take as long as 2-3 years before delivery if the shippards are busy. This prevents the ship owners in responding immediately to an upswing in market rates. A merchant ship has an average lifetime of 15-30 years so responding to a sudden decrease in demand is a prolonged business.

The supply part of the NORBULK/TANK model by Norman and Wergeland (1981) accounts for the size of the fleet, the fuel price and freight rates. The similarities between the supply side of the NORBULK/TANK model and the shipping market model by Stopford (2009) are many. Stopford (2009) describes the fleet size factor more closely, but excludes the importance of the fuel price on supply. We have based our assessment of the supply of sea transport on the shipping market model by Stopford (2009) but taken the fuel price factor from the NORTANK model into account as relevant for the supply module. Stopford (2009) mentions five influences on the supply of sea transport as particularly important. The five influences are the merchant fleet, fleet productivity, scrapping and losses, shipbuilding and freight rates. The influences are more detailed explained below and will explain how the adjustment process of supply is controlled.

The world merchant fleet

A merchant vessel is defined as a vessel that transports goods or passengers. The world merchant fleet is therefore the total amount of transport capacity in the world, transporting goods or passengers measured in deadweight tonnage. The merchant fleet is a natural starting point for a discussion of the supply of sea transport. According to Stopford (2009) the world merchant fleet is the most influential driver of ship supply. As of January 1st 2011 the world fleet consisted of 1 303 700 dwt.¹⁵. In the long run scrapping and deliveries determine the rate of fleet growth. This is more detailed explained under Shipbuilding

¹⁵ (Platou, 2011)

production, scrapping and losses further in this section.

Fleet productivity

Total size of the world merchant fleet is an important factor for describing the total supply of sea transport in the world, but the productivity of the world merchant fleet is equally important. The productivity of a fleet of ships is measured in ton miles per dwt. and depends upon four main factors. These four factors are speed, port time, deadweight utilization and loaded days at sea. Speed determines the time a vessel uses to complete a voyage. The design of the vessel determines the maximum speed of the vessel and newer more modern vessels often have more speed optimizing design. Ship owners can also choose to reduce speed of their vessels to optimize voyage costs. High costs of bunkers fuel as a result of higher oil prices are a contributing factor to why the ship owners choose to reduce the voyage speed. Deadweight utilization refers to how well the ship owners utilize their ships cargo capacity. In economic downturns lower deadweight utilization is a typical phenomenon because ship owners tend to carry part cargoes.

Shipbuilding production, scrapping and losses

Shipbuilding, scrapping and losses refers to the amount of cargo capacity that enters or exits the supply side of the shipping market model. The rate of growth of the merchant fleet introduced earlier depends on the sums of new ship deliveries, scrapping of old ships and ships that are lost at sea. The ship new building and scrapping industry plays an important part in the fleet adjustment process described later in section 3.3.

Freight rates

Freight rates are an important influence on the supply of sea transport because of its significant impact on the profitability of a ship. The total revenue of a ship is determined by the load of a good transported together with the freight rate of the specific commodity. The ship owners will therefore only have their ships trading in the market if the freight rates are at a satisfying level where revenues are greater than total operating expenses of the vessels. Freight rates are shown in Figure 3.1 as an adjustment mechanism in the freight module that adjusts any imbalance between the supply and demand modules.

Oil price

Wijnolst and Wergeland (2009) explains that the supply side of the shipping market is affected by the price

of bunkers which is highly correlated with the price of crude oil. The optimal speed of a vessel is a battle between two opposite forces. The higher speed a vessel holds, the faster it can deliver its cargo and take on new shipping contracts, resulting in more income per day. However the higher speed results in higher costs as the vessels uses more bunkers. The optimum speed of a vessel will therefore depend on the oil price and thus the supply of available vessels for shipping will be influenced by the oil price.

3.1.3 The freight rate mechanism.

The third module in Stopford's shipping market model is called the freight rate mechanism and is an adjustment mechanism that adjusts for imbalances between supply and demand in the long run through the two adjusting factors described earlier in section 3; transport costs and freight rates. Supply and demand are connected through the freight market where ship owners and shippers negotiate and try to reach an agreement for a specific freight rate, which reflects the balance of available ships (supply) and cargo (demand) in the market. Intuitively freight rates tend to be low when there is a surplus of ships and high when there is a shortage of ships. To fully understand how the freight rate mechanism works, it is essential to study the supply and demand functions.

3.2 Supply and demand functions

Supply function

Section 3.1 stated that the supply function describes the amount of transport the world merchant fleet can provide at different levels of freight rates. Figure 3.2 illustrates how the market adjusts to supply provided by a fleet of ten vessels. The same function applies for the world merchant fleet. In response to changes in freight rates the supply function adjusts supply by moving vessels in and out of layup. A vessel is laid up when the supply of vessels leads to freight rates that are lower than the vessels operating costs. The slope of the short-term supply curve in figure 3.2 is affected by the age of the vessel, the size of the vessel and the relationship between speed and freight rates. The age of the vessel decides when it will be taken out of service and laid up. An older ship has usually higher operating costs than new vessels, so lay-up will occur at higher freight rates. The size of the vessels affects the transportation costs per ton of cargo and larger ships tend to benefit from this. The third factor is the relationship between speed and freight rates. This relationship can be defined from economic theory where in a perfectly competitive market the vessel will be operated at a speed where its marginal cost equals the freight rate.¹⁶





Demand function

Figure 3.3 illustrates how the shippers adjust their demand for transport to the price changes in the market. The demand for transportation is very inelastic. As seen in figure 3.3 the demand curve is almost vertical and this is due to the fact that there are few competing transportation modes available in the market. The shippers are in need of transporting their cargo and transportation by sea is in most cases the only possible way. They must therefore ship the cargo by sea regardless of cost.

¹⁶ (Stopford, 2009) ¹⁷ (Stopford, 2009), p.161



Figure 3.3 The demand curve.¹⁸

The cost of transporting goods represents only a small share of the total cost of the products that are being transported. The typical cost to a consumer in the United States of transporting crude oil from the Middle East, in terms of the purchase price of gasoline at the pump, is about half a US cent per litre¹⁹, while the average price of gasoline in the United States in September 2011 was 79 US cents per litre²⁰. The demand will therefore not be greatly influenced by increasing freight rates.

3.3 The Four Shipping Markets

In order to understand why freight rates behave the way they do we have to take a closer look at the four markets that control the shipping industry. These four markets are the freight market, second-hand market, new building market and the demolition market.

The freight market is the main source of income for the shipping companies. When the freight rates increases the prices of second hand vessels will also increase because of the opportunity in the market for making good profit. When the demand for vessels increases, the second hand prices for vessels also increase. When the prices of second hand vessels reach very high levels because of reduced supply, ship-owners will start looking at the new building market for ordering of new ships. Shipbuilding is a long-cycle

¹⁸ (Stopford, 2009), p.161

¹⁹ (Shipping Facts, 2012)

²⁰ (American Petroleum Institute, 2011)

business and has a time-lag between ordering and delivering of approximately 1 to 4 years depending on the ship type and existing order book of the shipyards. When the vessels are delivered a few years later, the supply side of the market will increase and in most cases move towards a more balanced situation between supply and demand resulting in decreasing freight rates. As a result of the falling rates, ship owners with a constrained balance sheet will have difficulties meeting their financial obligations like loan repayments and interest costs. In a period with low rates a lot of the ship owners can only obtain freight rates that are lower than the operating costs of their vessels and many of them will therefore be forced to sell ships in the second hand market to obtain liquidity to service debt. This will result in a situation where owners of the oldest ships will be forced to sell ships for scrapping in the demolition market because of low liquidity in the second hand market for the oldest vessels. When ships are sent to demolition, this will result in fewer ships available in the market and the demand side will once again exceed the supply side. The process will therefore start over again, with rising freight rates, caused by the shortage of supply in the market. As described earlier, for new building of ships there is a time lag between ordering and the delivery of the ship. Ships are ordered based on current market conditions but when they are delivered the market conditions may have worsened.²¹ Because of the time lag, an already weak market will be further depressed when the ships that were ordered during the good times are delivered and supply is added to the market. The market experiences oversupply and the rates continue decreasing. This is what happened in the tanker shipping market during the period after the financial crisis in 2007. In 2008 – 2010 the tanker market was depressed because of the turmoil in the world economy leading to lower demand for oil. This period came suddenly after several years of record breaking rates and high demand in the period 2004- 2007 and consequently a large number of new builds were ordered during this period. When the new buildings was to be delivered into the beat down market in the aftermath of the financial crisis, the supply side kept on growing and the rates dropped to levels far below break-even for most ship owners.

Another factor is that investors who have ordered ships may cancel their new building contracts when recessions like the one in 2007 hits. Asian countries like China are well known for walking away from new building deals during recessions. This causes the shipbuilders to be left with a ship that is not paid for, but the need for cash. They therefore have to lower the price of the ships in order to obtain cash.

²²

²¹ Stopford 2009 : 207

3.4 Tanker shipping market model

The tanker shipping market includes around one third of the global shipping market so that its influencing factors are quite similar to the factors described in The Shipping Market Model in section 3.1 is no surprise. However there are some differences and distinctive characteristics to the tanker shipping market. Beenstock and Vergottis (1989) concluded that the different shipping segments in the shipping market are interdependent and that developments in one segment will spill over into others. The main spillover effects between the dry bulk and tanker market is the fact that combined carriers may be switched between the tanker and dry bulk market and that shipbuilders may build dry bulk or other vessel types instead of tankers. These substitution effects bind the shipping markets together²².

3.4.1 The demand for tanker shipping

Tanker shipping involves transporting liquid petroleum products from net exporting to net importing regions in the world. The demand for tanker shipping is correlated with the demand for oil transportation. There are several factors that influence the demand for oil transportation. In section 3.1.1 we introduced the five most important factors that influence the demand for sea transport. The key parameters for oil transport demand is closely related and in some way developed from the factors for sea transport demand, but more specifically explained to only include the liquid petroleum transport part of seaborne transport. The key parameters are listed below:

- The reserves of oil;

- Total demand for energy;
- Distribution of demand on energy sources;
- Developments in producing and exporting areas;
- Distance implications of trade patterns.

The recent years have included discussions about peak oil, the situation where oil production can no longer increase per year. Oil reserves have in a historical perspective shown to be a dynamic concept. The R/P ratio is a definition of how many years the current proved oil reserves will last with the current production rate. Despite the large amount of almost 80 million barrels of oil per day actually produced, the R/P ratio is actually higher today than 25 years ago. The increasing R/P ratio is due to new oilfields, new technology and

²² (Beenstock & Vergottis, 1989)

new extraction methods of extracting oil where the subsea industry in the North Sea is a good example.²³ The total demand for energy is highly influenced by the world economic growth, population growth and the world industrial development. The last decade has witnessed a substantial increase in the world's demand for oil, primarily because of the dramatic economic growth in developing countries, particularly China and India. World oil demand has grown by 7 million barrels per day since 2000; of this growth, 2 million barrels each day have gone to China.²⁴

3.4.2 The supply of tanker shipping

The tanker fleet consists of many different types of vessels as described in section 2.1. The supply side of the tanker shipping model will therefore consist of the different type of tanker vessels all included in the world tanker fleet. Similar to the Shipping Market Model, the supply side of tanker shipping highly influenced by the world tanker fleet. The world tanker fleet is adjusted through new building, scrapping and losses as described in section 3.1.2 and 3.3. A specific relationship for the tanker market supply side is the alternative use of tankers. For owners of the combined carriers (OBOs) that were introduced in section 2.1, a depressing tanker market will not automatically lead to scrapping and layups of vessels. The OBOs can easily start trading in the dry bulk market where the freight rates might be at higher levels, resulting in reduced losses. Another feature specific for the tanker market is that the tanker vessels may be used as floating storage in times when freight rates are at depressing levels. This will also lead to reducing the losses of the tanker vessel owners. The ability to move supply quickly in and out of the market, avoiding scrapping and sale of vessels is something that contribute to less aggressive drops in prices of second hand tanker vessels. This theory however is seldom seen in the real life because of the limited amount of OBOs and demand for floating oil storage.

²³ (Wijnolst & Wergeland, 2009) p. 117

²⁴ (Yergin, 2006) p. 71

4. Macroeconomic risk factors and the tanker portfolio

This section will introduce the composition and methods of performance measuring for our dependent variable, the tanker portfolio. We will also introduce our independent variables which are macroeconomic risk factors we think can explain return on tanker shipping equities. An introduction to how the independent variables will impact the dependent variable is also included in this section.

4.1 Data Sources

We have used Datastream²⁵ and Clarksons Shipping Intelligence Network²⁶ to access all the stock quotes and most of the macroeconomic variables. The data for the tanker spot rates were collected by RS Platou ASA and given to us upon request. We have collected the variables for the fleet size factor from the monthly analysis of the shipping market published by Drewry publications.

4.2 Tanker portfolio – The dependent variable

Our sample consists of 18 shipping companies, listed in 10 stock exchanges worldwide and whose shares have been actively traded between February 1990 and September 2011. The focus of the study is on companies whose prime business is in the operation of tanker vessels. Some of the companies in the portfolio have business interests in other segments than tanker shipping; however all of the chosen companies have the majority of their operations within the tanker segment. The tanker segment is defined as the transportation of crude oil, refined products or liquid gas on international and national routes. Not all of the equities in the portfolio are represented with stock quotes throughout the whole period, however we consider our portfolio as representative for the tanker equity market in all periods as the tanker market has developed together with the new listings of tanker firms. Our assessment is based on the fact that the tanker equity market continually evolves in line with listing of new companies.

Shared ownership with outside investors through an IPO allows shipping companies to augment and diversify their sources of financing, improve their image and prestige, strengthen bargaining power with creditors, and enhance their entrepreneurial opportunities²⁷. Pagano, Panetta & Zingales (1998) find in their research that company size is significantly correlated with the probability of listing. The portfolio of listed equities will therefore represent the largest companies in the segment and account for a significant share of

²⁵ (Datastream, 2012)

²⁶ (SIN, 2012)

²⁷ (Mourdoukoutas & Stefanidis, 2009)

the total tanker market. We hereby consider the total collection of tanker companies that are stock listed in a given period to be representative for the tanker market and thus our portfolio to also be representative for the tanker market in its entirety.

Portfolio restrictions

Tanker equities are collected using certain restrictions to obtain a portfolio that is representative of the tanker equities market. We believe that by controlling for to many factors in the portfolio, we in some way create our own desired result and bias the results because of preconditions forced onto the input data. However, believe that controlling for some factors must be done in order to obtain a dependent variable that will represent what we want to test in the regression. One restriction is to include only companies whose prime business is in the operation of tanker vessels. We consider a fleet composition of at least fifty percent tanker vessels transporting liquid bulk (crude, products & gas) as satisfying for this restriction. We have assembled a portfolio in accordance with the above mentioned guidelines, with lenient control for fleet composition and hence omitting companies whose cash flows are mainly influenced by other business segments.

4.2.1 Measuring performance

In order to correctly compare equity returns, it's imperative to realize the role dividends play in an investment portfolios performance and in its comparable index²⁸. We have chosen to use a total return index for each stock as a measurement for performance. The total return indexes includes dividends, interest, rights offerings and other distributions realized over a given period of time and therefore gives a more accurate measurement of performance. Monthly data on stock total return index (TR_{it}) are obtained from DataStream International Service. These are used to calculate monthly returns, measured in percent for each company i, as:

$$r_{it} = \ln(TR_{it}/TR_{it-1})$$

 r_{it} = Monthly return in period *t* for company *i*.

 TR_{it} = Total return index value for company *i*, in period *t*.

The companies included in the tanker portfolio, together with summary statistics are presented in table 4.1. The average monthly total returns in percent for 10 out of the 18 tanker companies are negative, while their

²⁸ (PortfolioRethink.com, 2011)

industry average is - 0.027%. This return is lower than the corresponding excess return on the MSCI World Equity Index, which is marginally positive and stands at 0.325%. Total average risk in the industry, as measured by the average standard deviation of monthly total returns, is 13.35%, much higher than the standard deviation of the MSCI Index, which is 4.79%. Coefficients of skewness are on average negative.

Company name	Exchange	Mean	Std. Dev.	Skewness
Frontline	OSE/NYSE	0,0101	0,1666	-0,5540
Overseas shipholding group	NYSE	-0,0004	0,1072	-0,2794
Euronav	BR(Brussel)	-0,0146	0,1198	-1,3427
Tsakos	NYSE	0,0014	0,1199	-0,1772
General maritime	OTC	-0,0224	0,1733	-1,7436
Teekay Tankers	NYSE	-0,0238	0,1658	0,0712
Torm A/S	NasdaqGS	-0,0015	0,1141	-0,4619
Double hull tankers	NYSE	-0,0213	0,1295	-1,0116
Ship Finance	NYSE	0,0044	0,1307	-1,2590
Concordia maritime	Stockholm	-0,0008	0,1174	0,2169
Kyoei Tanker Company	Tokyo	-0,0077	0,1319	0,7228
Meiji Shipping Company	Tokyo	-0,0112	0,1458	1,6302
Premuda	Borsa Italia MTA	0,0065	0,0948	0,7819
Tankerska Plovida	XZAG	0,0170	0,1763	1,1551
China Merch. Shipping	Shanghai	-0,0146	0,1378	-0,6237
Knightsbridge Tankers Ltd.	NasdaqGS	0,0079	0,1112	-0,2582
Golar LNG	NasdaqGS	0,0184	0,1504	-0,5391
I.M. Skaugen	OSE	0,0047	0,1099	0,2831
Portfolio average		-0,00266	0,1335	-0,1883
MSCI World Equity Index		0,00325	0,0479	-0,6958

Table 4.1 Companies included in the tanker portfolio and summary statistics.

4.2.2 Portfolio weighting

Tanker shipping market is described by a portfolio consisting of 18 international tanker shipping companies. We have chosen to weight the monthly returns for each company according to their size relative to the other companies. Each company in the portfolio is value-weighted where its portfolio weight is derived from the size of the company market capitalization in proportion to the total value of the portfolio market capitalization. The portfolio weights are recalculated each month, sum to one and are always positive. The dependent variable in our regression will be the weighted monthly net portfolio return given by:

$$R_t = \sum_{i=1}^n x_{it} r_{it}$$
 Ea. 4.2

 R_t = Portfolio return in period t.

 x_{it} = weight of company i in the portfolio at time t.

me t. r_{it} = Monthly return in period *t* for company *i*.

n = number of companies.

Company name	Average port. weight	Average mcap.
Frontline	16 %	1875,8
Overseas shipholding group	27 %	1062,4
Euronav	7 %	1335,3
Tsakos	4 %	670,4
General maritime	6 %	744,8
Teekay	2 %	276,8
Torm A/S	7 %	611,5
Double hull tankers	2 %	306,9
Ship Finance	8 %	1530,5
Concordia maritime	2 %	97,2
Kyoei Tanker Company	4 %	99,8
Meiji Shipping Company	7 %	158,2
Premuda	1 %	110,5
Tankerska Plovida	2 %	299,1
China Merch. Shipping	15 %	3197,5
Knightsbridge Tankers Ltd.	2 %	381,2
Golar LNG	4 %	915,5
I.M. Skaugen	1 %	121,9
Portfolio total		7890.0

Table 4.2 Companies included in the tanker portfolio and summary statistics.

*Market capitalization in USD millions.

The portfolio weights in table 4.2 are average portfolio weights throughout the whole time period which the time series are obtained from. The portfolio weights are recalculated each month so the average portfolio weights listed in table 4.2 will not sum to 100%, however the portfolio weighting for each month will sum to 100%. As we can see from table 4.2 there are some equities that stand out with very high average portfolio weights. The reason for this is that in the beginning of the time period our time series are captured from there are only a few equities which are represented and therefore have a high portfolio weight the first years, thus having a high average portfolio weight throughout the whole period.

4.2.3 The development of the tanker portfolio



Figure 4.1 The figure shows the development of the portfolio of tanker stocks in the period 1990-2011. The return series are displayed on an index starting at 100 in the year 1990.

As we see from figure 4.1 the tanker portfolio has a clearly negative development in the first three years and last three years. In the period 1990 - 1993 the portfolio experienced a substantial negative return and the same applies for the period 2007 - 2011. The reasons for these substantial negative developments are two well-known crises in the world economy.

As the new decade began in 1990, it was also the opening of a long term downturn in the world economy. Many had in the 1980s raised debt in confidence of the bright prospects of the future. But in the late '80s the rising debt burden started to dampen people's consumption. While the inflated stock market and real estate prices burst like soap bubbles, it was the beginning of a worldwide crisis that came to dominate the early years of the 1990s. The turmoil in financial markets, and especially the first Gulf war 1990/91 (war Iraq-Kuwait) gave the emerging crisis an extra kick. Also soaring oil prices in August 1990 gave the downturn a nudge in the wrong direction. In Europe and especially Germany, economic problems followed the reunification between West and East Germany. In Asia the Japanese crisis started and lasted into the next century.

The period 2007-2011 is called the financial crisis and was a comprehensive crisis in the world financial system. The crisis had its origins in the price of debt securities, particularly those related to the U.S. housing market had become too high - a typical financial bubble. The discrepancy between actual and recorded

values appeared first in the so-called subprime loans. In autumn 2008, parts of the international financial market crashed, followed by many of the world's largest commercial banks hesitant to lend to each other. Governments worldwide needed to intervene to finance their respective financial systems. Nevertheless, a number of renowned financial institutions went bankrupt since the financial panic began. In autumn 2008 a severe recession in most Western industrialized countries further lead to a negative development in the equity markets around the world.

4.3 Macroeconomics Risk Factors – Independent variables

To try and explain tanker stock returns we will investigate the relationship between macro factors and tanker equities. By using time series of data for our chosen macro factors we will be able to study their impact on our portfolio of tanker equities by using empirical analysis. The independent variables in our analysis will be the simple returns of our chosen macroeconomic factors.

All returns will be given by:

$$c_{it} = \ln(V_{it}/V_{it-1}) \qquad \qquad \text{Ea. 4.3}$$

 c_{it} = Monthly change of variable i at time t. V_{it} = Indexed variable i at time t.

Table 4.3 shows the symbols associated with the macroeconomic risk factors we have chosen in our attempt to explain tanker stock returns. The last column in the table describes the hypothetical impact each variable will have on tanker stock returns. The risk factors and their hypothetical impacts are described in the section below.

Symbol	Description Hypothetica	al impact
d_msciworld	Changes in the return of the MSCI World index of over 6,000 world' stocks.	+
d_fleetsize	Changes in the size of the world total tanker fleet.	-
d_vlccspot	Changes in market spot rates for modern VLCC crude carriers.	+
d_prod_oecd	Changes in total industry production level in the OECD countries.	+
d_inv_petr	Changes in petroleum inventories.	+/-
d_oilwti	Changes in the price of West Texas Intermediate (WTI) oil.	+/-
d_exr_useu	Changes in the USD/EUR exchange rate.	+/-
d_prod_us	Changes in total industry production level in the United States.	+

Table 4.3 Description of the chosen independent variables and their hypothetical impacts.

MSCI World index

This factor includes changes in the return of the MSCI World Index. The MSCI is a stock market index which includes over 6,000 different stocks from all around the world. Both Kavussanos and Alizadeh (2002) and Stopford (2009) explained that shipping is clearly influenced by the world economy because of its international presence. Changes in the world economy measured as the return in global equity markets is therefore believed to have positive impacts on tanker stock returns. Our hypothesis is derived from macro-economic relations: As the world economy is growing more money will come into circulation leading to increased demand on a world basis. Increased demand influences industrial activity which further leads to an increase in energy consumptions. The increase in energy consumption leads to increased demand for oil which as described in section 3, makes the freight rate mechanism adjust for the imbalance between supply and demand by increasing freight rates. Freight rates are the main source of income for the tanker shipping companies and they therefore have a direct impact on the pricing of the companies. Earlier findings by Grammenos & Arkoulis (2002) and Mitter & Jensen (2006) have confirmed this relationship.

World tanker fleet size

World Tanker fleet size factor covers the changes in the operating world tanker fleet. The operating tanker fleet size is a result of the total shipbuilding, scrapping, losses and laid up vessels. We have used monthly operating tanker fleet size values, collected from the journal "Shipping Insight monthly" by Drewry Publications, for the period 1990 – 2011.

To explain why we believe fleet size is a factor influencing the tanker shipping stock returns we must look to the relationship between supply and demand introduced earlier in section 3 of this thesis. As demand for transportation of oil increases, the freight rates increases, due to the freight rate mechanism which adjusts for any imbalance between supply and demand. The increase in freight rates makes shipping companies order new ships because they see a bright future ahead with revenues much higher than their operational costs. When the new built ships enter the market, supply increases and the freight rates decrease. Our hypothesis is that an increase in the size of the world tanker fleet will have a negative influence on tanker stock returns. An increase in fleet size causes an increased level of supply leading to a decrease in the freight rates and therefore a reduction in tanker stock returns.

VLCC spot rate

According to Randers and Göluke (2007) tanker freight rates are strongly correlated over time in the competitive shipping markets. We therefore conclude that any choice of market spot rates, for any type of tanker vessels will prove to be adequate in an econometric analysis. We have chosen to use market spot rates for modern VLCC crude carriers obtained by Economics Research at RS Platou. As explained in section 2.2, the spot market for tankers consists of different type of contracts. The factor vlccspot is the price of freight contracts. Freight contracts are established when the charterer buys a single transport from the ship owner at a fixed price per ton of cargo. We have chosen to include spot rates as a hypothetic influential factor because of its direct impact on the tanker shipping companies' revenue. Our hypothesis is that it will have a positive influence on tanker shipping stocks.

Exchange rate between USD and EUR

The *exr_useu* factor represents the changes in the exchange rate between US dollars and Euro. The relationship between the US dollar rate and other exchange rates is an important factor for shipping companies. We have chosen the relationship with the Euro because of its prevalence and major position as the main currency of Europe. The euro was introduced as an accounting currency on January 1st 1999, replacing the former European Currency Unit ("ECU) at a ratio of 1:1 (US\$1.1743). The ECU was a basket of the currencies of the European Community member states, used as the unit of account of the European community. The variables in our time series dated earlier than January 1st 1999 is the exchange rate between US dollars and the ECU. Since our tanker portfolio mainly consists of companies based in the US, Europe or China it was natural to include the exchange rate between the US dollar and Euro as a risk factor in our empirical research. The exchange rate between USD and Chinese Yuan was rejected because of its long history of being fixed against the USD. The Yuan was pegged to the US dollar during most of the 20th century and the peg was finally lifted on July 21 2005. China still keeps the Yuan pegged to a basket of currencies, most notably the U.S. dollar.

The reason for the importance of the US dollar regarding tanker stock returns is simple. Most shipping companies have their capital costs, voyage costs and revenues in dollars and are often based in non-dollar countries with returns and performance reported in local currencies. Some shipping companies also have their revenues in a local currency, their loans in EUR and operating costs in dollars, there are a lot of variations. The effects of changes in the value of the dollar can be divided into direct effects and indirect effects. The direct effect of the dollar increasing in value relative to other currencies is an increase in the

freight rates. The indirect effect will come as a sequence of macroeconomic connections. An increasing value of the dollar relative to other currencies will lower the demand for goods quoted in dollars, such as oil. This will cause a decrease in the international trade and thus the demand for transportation of oil decreases. Our hypothesis is therefore that dollar appreciation will have both a direct positive impact on the tanker stock returns because of the exchange rate effect on freight rates and an indirect negative impact where the appreciation leads to a lower demand for oil. Further investigation by looking at empirical results must be conducted.

Industrial production in OECD countries

This factor covers the total industrial production aggregated for all OECD countries. Financial theory regarding industrial production propose a positive correlation with equity returns because of the relationship between higher industrial production and improving economic conditions, leading to higher return on equities²⁹. Already in 1938, Isserlis³⁰ pointed out that fluctuation in freight rates exhibit similar trends as cycles in the world economy. Stopford (2009) examined the relationship between the growth rate in OECD industrial production and the growth rate in seaborne trade and concluded that trends in the OECD economy was positively correlated with cycles in sea trade during the period 1963 ± 1995. Increase in the industrial production is a direct effect of an increasing world economy. As described in section 3.1.1, the world economy is one of the main factors that influence demand for sea transport. Thus since industrial production increase demand for sea transport, our hypothesis is that the relationship between the industrial production in OECD and international tanker shipping stock returns is expected to be positive.

Industrial production in the US

The prod_us factor is closely related to the prod_oecd factor. It includes the total industrial production in the United States of America. Out hypothesis will be as the same as for the industrial production in the OECD. Industrial production increase demand for sea transport independent on the location of the production. The relationship between the industrial production in the US and international tanker shipping stock returns is expected to be positive.

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 ²⁹ (Chen, Roll, & Ross, 1986)
 ³⁰ (Isserlis, 1938)

Oil price of WTI oil

The variables of the factor *oil_wti* are the changes in the price of Western Texas intermediate oil. WTI oil is a grade of crude oil used as a benchmark in oil pricing. Historically it has traded closely to Brent oil and the OPEC basket with respect to pricing.

In section 2.3 we introduced the different costs of running a ship. Further in section 2.3.3 voyage costs are described, where one of the main costs is bunkers costs for running the ship. The price of the bunkers is closely correlated with the oil price. As the oil price increases, the cost of running a ship increases correspondingly. Our first assessment is therefore that an increase in the WTI oil price will lead to decreasing returns on tanker shipping stocks because of the higher operating costs leading to lower profits. Further we can also consider the oil price as a factor which while increasing improves the profits and returns of the tanker shipping stocks. A high oil price will also be an indication of a world economy in good shape which forms the foundation for increased demand for oil products, and as seen in table 4.4 the correlation between the historical oil price and the earnings of tanker vessels is highly visible. Several studies have been made investigating the fact that the oil price is a significant factor for the influence of stock returns; however the studies have reached different conclusions. Chen and Jordan (1993) concluded that oil prices are negatively related to stock returns in the US, while Chen, Roll & Ross (1986) found on the contrary marginally significant positive relationship. Hamao (1988) investigated the effects of changes in the oil price on stock returns in Japan, but could not find a significant relationship between the two factors. The different results in studies and the clear influence oil price have on both the cost and revenue aspect of the tanker vessels make our hypothesis difficult to derive. Our concluding hypothesis is that the oil price will have significant influence on the tanker stock returns; however it could be both positive and negative. The impact of changes in the oil price is difficult to determine and we therefore introduce another variable that is related to oil petroleum inventories to better explain the impacts of the energy commodity market.



Figure 4.2 Clarksea Index for tanker earnings vs. Brent Crude oil price 1990 – 2012. Values on a logarithmic scale.

Petroleum inventories in the US

We have earlier described that the demand for tanker shipping depends on world economic activity and the energy commodities markets, the oil market. We have already introduced the changes in oil price under the *oil_wti* factor. The factor *inv_petr* covers the second factor in the oil market, the petroleum inventories and represents the monthly change in the U.S. petroleum inventory. Petroleum is a technical term that includes both the liquid crude oil and natural gas. The U.S petroleum inventory measures the amount of petroleum products stored for future use. Changes in petroleum inventories provide insight into oil demand and prices. A significant decrease in inventories suggests that there is a mismatch between the supply and demand for crude oil and natural gas, which puts upward pressure on oil prices. After discussing the impacts of the two main factors for the oil market; petroleum inventories and oil prices, we conclude that both factors may have both negative and positive impacts on tanker stock returns. Further investigation by looking at empirical results must be conducted.
5. Basic issues in time series analyzes

As explained in the thesis introduction, the desired outcome of this study is to test of the theoretical relationship between predetermined macroeconomic factors and stock price fluctuations of tradable tanker equities. Our goal is to establish an empirically proven relationship based on what's been pictured in traditional maritime economic literature during the two last decades. The basic assumption is that macroeconomic variables affect supply and demand, which is assumed to ultimately affect the stock-price. Section 5 explains the assumptions taken and the different methods used during the econometric modeling.

5.1 Stationarity and spurious regressions

5.1.1 Stochastic processes

One may think of the time series used as a collection of continuous random variables observed at discrete points in time, here monthly. Based on the method derived in Basic Econometrics³¹ a time series variable is denoted as Y_t where Y represents the random variable and t the discrete point in time. The figure represented by Y is a realization of all possible outcomes and hence the combined observed values of Y_t is a realization of a stochastic process from t=0 to t=T in a given sample. Although the random values of a stochastic process may be independent random variables, in most situations they exhibit complicated statistical correlations. In the following, we will use this realization to draw a conclusion about the underlying stochastic process.

5.1.2 White noise process

One should also be aware of a special type of the stochastic process, namely a white noise process. White noise processes is typically characterized by the properties having zero mean, a constant variance and have zero auto covariance except at lag zero. Autocorrelation function (ACF) will be zero except from lag 0 where ACF is 1. It can be said that a white noise process is serially uncorrelated.

The definition of white noise process is

$$E(y_t) = \mu$$
 Eq. 5.1
 $Var(y_t) = \sigma^2$ Eq. 5.2

³¹ (Porter & Gujararti, 2009)

$$\varphi_{t-r} = \begin{cases} \sigma^2 \ if \ t = r \\ 0 \ otherwise \end{cases}$$
5.3

Autocorrelation can be described in the following way, $\tau_s = \frac{\varphi_s}{\varphi_0}$, where $s = lag 0, 1, 2 \dots$ and $\varphi_s =$ auto covariance at lag s.

 Y_t is assumed to be normally distributed which implies that the sample autocorrelation coefficients $\hat{\tau}_s \sim approx. N(0, 1/T)$ are approximately normally distributed. Significance tests can be set up for an autocorrelation coefficient to conclude if the coefficient is significantly different from zero. In addition, a joint hypothesis can be set up that all of the correlation coefficients of a $m = maximum \ lag \ length$ are jointly equal to zero. A Q statistic developed by Box and Pierce 1970 $Q = T \sum_{k=1}^{m} \hat{\tau}_k^2$ are applied to test the joint hypothesis, where $T = Sample \ size$, $m = maximum \ lag \ length$. The Q statistic is asymptotically distributed as χ_m^2 and a null hypothesis that all m autocorrelation coefficients are zero. The test statistics will be used test of linear dependence, also referred to as Portmanteau statistic.

5.1.3 Stationary processes

A highly debated topic within time series statistics is the distinction between stationary and non-stationary variables. Strict stationary times series have the same distribution of its values as time progress, a probability of an y within a particular interval remains the same at any point in time. More interesting in this context is restrictions given by a weakly stationary time series. Weakly stationary time series should have a constant mean, variance and auto covariance structure. The auto covariance restriction implies that a variable should have a constant auto covariance with previous realizations. Auto covariance should only depend on the difference in time between observations and not on which point in time measured. More intuitively written covariance between Y_{t-1} and Y_{t-2} should be the same as covariance between Y_{t-5} and Y_{t-6} and scholars often refer to such series as time invariant. Stationary time series will have distinct properties which makes them useful for statistical modeling due to the mean reversion effect of a finite variance.

We can list the following restrictions for weakly stationarity as a set of equations:

(1)
$$E(y_t) = \mu$$
 Ea. 5.4

(2)
$$E(y_t - \mu)(y_t - \mu) = \sigma^2 < \infty$$
 Ea. 5.5

(3)
$$E(y_{t1} - \mu)(y_{t2} - \mu) = \varphi_{t2-t1} \quad \forall t_1, t_2$$
 Eq. 5.6

Gujarati and Porter have the following formulation:

"A stochastic process is said to be stationary if its mean and variance are constant over time and the value of the covariance between the two periods depends only on the distance or gap or lag between the two periods and not the actual time at which the covariance is computed" $^{\rm 32}$

5.2 Non-Stationarity and spuriousness

5.2.1 Non-stationary Models

The following models are commonly used to depict non-stationarity.

The Random walk with drift

$$y_t = \mu + y_{t-1} + u_t$$
 Ea. 5.7

And a trend-stationary process

$$y_t = \alpha + \beta t + u_t$$
 Ea. 5.8

The Random Walk with drift generalized

$$y_t = \mu + \phi y_{t-1} + u_t \qquad \qquad \text{Eq. 5.9}$$

A stationary time series will follow a mean reverting stochastic process as described earlier. In equation 5.9 it usually means a situation where $\emptyset < 1$, . The case of explosive time series where $\emptyset > 1$ is not considered as we find this unlikely to be relevant for the data considered and we do not expect that random shocks will be more influential over time. Hence equation 5.7 is the one considered when referring to random walk with drift $\phi = 1.^{33}$

 ³² (Porter & Gujararti, Basic Econometrics, 2009)
 ³³ (Brooks, 2008)

5.2.2 Spurious regressions

The typical problem of applying OLS on non-stationary time series is regression results that cannot be trusted. There is a significant risk present of making type 2-errors and this basically means that we might accept a relationship between the X and Y variables that appears significant even though the relationships does not exists. Econometric theory refers to such a "nonsense" regression as the spurious regression problem.

5.3 Dickey Fuller and Augmented Dickey Fuller test

To allow for autoregressive higher orders an augmented Dickey-Fuller test are chosen as an appropriate test statistic. This will be solved by applying an augmented test, where several lags are included to control for serial correlation. A challenge with the Augmented Dickey-Fuller test occurs when appropriate numbers of lags should be chosen. Too many lags will affect the degrees of freedom, while too few lags will not give sufficiently control of the serial correlation as explained by Ng and Perron (2001). They recommend to use the last significant lag criterion as a determinant when choosing the number of lags.

A generalized model can be written: (AR(1))

$$y_t = \phi y_{t-1} + u_t$$
 Ea. 5.10

For ease of computation y_{t-1} can be subtracted from each side giving the expression below:

$$\Delta y_t = \omega y_{t-1} + u_t \qquad \qquad \text{Ea. 5.11}$$

In the generalized model, we will test for unit root with a null hypothesis where $\emptyset = 1$ against the one sided alternative hypothesis $\emptyset < 0$. The null hypothesis indicates that the series has a unit root while the alternative hypothesis indicates that the series is stationary. While in the simplified model we will test the null hypothesis that $\omega = 0$, ($\omega = \emptyset - 1$).

Dickey fuller test can also be conducted including an interceptor and a deterministic trend.

The model for the unit root test in each case:

$$y_t = \phi y_{t-1} + \mu + \lambda t + u_t \qquad \text{Ea. 5.12}$$

For ease of computation y_{t-1} can be subtracted from each side giving the expression below:

$$\Delta y_t = \omega y_{t-1} + \mu + \lambda t + u_t \qquad \qquad \text{Eq. 5.13}$$

In the case of autocorrelation in the dependent variable in a regression on first lag, augmented Dickey Fuller will be applied as a unit root test. Number of lags will be determined by Akaike information criterion, described later in this chapter.

Written in easy computational form below:

$$\Delta y_t = \omega y_{t-1} + \sum_{i=1}^p \alpha_i \Delta y_{t-i} + u_t$$
 Ea. 5.14

The actual procedure of implementing the Dickey Fuller test involves several decisions. First, we need to choose which model for the unit root test to consider, that is we need to choose a model among: random walk (RW), RW with a drift (single mean in EG) and RW with drift around a deterministic trend. Considering the nature of our data, which are financial time series, we know from financial theory that these will often have the shape of RW with drift $\Delta y_t = \omega y_{t-1} + \mu + u_t$, but we will need to investigate and make a final decision based upon a visual investigation, looking at financial theory and conducting formal tests.

Secondly, in order to have an unbiased estimation of ω we need to verify that there is no autocorrelation in the error terms. Accordingly, we run the LM test and, in case of autocorrelation, we modify the RW with drift equation introducing as independent variable *i* lags of the dependent variable (augmented Dickey-Fuller test). We will add as many lags as necessary to obtain a model without autocorrelation. Only when we have a model without autocorrelation we can rely on the estimation of ω and decide about stationarity.³⁴

³⁴ (Sand, 2010)

5.4 Autoregressive and Moving Average Processes

This discussion about stationarity will begin considering the presences of autoregressive or moving average processes. In short, an Autoregressive time series variable y_t will depend on past values of itself, have an independent error term with the expected value of 0 and constant variance, σ^2 .

Consider the specification below of an AR(p) model:

$$y_t = \mu + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \dots + \phi_p y_{t-p} + u_t$$
 Ea. 5.15

Written using Sigma notation

Where u_t is the error term, y_{t-i} is the value of the variable at period t - i. If the data has a y_t is the part which trends the behavior. y_t is autoregressive of an order given by p and hence referred to as AR(p). Here p represents the number of lags which is statistically significant different from 0.

Moving average model is a linear combination of white noise processes. The current Y_t depends on current and previous white noise term. To manipulate this model a lag operator can be introduced.

A qth order moving average mode and be denoted MA(q) and can be expressed in the following way.

$$y_t = a + \sum_{i=1}^{q} \theta_i u_{t-i} + u_t$$
 Ea. 5.17

A moving average process has a constant mean (*a*), variance (σ^2) and autocovariances that may be to lag q hence the MA(q), but thereafter will always be zero.

5.5 ARIMA

Previous literature of empirical relationships between different macroeconomic variables and stock returns within different industries and also specifically within shipping has used an ARIMA related methodology in order to measure how unexpected shocks affect stock price. The main reasoning behind this approach is to obtain a result from the regression which only contains unexpected factors. To create an equation which only contains the factors which we are interested in, an ARIMA filter is applied for the time series were we conclude that ARIMA modeling may improve the description of the series. We assume that the unexpected part of a shock is the interesting part of a change in the tanker stock returns, this given an efficient market where expected changes will already be incorporated in the price of today. Identifying time series where

ARIMA modeling may improve the description of the variables are done by using the Box-Jenkins method as described 5.6.2.

To choose between the different ARIMA models our approach is to use the Akaike Information Criterion (AIC)³⁵ to determine the model with the best forecasting power.

5.5.1 Partial autocorrelation function

Partial autocorrelation function, hereafter called *pacf* measures correlation between an observation y at a previous point in timek and the observation at the desired point in time y_t , but controlling for any lags in between. Explained in a more intuitive way, *Pacf* measures the correlation between y_t and y_{t-k} after controlling for all periods in between y_t and y_{t-k} .

5.5.2 ARMA Processes

If a model for the DGP process of a time series involves both an AR (p) and a MA(q) process, where we have an ARMA (p,q) model. ARMA model basically means that the current value of y depends on a linear combination of its previous values and some relationship with its current and previous white noise error term. While Autocorrelation Function (ACF) is useful to distinguish between a pure AR and a pure MA. We will need to look at both (ACF) and (PACF) when comparing an AR and an ARMA process, Brooks (2008). ARMA model can be written with L as a lag operator, to ease the algebra.³⁶

$$\emptyset(\mathbf{L})\mathbf{y}_{t} = \mu + \theta(\mathbf{L})\mathbf{u}_{t}$$
Ea. 5.19

Where

$$\begin{split} \mathfrak{g}(\mathrm{L}) &= 1 - \mathfrak{g}_{1}\mathrm{L} - \mathfrak{g}_{2}\mathrm{L}^{2} - \cdots - \mathfrak{g}_{p}\mathrm{L}^{p} \\ \mathfrak{g}(\mathrm{L}) &= 1 + \mathfrak{g}_{1}\mathrm{L} + \mathfrak{g}_{2}\mathrm{L}^{2} + \cdots + \mathfrak{g}_{n}\mathrm{L}^{q} \end{split}$$

Or, without L

$$y_{t} = \mu + \phi_{1}y_{-1} + \phi_{2}y_{t-2} + \dots + \phi_{p}y_{t-p} + \theta_{1}u_{t-1} + \theta_{2}u_{t-2} + \theta_{q}u_{t-q} + u_{t} \qquad Ea. 5.20$$

With

$$E(u_t) = 0; E(u_t^2) = \sigma^2; E(u_t u_s) = 0, t \neq s$$

³⁵ (Akaike, 1973)

³⁶ (Brooks, 2008)

5.5.3 Box-Jenkins method for identifying ARIMA models.

After determining stationary time series, investigation of whether an ARIMA model would improve the description of the series can be conducted. Investigation is carried out by using the Box-Jenkins method and looking for typical patterns in the ACF and PACF correlograms.

Type of model	Typical pattern of ACF	Typical pattern of PACF
AR(p)	Decays exponentially or with damped sine wave pattern or both	Significant spikes through lags p
MA(q)	Significant spikes through lags q	Declines exponentially
ARMA(p,q)	Exponential decay	Exponential decay

Table 5.1 Box-Jenkins table for ACF and PACF interpretation. ³⁷

The Box-Jenkins table in table 5.1 is used to determine if ARIMA models will improve the description of the time series. The Box-jenkins methodology is however not intended for identification of mixed ARIMA models, the models that contain both an AR as well as an MA term. Mixed ARIMA models of low orders such as (ARIMA 1,1,1), ARIMA (1,0,1) or ARIMA (2,0,1) are always alternatives to the models conclude using the Box-jenkins method. Normally, if an AR model with a high order looks to be the best fit model according to Box-Jenkins, it might be easier and similar effective to apply a mixed ARIMA model of low order.³⁸

5.6 Stationarity transformation and model improvement

Let us further assume for non-stationary time series that $\phi = 1$. This implies that shocks stay influent and contrary to stationary series is withheld in the system and never die out. The first case, Random walk with drift is known as a stochastic non-stationarity which implies that there is a stochastic trend in the data. As we see from the equations 5.7 and 5.8 the models are not stationary, the stochastic process are influenced permanently by shocks and hence cannot be referred to as mean reverting.

³⁷ (Porter & Gujararti, 2009)

³⁸ (Porter & Gujararti, Basic Econometrics, 2009)

To assess whether a time series is stationary or not, we first perform a graphical inspection of the autocorrelation function (ACF) and the partial autocorrelation function (PACF), before continuing with a unit root test and thereafter investigates if ARIMA can improve our results and look for signs of AR or MA based on Box Jenkins. If the ACF has Exponential decay this indicates either an AR or an ARMA process. However if PACF also shows signs of exponential decay in partial autocorrelations function, this indicates signs of mixed ARMA processes.

5.6.1 Random Walk with Drift

If we subtract y_{t-1} from both sides of equation 5.7 the following equation can be written

$$y_t - y_{t-1} = \mu + y_{t-1} + u_t - y_{t-1}$$
 Eq. 5.21

$$y_t - y_{t-1} = \mu + u_t$$
 Eq. 5.22

$$\Delta y_t = \mu + u_t \qquad \qquad \text{Ea. 5.23}$$

The variable Δy_t will be stationary by taking first differences; y_t will be known as unit root process presented in 5.3. A typical solution to non-stationarity may be taking first differences, if a variable is differentiate *d* times to obtain stationarity, the time series is integrated of an order (*d*). If we try to differentiate each variable with a high (*d*) order to make them stationary an additional problem would also appear, our estimation would only consider the short-term effect of a change in the explanatory variable. Considering the weakness with a high (*d*) to obtain stationarity, our results might be stationary but not very interesting in an empirical research setting. Often in econometric modeling the researchers would be more interested in the long term effect of exogenous shocks and hence we must rely on other methods.

5.6.3 Model selection

The AR order selection criteria's can be written in a general form

$$Cr(n) = \log \tilde{\sigma}^2(n) + c_T \varphi(n)$$

$$\varepsilon_{a. 5.24}$$

$$\tilde{\sigma}^2(n) = T^{-1} \sum_{t=1}^T \hat{u}_t(n)^2$$

. .

Where:

If the error variance estimator is based on the OLS residuals $\hat{u}_t(n)^2$ from an AR model of order n, c_T is a sequence indexed by the sample size, and $\varphi(n)$ is a function that penalizes large AR orders. The criteria $\varphi(n)$, is the order of the fitted process and c_T is a weighting factor that may depend on the sample size. The way this factor is chosen effectively distinguishes the different criteria. The first term on the on the right hand side $log \hat{\sigma}_u^2(n)$ measures the fit of the model with order n. This term decreases for increasing order since there is no correction for the degrees of freedom in the variance estimator. It is important to notice, that the sample size is assumed to be constant for all orders of n and hence the number of pre sample values set aside for estimation is determined by the maximum order p_{max} . The order that minimizes the criterion is chosen as estimator \hat{p} of the true AR order p. Methods of determining the criteria may be the AIC and Schwarz criterion (SC)³⁹

$$AIC(n) = \log \tilde{\sigma}_u^2(n) + \frac{2}{T}n \qquad \qquad Ea. 5.25$$

$$SC(n) = \log \tilde{\sigma}_u^2(n) + \frac{\log T}{T}n$$
 Ea. 5.26

Most often will these methods give the same conclusion. SC is said to be consistent, but inefficient and AIC is said to be not consistent but is more efficient. AIC will have a lower average variation in selected model order from different samples within a given population than SC. We will focus on AIC since this order selection criteria is automatically given automatically by the SAS Enterprise Guide statistical package and most widely used.

5.7 Presence of Heteroscedasticity and Autocorrelation in OLS regressions

5.7.1 Heteroscedasticity

One of the basic assumptions in classical linear regression model (CLRM) has constant variance in the error terms, namely homoscedasticity $var(u_t) = \sigma^2 < \infty$. If this assumption is broken the regression will still be unbiased, but no longer be best linear unbiased estimator (BLUE). Heteroscedasticity tests and adjustments must be performed. Whites test will be applied to detect heteroscedasticity and White adjusted standard errors will be used to correct for the same.

³⁹ (Schwarz, 1978)

5.7.2 Autocorrelation

In CLRM, one of the assumptions is that the covariance between error terms over time should equal zero $cov(u_i, u_j) = 0$ for $i \neq j$. When this assumption is broken CLRM, econometric theory refers to this as Autocorrelation. To test for the presence of autocorrelation Godfrey serial correlation Lagrange multiplier test will be applied in order to jointly test for autocorrelation between \hat{u}_t and several lagged values at the same time.

Godfrey recommends using 12 lags for monthly data, which will be investigated, but for practical reasons only 4 lags will be reported further in this thesis due to practical reasons. The authors can already reveal that both 4 and 12 lags will lead to the same conclusion. Ignoring autocorrelation when present is similar to ignoring heteroscedasticity. The coefficients are still unbiased, but not BLUE. This means that the standard errors cannot be trusted.

The model for the errors up to rth order under this test can be stated as follows.

$$u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + \dots + \rho_r u_{t-r} + v_t \qquad v_t \sim N(0, \sigma_v^2)$$
 Ea. 5.27

H0:
$$\rho_1 = 0$$
 and $\rho_2 = 0$ and ... and $\rho_r = 0$
H1: $\rho_1 \neq 0$ and $\rho_2 \neq 0$ and ... and $\rho_r \neq 0$

Note, that for joint tests only parts of the null hypothesis need to be rejected in order to reject H₀. Adjusting for Autocorrelation can be performed by creating dynamic models. A dynamic model we allow for non-contemporaneous relationships between the variables. I order to maintain the approach that supply and demand determines tanker equity return only distributed lag models will be considered. In a case where both heteroscedasticity and autocorrelation is present, Newey and West (1987) modified standard errors will be considered. Here the variance covariance estimator will be consistent both in both cases and hereafter will be referred to as HACSE. SAS coding for Newey and West Autocorrelation and Heteroscedasticity consistent standard errors can be found in Appendix 1.

6. Analysis of the time series

6.1 Visual and numerical investigation of data

The priori assumption of the relationship between global market cycles and stock-prices are based on previously hypothesized relationships depicted in classical macroeconomic and shipping literature. An investigation of the dataset begins with an individual plot of both the dependent and independent series as a function of time. This provides a first impression of the data generating process and we can make up a subjective judgment about whether the time series shows signs of non-zero or zero means and if there is presence of trends in the time series. A typical challenge with such a visual test is the scaling problem that arises for variables with different scales. This is solved by log transforming all of the variables to have the indexed values on the same logarithmic scale.

6.1.1 Time series as a function of time

The following figures first show the development of the tanker stock portfolio and all independent variables from February 1990 to September 2011.



Figure 6.1 The price of WTI crude oil on log scale.







Figure 6.4 The volume of industrial production (OECD) on log scale.

Figure 6.3 The MSCI world composite index on log scale.





Figure 6.5 The volume of industrial production (US) on log scale







Figure 6.8 The VLCC spot rate on log scale.

Figure 6.6 The USD/EUR exchange rate on log scale (90–99 USD/ECU).





Figure 6.9 The world tanker fleet size on log scale.

From the graphs it seems apparent that there are problems related to the level time series values. There are clear signs of a non-zero mean in all of the time series and presence of a trend cannot be rejected for most of them. The three factors USD/EUR exchange rate, the tanker stock portfolio and the VLCC spot rate looks to have a single mean value and not follow a trend. Using reasoning from economic theory we can expect the USD/EUR exchange time series to have a zero mean. For the other two factors their single mean is caused by different macroeconomic incidents. If we first look at the tanker stock portfolio we clearly see that from 1990 – 1993 the portfolio experienced a substantial decrease and had clearly negative trend. Also between 2007 and 2010 the tanker portfolio experienced a downturn. As described earlier in section 4.2.3 these negative trends are caused by well-known crises in the world economy. Two crises of such a magnitude over a short time frame will make economical reasoning around the applicable model for the series invalid and further be the reason that the tanker portfolio time series does not have a trend, but have a single mean. The two global crises is also the reason that the VLCC spot rate has a single mean and not a trend which we would expect.

Further investigation similar to the one described in section 5, a graphical inspection of the autocorrelation function (ACF) and the partial autocorrelation function (PACF) needs to be conducted to look for stationarity in the series. It is important to check the time series for stationarity because the regression of one non-stationary series on another might lead to spurious regressions as described in section 5. A numeric unit root test for stationarity must be applied to conclude if the time series is stationary or not. The Dickey-Fuller Unit Root test as introduced in section 5.3 is therefore applied.

6.1.2 Stationarity investigation

To look for stationarity in the time series we start by presenting the ACF and PACF correlograms for our dependent and independent variables.



Figure 6.10 ACF and PACF correlograms for the tanker stock portfolio



Figure 6.11 ACF and PACF correlograms for the WTI oil price



Figure 6.12 ACF and PACF correlograms for the MSCI world index



Figure 6.13 ACF and PACF correlograms for the industrial production in the OECD.



Figure 6.14 ACF and PACF correlograms for the industrial production in the US.



Figure 6.15 ACF and PACF correlograms for the exchange rate for USD/EUR.



Figure 6.16 ACF and PACF correlograms for the Petroleum stock levels in the US



Figure 6.17 ACF and PACF correlograms for the VLCC spot rate



Figure 6.18 ACF and PACF correlograms for the Tanker fleet size.

From the theory introduced in section 5, we know that the ACF correlogram for a non-stationary series is linearly declining with a number of significant lags. In all of our time series the ACF is evidently slowly declining, and this constitutes a sign of non-stationarity. The PACF for all of the time series shows that the partial autocorrelations are significantly different from zero for the first lags. The visual investigation of the time series correlograms gives us signs that the time series is non-stationary; however before we draw any final conclusion we have to look at the unit root test. We have performed a Dickey-Fuller Unit Root Test; however the actual procedure of implementing the test involves several decisions. First, we need to choose the correct model for the unit root test to consider. As introduced in section 5, the different models are: Random walk ("RW"), RW with a drift (single mean) and RW with a drift around a trend. In our case we have already concluded by looking at the visual presentation of the time series that there are clear signs of a trend in all of time series with three exceptions that have a single mean where presence of a trend can be rejected. We will therefore be looking at both single mean and trend values of the unit root test. The

Factors	Model	T statistic	Description
portfolio	Constant but no trend(Single mean)	-0,98	Non-Stationary
oil_wti	Constant and trend	-2,76	Non-Stationary
world msci	Constant and trend	-1,82	Non-Stationary
prod_oecd	Constant and trend	-0,74	Non-Stationary
prod_us	Constant and trend	-0,29	Non-Stationary
exr_useu	Constant but no trend(Single mean)	-1,67	Non-Stationary
inv_petr	Constant and trend	-3,12	Non-Stationary
vlccspot	Constant but no trend(Single mean)	-3,38	Non-Stationary
fleetsize	Constant and trend	1,89	Non-Stationary

Table 6.1 Unit root test results for independent and dependent factors.

All of our time series contains 259 observations. At 5% level of significance the critical value of the t statistic is -3,43 for series with a constant plus trend and -2,88 for series with a constant without a trend⁴⁰. The DF test says that the null hypothesis can be rejected if the t statistic is more negative than the critical value. The null hypothesis of the DF-test is non-stationarity. As seen on table 6.1, none of the t statistics for our

⁴⁰ (Fuller, 1976)

time series are more negative than the critical values and we can therefore not reject the null hypothesis about non-stationarity.

6.2 First difference time series

Having concluded that all of our time series are non-stationary, it is necessary to find an appropriate transformation of the time series to obtain stationarity. Previous research indicates that most economic time series tend to wander and are not stationary, but that differencing often yields a stationary result. Since we have concluded that the time series are random walks with drift or have trend and have presence of non-stationarity, we will use first differencing of the series. Although this is a common procedure it does not guarantee that ΔY_t , the first difference of the series, is stationary processes. We therefore move forward with the same procedure as with the log series, looking at the ACF, PACF and conduct a unit root test of the series.

We start by investigating the first difference series by plotting the first difference of the dependent and the independent variables as a function of time. This will help us gain intuition of the series variance and zero or non-zero mean.

The following figures will show a visual presentation of the time series presented in section 6.1 where all the variables are on first difference basis.







Figure 6.20 First difference of our tanker portfolio index.















Figure 6.22 First difference of the industrial production in OECD.



Figure 6.24 First difference of the exchange rate of USD and EUR.



Figure 6.26 First difference of the VLCC spot rate.



Figure 6.27 First difference of the tanker fleet size.

There are some important things to notice from the graphs of the time series on a first difference basis. The mean of return seems to be constant over time for all of the series. Secondly the first difference of a random walk with drift is a stationary process but it will have a non-zero constant mean. In this collection the mean is close to zero for a lot of the series, however it looks slightly above zero for the all of the series with three exceptions; the exchange rate between USD and EUR, VLCC spot rates and tanker spot portfolio which looks like it has a zero mean.

6.2.1 Investigation of stationarity

To assess whether the time series are stationary or not, it is necessary to perform a graphical inspection of the autocorrelation function (ACF) and the partial autocorrelation function (PACF), followed by a unit root test. We start by presenting the ACF and PACF correlograms for our dependent and independent variables.





Figure 6.28 ACF and PACF correlograms for the tanker stock portfolio on first difference form.

Figure 6.29 ACF and PACF correlograms for the WTI oil price on first difference form.



Figure 6.30 ACF and PACF correlograms for the MSCI world index on first difference form.



Figure 6.31 ACF and PACF correlograms for the industrial production in the OECD on first difference form..



Figure 6.32 ACF and PACF correlograms for the industrial production in the US on first difference form.



Figure 6.33 ACF and PACF correlograms for the exchange rate for USD/EUR on first difference form.



Figure 6.34 ACF and PACF correlograms for the Petroleum stock levels in the US on first difference form.



Figure 6.35 ACF and PACF correlograms for the VLCC spot rate on first difference form.



Figure 6.36 ACF and PACF correlograms for the Tanker fleet size on first difference form.

We observe by a visual inspection of the ACF and PACF graphs that for all of the series ACF is declining much quicker and PACF is statistically significant for none or the first few lags. However there are some correlograms that creates an uncertainty about whether the time series is stationary or not. For example the correlograms of the tanker fleet size is not as quickly declining as the others and has significant spikes in the first 6 lags. The time series of industrial production, both in the US and OECD also have significant spikes in the first lags of ACF. This is something that can give us the impression that these time series on first difference may be non-stationary. To come up with a conclusion of the time series' stationarity we must conduct a unit root test. We will use the same method as in section 6.1.2, the Dickey-Fuller unit root test.

Factors	Model	t statistic	Description
d_portfolio	No constant, no trend (zero mean)	-13,55	Stationary
d_oil_wti	Constant but no trend(Single mean)	-13,53	Stationary
d_world msci	Constant but no trend(Single mean)	-14,2	Stationary
d_prod_oecd	Constant but no trend(Single mean)	-9,23	Stationary
d_prod_us	Constant but no trend(Single mean)	-12,27	Stationary
d_exr_useu	_exr_useu No constant, no trend (zero mean)		Stationary
d_inv_petr Constant but no trend(Single mean)		-16,21	Stationary
d_viccspot No constant, no trend (zero mean)		-16,91	Stationary
d_fleetsize	Constant but no trend(Single mean)	-11,45	Stationary

 Table 6.2
 Unit root test results for independent and dependent factors on first difference form.

We can see from the results of the Dickey-Fuller unit root test that first difference transformation of the time series makes the series stationary. T statistics for all of the time series is more negative than the critical value of -2,88 for the series with single mean and -1,95 for the series with a zero mean. We can therefore reject the DF null hypothesis for all the time series.

The tests above are only valid if the time series does not contain any autocorrelation. The solution is to "augment" the test using p lags of the dependent variable. We have chosen to not check for autocorrelation in the error terms of the time series because the Augmented Dickey-Fuller test shows that all the time series were stationary for models with up to 5 autoregressive orders.

6.3 Will an ARIMA model improve the description of the time series?

After determining that the return series are stationary we can investigate whether an ARIMA model would improve the description of the series. This is a method suggested by Ben Sand through the course Applied Econometrics at CBS⁴¹. Because the time series on first difference basis is stationary d=0 and we only need to investigate whether our series shows signs of being generated from either MA- or AR-processes. Our investigations are carried out by looking at the ACF and PACF correlograms from section 6.2 and interpret the results using the Box-Jenkins method introduced in section 5.2.1.

⁴¹ (Sand, 2010)

Looking at the ACF and PACF correlograms introduced in section 6.2, we can see that there are four series that stand out from the others. These series are industrial production in OECD and US (Figure 6.31 and 6.32), Petroleum stock levels (Figure 6.34) and the tanker fleet size (Figure 6.36). For the other time series there are some lags that have borderline significant lags in the PACF, however since the ACF after lag 0 drops immediately below the significance level for all of them, there are no signs of an AR(p) process. Regarding the MA(q) process , we concluded that since the PACF drop immediately below the significance level there are no signs of an AR(p) process. We therefore conclude that an ARIMA model will not improve the description of the other time series. The four time series that are standing out will need an individual analysis to determine a correct ARIMA model which will improve the series description.

Industrial production in the OECD and US (d_prod_oecd & d_prod_us)

We first look at the industrial production in OECD and US which are displayed in Figure 6.31 and 6.32. Both series have an exponentially decaying pattern of ACF and significant spikes in PACF. For the OCED series have significant spikes through the first 2 lags of PACF, while the US series have significant spikes through the first 3 lags. It therefore looks like an AR(2) model will improve the description of the OECD series while an AR(3) would be the best model for the US series.

Petroleum stock levels (d_inv_petr)

The petroleum stock levels in Figure 6.34 have completely different ACF and PACF correlograms, however they also are guiding us towards an AR(p) model. The ACF has a damped sine wave pattern and the PACF has a significant spike in lag 12. Our first impression is that an AR(12) model will give the best improvement of the description of the time series. In section 5.2.1 we explained that in most cases mixed ARIMA model of low order are alternatives to an AR and MA model of high order and are easier to apply. To choose between the AR(12) interpreted using the Box-jenkins method and a mixed ARIMA model of low order we must investigate which model will give the best fit. The "best" model for each factor is the model with the lowest not absolute Akaike Information Criterion (AIC) value. Experimentation with the different proposed models in SAS shows that the use of an AR (12) model will give the best fit according to the AIC criterion with an AIC value of -1701,1. The ARIMA (1,0,1) model received an AIC of -1624,49, while the ARIMA (2,0,1) resulted in an AIC of -1626,18.

Tanker fleet size (d_fleetsize)

The last time series which stood out was the tanker fleet size in figure 6.36. The ACF correlograms decays exponentially and then continues into something that can be compared to a wave pattern. The series have significant spikes in the first three lags of the PACF correlogram. Using the Box-jenkins method we conclude that an AR(3) model will be appropriate for the series.

After choosing the best model for each factor we save the residuals from the ARIMA models. The residuals are put together with the variables of the factors we determined ARMIA modeling would not have any impact on The collected variables are now ready to be used as input in a stepwise OLS regression.

7. Shipping market model tested

This section offers the results and analysis for all tests conducted during our time series modeling. The individual results will be discussed and compared together with maritime economic and macroeconomic theory previously presented. The demand and supply model introduced in section 3 will be tested in a multifactor model and the results will be analyzed. Theoretical relationships based on shipping market models by Martin Stopford and Tor Wergeland will be scrutinized and compared with our findings. We have tested if shipping companies with substantial part of their fleet in tanker shipping will have any relationship with predefined macroeconomic variables.

7.1 Empirical test and results

7.1.1 Static model

The first model that we go forward with depicts the long term relationship between macroeconomic factors and tanker shipping return. In order to estimate the impact of the factors described in section 3, they are regressed on the dependent variable shipping equity return by applying an OLS regression model. In order to exclude insignificant variables, modeling follows a stepwise procedure where the insignificant variables are omitted from the model. We end up with the following model, that we name Model1.

MODEL 1: $d_{portfolio} - r_f = f(d_{exr_useu}, d_{oil_wti}, d_{inv_petr}, d_{msciworld}, d_{vlccspot}, d_{fleetsize})$

The coefficients in Table 7.1 describe the relationship by regressing the explanatory variables onto the explained variable.

	Coefficient	Std.error	t-value	t-prob
Constant	-0,00940	0,00349	-2,69	0,0076
d_exr_useu	-0,35260	0,12144	-2,90	0,0040
d_oil_wti	0,09242	0,03727	2,48	0,0138
d_msciworld	0,86003	0,07724	11,13	0,0001
d_vlccspot	0,02349	0,01161	2,02	0,0441
d_fleetsize	2,45476	1,04941	2,34	0,0201
R ²	0,3720			
F(5,259)	29,98			

Table 7.1 – Parameter estimates for MODEL 1

Table 7.2 shows assumptions that have to be satisfied in order to use OLS.

Assumptions for using OLS	Test	Critical values (5%)	Test values
$E(e_t)=0$			0
$Var(u_t)=\sigma 2$	White test	$\chi^2_{0.95}$ (20)= 31,41	42,03
Cov(u _i ,u _j)=0	Godfrey's LM test	p ₁ =3,84 ; p ₂ = 5,99 ; p ₃ =7,81 p ₄ =9,49	3,52 ; 9,15 ; 9,55 ; 12,99

Table 7.2 Assumptions and test results for OLS; MODEL 1

We can see from the results of the White's test that the test statistic exceeds the critical value of the χ^2 distribution with 20 degrees of freedom. Thus, we reject H₀ about homoscedasticity and we have detected presence of heteroscedasticity in the error terms. As seen from the Godfrey's Serial correlation test in the table, the OLS assumption of no autocorrelation in the residuals is broken. The test statistics exceeds the critical values for the second, third and fourth order of autocorrelation. We observe that we have signs of both heteroscedasticity and autocorrelation in the chosen model and this is not desirable. Both heteroscedasticity and autocorrelation in the model will lead to misleading coefficient standard errors. Autocorrelation in the residuals is often caused by a dynamic structure in the dependent variable that has not been modeled and so has not been captured in the fitted values. A solution may be a dynamic model that allows for this extra structure in the dependent variable.

7.1.2 Dynamic model

The model considered so far has been static in nature, meaning that the model has only had variables with a contemporaneous relationship, a relationship which says that a change in one or more of the independent variables at time t have an instant impact on the dependent variable at time t. Our static model can easily be transformed into a model where the current value of the dependent variable depends on previous values of one or more independent variables or the previous value of the dependent value itself. Moving from a static model to a model with lagged effects is likely to reduce, and possible remove, autocorrelation which was present in the static model's residuals.⁴²

The Inclusion of the lagged term implies that official information on the market activity from a previous point in time period will be priced at a later stage. Different set of variables may be significant across a

⁴² (Brooks, 2008)

multiple factor model and hence such an investigation should be performed to ensure a model with sufficient amount of independent variables.

Often an announcement of macroeconomic or market indicators will not occur simultaneously as the condition depicted. The Variable Beta Model as described by Krueger and Rahbar⁴³ is modified with respect to timing of the report of financial or economic variables. Additional modification to the model when concern market variables, leads to an assumption that information is not necessarily symmetrically priced in the market in an efficient manner

The dependent factor will be tested for significant relationship with lagged values due to inertia of the dependent variables relationship with some of the macroeconomic factors. Not all possible combinations will be discussed in this thesis, but more or less all possible combinations has been reasoned against economic theory and tested when preparing this thesis. Number of lags will be limited to two, testing shows that including additional lags will not result in significant factors. In addition, testing which including several lags will not improve the descriptive power. In the same manner as when constructing model 1, the modeling of the dynamic model follows a stepwise procedure where the insignificant variables are omitted from the model. We end up with the following model, that we name Model2.

MODEL 2: $d_portfolio - r_f = f(d_exr_useu, d_oil_wti, d_msciworld, d_msciworld1, d_vlccspot1, d_fleetsize)$

Assumptions for using OLS	Test	Critical values (5%)	Test values
E(et)=0			0
Var(ut)=σ2	White test	$\chi^2_{0.95}$ (27)= 40,11	35,74
Cov(ui,uj)=0	Godfrey's LM test	p1=3,84 ; p2= 5,99 ; p3=7,81 p4=9,49	1,72 ; 14,98 ; 15,35 ; 18,84
		1.5	

Model 2: d_msciworld1 is the first lag of the differenced world market portfolio and d_vlccspot1 is the first lag of the differenced VLCC spot rate.

Table 7.3 Assumptions and test results for OLS; MODEL 2

As seen from the test statistics for Model 2 in table 7.3 the test statistic for White's test is lower than the critical value of the χ^2 distribution with 27 degrees of freedom. Thus, we accept H₀ about homoscedasticity and we can reject the presence of heteroscedasticity in the error terms. The test statistics from the

⁴³ (Krueger & Rahbar, 1995)

Godfrey's LM test shows that the model has no presence of first order autocorrelation, however the LM values for the second, third and fourth lag are clearly above the critical values meaning that we can reject the null hypothesis of no autocorrelation.

After transforming our static model into a dynamic model by including lagged values of the independent variables we have obtained a model which has no presence of heteroscedasticity. The new model has not been able to solve the autocorrelation problem identified in Model 1. Godfrey's LM test concluded positive signs for autocorrelation in second, third and fourth order for Model 2.

7.1.3 Heteroscedasticity and autocorrelation consistent standard errors (HACSE)

Newey and West (1987) have developed a variance-covariance estimator that is consistent for models that presence of both heteroscedasticity and autocorrelation. So an approach to deal with autocorrelation in our model is to use standard error estimates modified according to Newey and West's correction method. The HAC standard errors are listed in table 7.4 below. Also the HACSE t-values and t-probability values are listed.

	Coefficient	Std.error	HACSE	t-HACSE	t-prob
Constant	-0,01029	0,00345	0,00423	-2,43**	0,0156
d_exr_useu	-0,32521	0,12225	0,1165	-2,79*	0,0056
d_oil_wti	0,09951	0,03697	0,0552	1,80***	0,0724
d_msciworld	0,85513	0,07703	0,1154	7,41*	0,0001
d_msciworld1	0,15112	0,07423	0,0736	2,05**	0,0410
d_vlccspot1	0,03244	0,01153	0,0101	3,22*	0,0015
d_fleetsize	2,46919	1,03403	1,0019	2,46**	0,0144
R ²	0.39	965			

F(6,259) 27,49

Table 7.4 Parameter estimates for MODEL 1

The use of adjusted HACSE will make sure that autocorrelation do not affect which factors that are relevant. Significance level is noted by using *,**,*** corresponding to significance level 1%, 5% and 10%. From table 7.4 we see that all coefficients are significant at the 5% level with the exception of d_oil_wti which is only significant at the 10% level. The factors d_exr_useu, d_msciworld and d_vlccspot1 are also significant at the 1% level. As seen in table 7.4 two lags factors are found to be significant. The factor d_msciworld1 is the first lag of the differenced world market portfolio and d_vlccspot1 is the first lag of the differenced VLCC spot rate. R^2 Measures the goodness of fit and are calculated according to standard OLS procedure by minimizing Sum of Squared errors. Combined the factors in the model yield a R^2 of 39.65%.

7.2 Comparing results with Theory

The findings in our analysis in section 7.1 are to some extent in line with the hypothetical impacts we introduced in section 4.3. However there are some results that came as a surprise when investigating the results. The regression of model 2 uncovers significant connections between the tanker stock portfolio and following risk factors; the instant and one-month lagged value of the MSCI world index and VLCC spot rate has a positive impact on the tanker portfolio. The tanker portfolio experiences positive impacts from the instant values of changes in the world tanker fleet size, petroleum inventories and the price of WTI oil. Further changes in the USD/EUR exchange rate have a negative impact on the portfolio. We will further compare our empirical findings with our initial hypothesis and described theory.

Symbol	Description	Predicted by theory	Empirical findings
d_msciworld	Changes in the return of the MSCI World index of over 6,000 world' stocks.	+	+
d_fleetsize	Changes in the size of the world total tanker fleet.	-	+
d_vlccspot	Changes in market spot rates for modern VLCC crude carriers.	+	+
d_prod_oecd	Changes in total industry production level in the OECD countries.	+	Inconclusive
d_inv_petr	Changes in petroleum inventories.	+/-	Inconclusive
d_oilwti	Changes in the price of West Texas Intermediate (WTI) oil.	+/-	+
d_exr_useu	Changes in the USD/EUR exchange rate.	+/-	-
d_prod_us	Changes in total industry production level in the United States.	+	Inconclusive

Table 4.3 Description of the chosen independent variables and their hypothetical impacts.

MSCI World Index

Changes in world return, represented by the return of the MSCI World Index, is positive correlated with returns of tanker shipping equities. This relationship is in line with our hypothetical impact and earlier findings by Grammenos & Arkoulis (2002) and Mitter & Jensen (2006) as well as theory introduced by Kavussanos and Alizadeh (2002) and Stopford (2009).

World tanker fleet size

The empirical findings in our research confirm a significant positive relationship between the world tanker fleet size and tanker stock returns. The findings are in sharp contrast with our initial predicted relationship

between the variables, which was a negative correlation on the basis of supply and demand theory. We suspect that the variables may be spurious due to underlying unforeseen conditions. The positive significant relationship pointed out by our empirical findings may originate from the fact that vessels are ordered during market booms and in most cases also delivered during market upswings, while vessels and sold during market downturns. This was explained in detail under section 3.3. The stock returns may therefore be more influenced by the underlying current market conditions and not the theoretical relationship between supply and demand for oil tankers. Our empirical findings related to this factor proved to be inconclusive.

VLCC spot rate

The changes in tanker freight rates, represented by the VLCC spot rate, have a positive relationship with the pricing of tanker shipping equities, but the impact is only visible when looking at lagged values. The relationship between freight rates and tanker stocks is in line with our earlier assumptions and theory introduced by Stopford (2009), however it was believed to also have a direct impact, not only a one month lagged impact. The positive relationship with the lagged variables is an indicator that changes in freight revenue do not have an instant reaction in the stock market, but an impact that the market uses some time to react to. The use of fixed long term contracts as described in section 2.2 could also be an explaining factor to the significance of the lagged freight rates

Industrial production in OECD countries

The lack of a relationship between industrial production and the tanker portfolio returns was a surprising result of our study. Our initial hypothesis was that an increase in the industrial production would have a positive impact on tanker stock returns because of the theoretical increased demand for sea transport it leads to. An explanation of the lacking relationship may be that the industrial production factor is intercepted in other variables, like the world return. The absent effects of changes in industrial production are in line with earlier findings by Grammenos & Arkoulis (2002) and Mitter & Jensen (2006).

Petroleum inventories in the US

We could not find a significant relationship between the changes in petroleum inventories and tanker stock returns. This is a bit surprising given the fact that the petroleum inventories are a big influential factor on the oil price which we found to have a significant relationship with tanker stock returns. During our modeling of the dynamic model we could see that there were signs of a negative relationship between the petroleum inventory and tanker stocks. However the relationship was not found significant at a 10% level. Earlier research by Mitter & Jensen (2006) has confirmed a negative relationship between lagged values of petroleum inventories and tanker stock returns. However our empirical findings related to this factor proved to be inconclusive.

Oil price of WTI oil

The relationship between the oil price and tanker stock returns proves to be significant and in line with a part of our initial discussion around the hypothetical impact of the factor. Our discussion about the impact of the oil price reached an incomplete conclusion because of its potential positive and negative impact on the tanker companies' income. However our analysis can confirm that there exist a positive relationship between the changes in oil price and returns of tanker stocks. This finding is in line with earlier findings by Chen, Roll & Ross (1986).

Exchange rate between USD and EUR

The exchange rate between USD and EUR is measured in the form USD/EUR which is the amount of dollars needed to buy one unit of Euro currency. Our research concludes that there is a significant negative relationship between the variables, meaning that there is a positive relationship between the USD exchange rate and the tanker stock portfolio. When USD appreciates, USD/EUR decreases and this will have a positive impact on tanker stock returns. This relationship is in line with our initial hypothesis about the factors potential impact.

Industrial production in the US

Our study shows no significant relationship between changes in the industrial production in the US and tanker stock returns. The reasoning under the industrial production in OECD factor also applies for the industrial production in the US.

8. Conclusion

This thesis deals with the behavior of tanker shipping stocks in relation to changes in different macroeconomic risk factors. The impact of the risk factors have been tested on a portfolio containing 18 shipping companies whose shares have been actively traded between February 1990 and September 2011, using a OLS function on the changes of each factor. The results of the regression were surprising as a lot of the preselected risk factors had an inconclusive relationship with the tanker stock portfolio when tested. Some significant relationships were proven and all of them except for the world tanker fleet size had influence on the tanker portfolio in accordance with our predefined hypothetical impacts. The tanker portfolio was proved to have a significant positive relationship with the development of the WTI oil price, VLCC spot rates, Tanker fleet size and the MSCI world index and exchange rate of USD. Further the analysis could not detect any significant relationship related to the industrial production in OECD and US or petroleum inventories in the US. The final model ended up with explanatory power of 39.7% which means that a large part of the changes in the tanker stock portfolio remain unexplained. The results of this thesis are for some relationships in line with earlier studies on risk factors and shipping stock returns, however some relationships differ from earlier studies. The positive relationship between the portfolio and MSCI world index and the lack of an impact from industrial production is in line with earlier work by Grammenos & Arkoulis (2002) and Mitter & Jensen (2006). The impact of the oil price on tanker stocks is in line with earlier findings by Chen, Roll & Ross (1986) who proved a significant relationship between the oil price and returns on stock listed equities. Earlier research by Mitter & Jensen (2006) has confirmed a negative relationship between lagged values of petroleum inventories and tanker stock returns and this was something that we could not prove in our analysis.

For further studies different approaches can be done to obtain a better modeling of the return of tanker stocks. Additional risk factors can be added to increase the explanatory power of the model, while a less general approach focusing on specific geographical areas of specific time periods may help to improve the modeling. Further, other approaches might be applied to investigate the data, whereas ARCH/GARCH is suggested as a possible approach from the authors. As a conclusion of this thesis we would like to remind the reader with Tor Olav Trøims wise words:

"After every storm the sun will smile, the survivors will have open seas and unimagined opportunities"

Appendix 1. SAS output and input - Whites test, Godfrey's general Lagrange multiplier test

(LM test) & Newey & West HAC procedure.

A1.1 White's test for heteroscedasticity

Model 1

We used the following model to calculated White's test for heteroscedasticity;

PROC MODEL DATA=WORK.SORTTempTableSorted

```
,
PARMS b0 b1 b2 b3 b4 b5;
d_portfolio_rf = b0 + b1 * d_exr_useu + b2 * d_oil_wti + b3 * d_fleetsize + b4 * d_msciworld + b5 * d_vlccspot;
fit d_portfolio_rf / PAGAN=(1 d_exr_useu d_oil_wti d_msciworld d_vlccspot d_fleetsize) white;
INSTRUMENTS d_exr_useu d_oil_wti d_msciworld d_vlccspot d_fleetsize;
run;
```

QUIT;

The model resulted in the following output;

Heteroscedasticity Test							
Equation	Test	Statistic	DF	Pr > ChiSq	Variables		
d_portfolio_rf	White's Test	42.03	20	0.0027	Cross of all vars		
	Breusch-Pagan	5.32	5	0.3782	1, d_exr_useu, d_oil_wti, d_msciworld, d_vlccspot, d_fleetsize		

Generated by the SAS System ('Local', W32_VSPRO) on 26. oktober 2012 at 1:02:48 PM

Model 2

The same code as in model 1 was used, only adjusted for 2 additional variables.

The output of the White's test was:

Heteroscedasticity Test							
Equation	Test	Statistic	DF	Pr > ChiSq	Variables		
d_portfolio_rf	White's Test	35.74	27	0.1212	Cross of all vars		
	Breusch-Pagan	7.01	6	0.3199	1, d_exr_useu, d_oil_wti, d_msciworld, d_fleetsize, d_msciworld1, d_vlccspot1		

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A1.2 Godfrey's general Lagrange multiplier test (LM test)

The output of the Godfrey's LM test in SAS:

Model 1

Godfrey's Serial Correlation Test					
Alternative	LM	Pr > LM			
AR(1)	3.5262	0.0604			
AR(2)	9.1565	0.0103			
AR(3)	9.5499	0.0228			
AR(4)	12.9905	0.0113			

Model 2

Godfrey's Serial Correlation Test					
Alternative	LM	Pr > LM			
AR(1)	1.7279	0.1887			
AR(2)	14.9814	0.0006			
AR(3)	15.3558	0.0015			
AR(4)	18.8475	0.0008			

A1.3 Newey-West procedure for Heteroscedasticity and Autocorrelation Consistent standard errors.

To perform Newey-West standard error correction, PROC MODEL is run specifying the GMM estimation method in the FIT statement. KERNEL=(BART, 5, 0) is also specified which requests the Bartlett kernel with a lag length of 4. The VARDEF=n option is specified to be consistent with the original Newey-West formula.

proc model data=WORK.SORTTempTableSorted; endo d_portfolio_rf; exog d_exr_useu d_oil_wti d_inv_petr d_msciworld d_fleetsize d_vlccspot1 d_msciworld1; instruments _exog_; parms b0 b1 b2 b3 b4 b5 b6 b7; d_portfolio_rf=b0+b1*d_exr_useu+b2*d_oil_wti+b3*d_inv_petr+b4*d_msciworld+b5*d_vlccspot1+b6*d_fleetsize+b7*d_msciworl d1; fit d_portfolio_rf /gmm kernel=(bart,5,0) vardef=n; run; quit;

The parameter estimates and the Newey-West corrected standard errors from the above analysis is showed in section 7. Note that with GMM estimation, when the instruments used are all the exogenous variables in the OLS regression model, then the parameter estimates are identical to the OLS estimates⁴⁴.

⁴⁴ (SAS Support Web)

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